

STATE OF FLORIDA
STATE BOARD OF CONSERVATION
DIVISION OF GEOLOGY

FLORIDA GEOLOGICAL SURVEY
Robert O. Vernon, Director

SPECIAL PUBLICATION NO. 9

**FLORIDA PETROLEUM EXPLORATION,
PRODUCTION, AND PROSPECTS**

By

Clarence Babcock, *Geologist*

TALLAHASSEE

1962

ERRATA

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Page 3 - (1st paragraph, 2nd line) 1 to 10, not 1 to 4.

Page 8 - (Table at top of page, heading of 2nd column) Florida offshore acreage under lease at the end of 1961, not Florida mainland acreage under lease in 1960.

Figure 3, facing page 8 - Legend at bottom of figure should read 1961, not 1962.

Page 13 - (Figure 4) Well "4" is an abandoned oil well, not a producer.
- (Figure 4) Dry hole spotted in sec. 24, T.48 S., R.29 E., at the center of southeast quarter, add the figure "9".

Page 15 - (Table 2) GCRC 1, under heading "Present Status", add Abnd oil well.
- (Table 2) GCRC 4, under same heading, Abnd oil well, not P & A.

Page 25 - (Table 4) South Florida Embayment, under column "Total thickness"
^a(418), not 418; also next column move 57+ up one line.

Page 31 - (Table 5) Footnote 2, 3rd line from bottom, 1 to 10, not 1 to 4.

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Discussions with the following oil company geologists were of great assistance: Mr. Joseph E. Banks and Mr. Wendell L. Roberts, of the Coastal Petroleum Company; Mr. E. L. Russell and Mr. J. F. Schindler, of the California Company; Mr. Robert Martin of the Gulf Oil Corporation, and Mr. Edward P. Riker, of the Sinclair Oil and Gas Company.

EXPLORATION

In 1961, eight exploratory wells were completed and all of these have been plugged and abandoned. A ninth exploratory test, the California Company, Florida State Lease 1011, No. 3 well was coring on December 31, 1961, at 12,390 feet with no shows reported. Data on these wells are given in appendix 1, and the wells are spotted on figure 1.

During the year, 87,737 feet of exploratory drilling was done in these nine wells. This is considerably more than the exploratory footage drilled in 1960 (53,866 feet).

A summary by counties of highlights of exploratory drilling in Florida in 1961 follows:

COLLIER COUNTY

The Humble Oil and Refining Company, Miles Collier No. 1 well, located about 6 miles southeast of the Sunniland oil field, was drilled to a total depth of 11,737 feet in the original hole, and 11,646 feet in a sidetrack hole. An oil show was reached at 11,634 feet in the sidetrack hole, the operator coring 2 feet into the show. Apparently an additional 10 feet of hole was cored, the last 1½ feet of the core being a gray, porous, rudistid rubble or very fine carbonate gravel which carried salt water.

Tests in the Sunniland pay interval of this well were as follows:

1. DST (drill stem test) - open hole: 11,631-11,636 feet (according to the Microlog, the lower part of the tested interval occurs in the top of a 90-foot zone of good porosity).

Choke : ¼ inch
Duration : 3 hours 53 minutes
Recovery : 4 barrels oil
 41 barrels water - 156,000 ppm (parts per million)
Pressures : BHF (bottom hole flowing) - 2,740 pounds
 BHSI (bottom hole shut-in) - 5,165 pounds
2. The rock at the tested depth was swabbed, and during more than 33 hours of swabbing over a period of about 2 weeks, approximately 50 barrels of oil and 3,000 barrels of salt water were recovered.

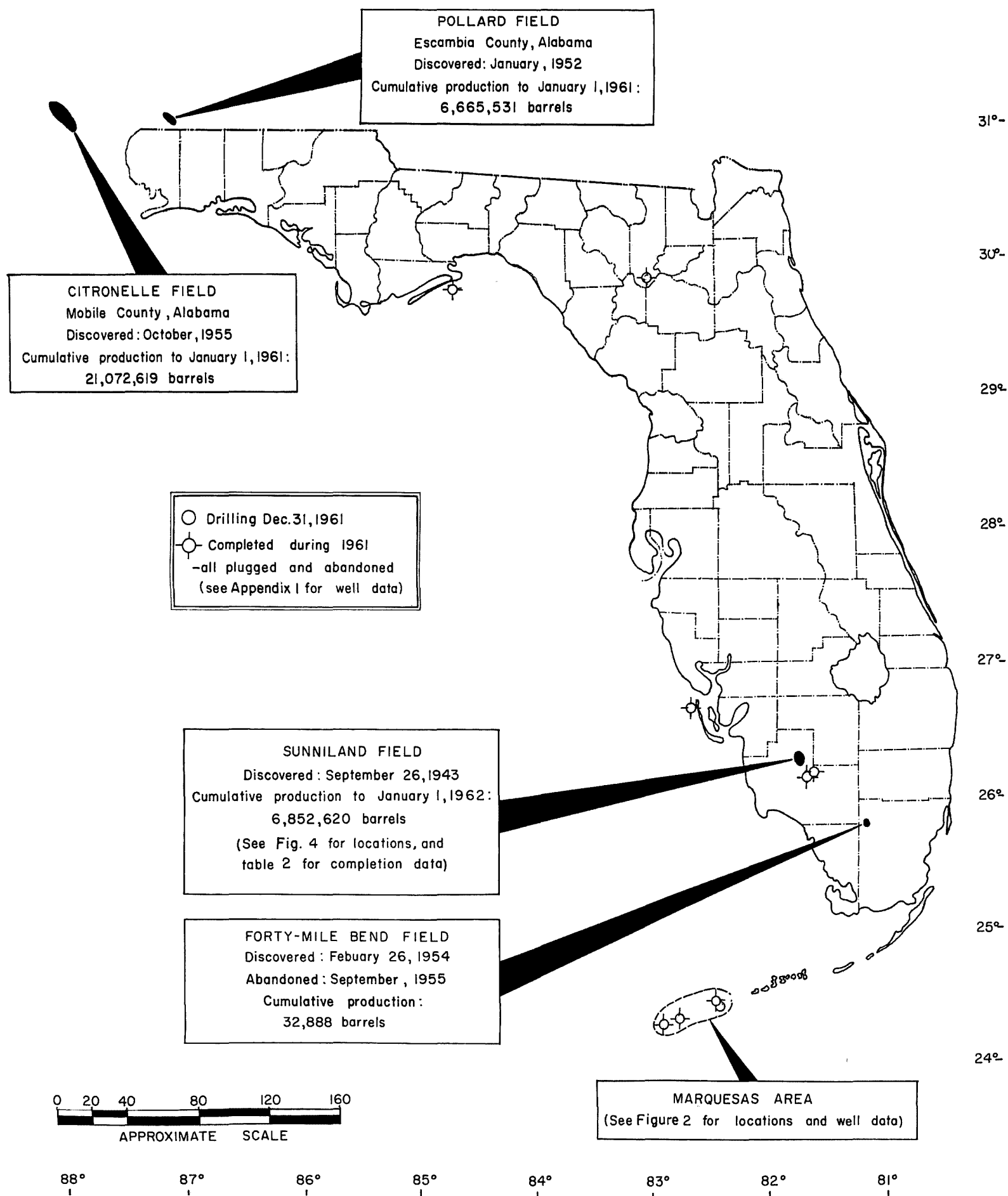


Figure 1. Florida petroleum exploration and production.

This test information showed that whereas the oil-to-water ratio was 1 to 4 in the drill stem test, it was 1 to 60 in the swabbing test. This unsuccessful completion is considered to be the most promising oil show in the past few years.

At the base of an anhydrite immediately overlying the limestone containing the Sunniland producing zones, this well lies at a structural elevation of about -11,555 feet, which is the same as that of the 1954 oil-water contact in the Sunniland field (Raasch, 1954, p. 30).

The Fredericksburg Limestone of late Lower Cretaceous age was swabbed at 9,812 to 9,822 feet, but recovered only salt water (117,000 ppm).

This was a seismic location.

The Humble Oil and Refining Company, Miles Collier No. 2 well was located slightly less than 1 mile northeast of the Miles Collier No. 1 well, and reached a total depth of 12,961 feet. The Sunniland limestone in this well was tested as follows:

Depth	: 11,745-11,757 feet
Choke	: ¼ inch
Duration	: 2 hours 28 minutes
Recovery	: 1 pint oil 9 gallons water
Pressures	: BHF - 415 pounds BHSI - 485 pounds

The Sunniland zone tested in the Miles Collier No. 2 well is separate and distinct from that tested in the No. 1 well; it occurs about 107 feet lower in the Sunniland limestone interval.

At the base of an anhydrite immediately overlying the limestone containing the Sunniland producing zones, the Miles Collier No. 2 well is about flat with the No. 1 well.

Cores of the Fredericksburg section at 9,750 to 9,754 feet and 9,802 to 9,828 feet contained oil saturation. A subsequent open hole test of the interval 9,735 to 9,829 feet recovered 3 gallons of brackish water containing a slight oil emulsion; pressures were very low.

This was a seismic location.

FLORIDA GEOLOGICAL SURVEY

COLUMBIA COUNTY

The Barton, Strahan, and Anderson, W.M. Davidson No. 1 well bottomed at 160 feet in beds of Eocene Age. The operators originally proposed to drill this well to a depth of 3,000 feet to test the updip pinchout of Upper Cretaceous sediments on the west side of the Peninsular Arch. Wells previously drilled in the vicinity of the W.M. Davidson No. 1 well found Early Ordovician (Beekmantown) sands, shales, and quartzites at about 3,000 feet.

This location was based on subsurface information.

ESCAMBIA COUNTY

The Emmette F. Gathright, State Lease 833, No. 1 well was drilled to a total depth of 7,043 feet, terminating in the Lower Tuscaloosa section of Upper Cretaceous Age. This test was located about 10 miles northeast of Pensacola. Though the Gathright well was permitted for 12,500 feet (which probably would have tested the deeper Lower Cretaceous section) it is reported that the intention was to abandon after testing the Lower Tuscaloosa section if the well was normal.

This was a gravity location.

FRANKLIN COUNTY - OFFSHORE

The California Company and Coastal Petroleum Company, State Lease 224-A, No. 2 well was drilled to a total depth of 10,566 feet, about 13 miles offshore from Carrabelle. This general area is high, according to regional gravity and magnetic surveys. A core taken at 10,324½ feet consisted of quartzite with coal inclusions containing pollen of probable Jurassic Age. There previously has not been such strong evidence that the Jurassic sea reached this far north and west in Florida and it is hoped that paleontology will provide information that will allow the subdivision of the thick Mesozoic carbonate and evaporate section of south Florida. It was postulated by Robert B. Campbell (unpublished report, 1934) that at least part of Florida was underlain by Jurassic rocks, which extended northward from the known Jurassic of Cuba. Campbell's 1934 paper refers to an opinion of J. Whitney Lewis (stated in *Am. Assoc. Petroleum Geologists Bull.*, v. 16,

p. 537) that the Jurassic of Cuba is the source of most of the oil and asphalt that occurs in the seeps and pools of Cuba.

This was a seismic location.

LEE COUNTY - OFFSHORE

The California Company and Coastal Petroleum Company, State Lease 224-B, No. 2 well reached a total depth of 12,600 feet in rock of Lower Cretaceous (Coahuila ?) Age. This well was located offshore and about 26 miles west of Fort Myers. It also lies about 3 miles north-east of California's offshore State Lease 224-B, No. 1 well, a dry hole that was plugged and abandoned in November 1960, at a total depth of 14,000 feet in lime and dolomite of undesignated age. In the No. 2 well the massive anhydrite was topped at 11,520 feet; on this marker the No. 2 well is 47 feet higher than the No. 1 well.

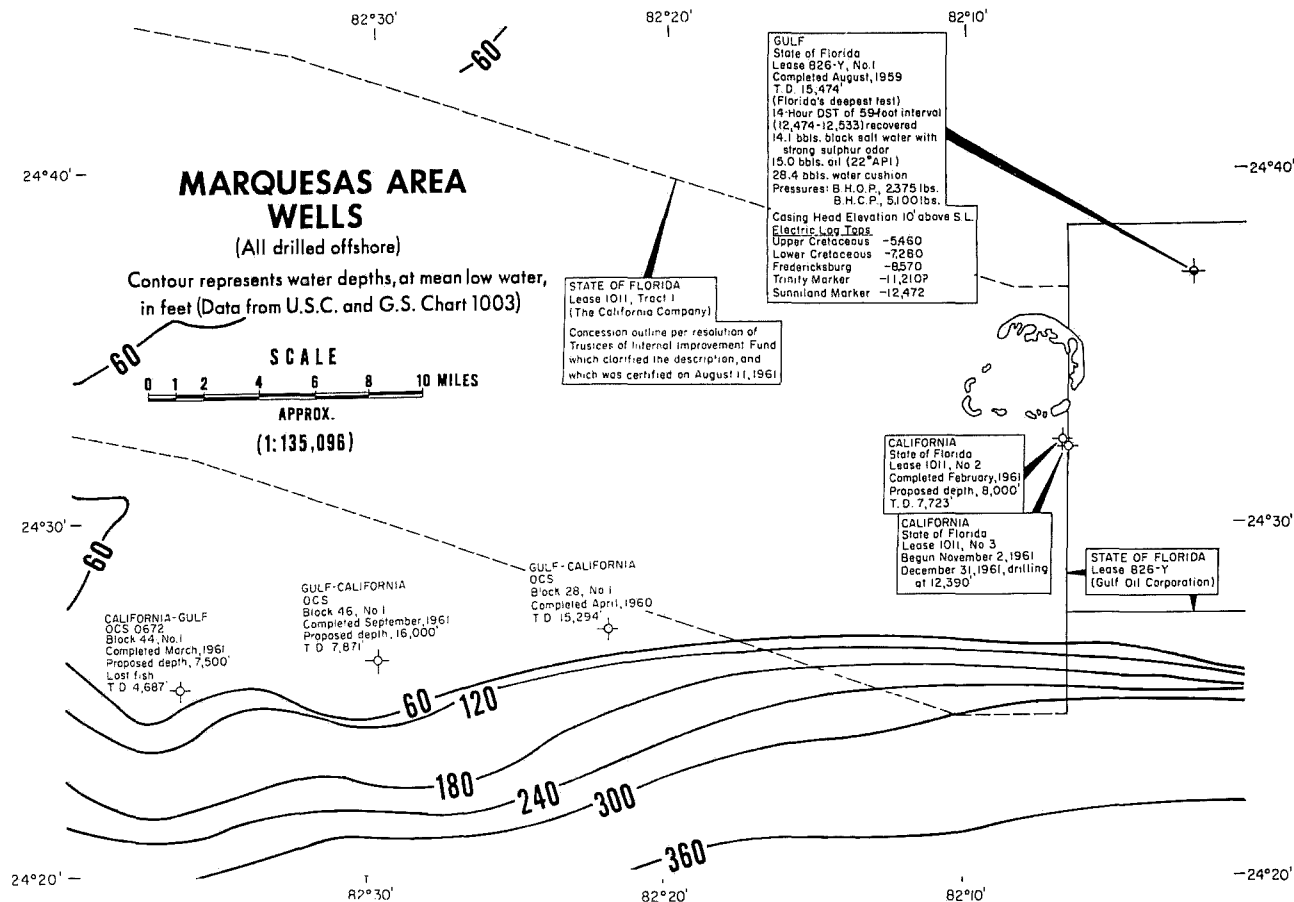
Two drill stem tests were run on State Lease 224-B, No. 2 well. The first tested a section of lower Upper Cretaceous age at 8,212 to 8,235 feet and recovered 2,439 feet of salt water. The second tested the Sunniland limestone of Lower Cretaceous (Glen Rose) Age at 11,285 to 11,355 feet and recovered 8,534 feet of salt water, analyzing 260,000 ppm total dissolved solids. For comparison, the total dissolved solids of the salt water produced in the Sunniland field from this formation, in the Humble Oil and Refining Company, Gulf Coast Realities Corporation No. 1 well, was 240,600 ppm.

This location was made on subsurface information.

MONROE COUNTY - OFFSHORE

In the Marquesas area four wells were drilled. The locations, drilling data, and the locations and data on other Marquesas area wells drilled in prior years, are shown on figure 2.

The California Company, Outer Continental Shelf, Lease 0672, Block 44, No. 1 well bottomed at a depth of 4,687 feet in sediments of Eocene Age when the drill pipe twisted off and could not be recovered. Originally the California Company proposed to drill this well to 7,500 feet because information from other Marquesas area wells indicated that this depth probably would have revealed the top of the Lower Cretaceous section.



This was a seismic location.

The California Company, State Lease 1011, No. 2 well reached a total depth of 7,722 feet.

This location was based on seismic information and was drilled to fulfill a lease obligation.

The California Company, State Lease 1011, No. 3 well was located 790 feet southeast of the California Company No. 2 well. The No. 3 well was planned as a Lower Cretaceous test with a proposed depth of 12,800 feet. As of December 31, 1961, the terminal date of this report, this well was coring at 12,390 feet. No shows had been recorded.

The Gulf Oil Corporation-California Company, Outer Continental Shelf Block 46, No. 1 well reached a total depth of 7,871 feet. Originally it was proposed that this well would be drilled to 13,000 feet, but drilling was discontinued when the drill pipe twisted off. Despite the fact that the fish was recovered, drilling was never resumed. This well penetrated sediments of Upper Cretaceous Age.

This was a seismic location.

LAND

FLORIDA MAINLAND

The latest detailed leasing information available to the Division of Geology pertains to 1960, and is from the *International Oil and Gas Development Year Book of 1961*, part 1, volume 31, page 63. This source, as supplemented by information from the State Land Office relative to offshore acreage, reveals that 12 companies in 1960 held oil and gas leases on undeveloped mainland acreage in 57 of Florida's 67 counties, as follows:

<u>Company</u>	<u>Florida mainland acreage under lease in 1960</u>
Coastal	643,969
Continental	297,055
Gulf	76,830
Humble	1,437,792
Mobil	290,129
Shell	136,337
Sinclair	199,160
Sun	192,626
Texaco	222,545
Tidewater	24,849
Union	15,742
	<u>3,537,034</u>

FLORIDA OFFSHORE

At the end of 1961, Florida acreage offshore from the west coast of Florida, according to information from the State Land Office, was held by three companies under oil and gas lease as tabulated below:

<u>Company</u>	<u>Florida mainland acreage under lease in 1960</u>
California	734,760
Coastal	3,910,460
Gulf	979,160
	<u>5,624,380</u>

An additional area of approximately 2,500,000 acres offshore from the Gulf Coast of Florida a distance of 3 leagues (10.36 miles) were available for lease at the end of 1961. These consist of water bottoms leased under the provision of State leases 833 and 826 (Blocks A-J and O-U). Furthermore, the offshore Atlantic Coast of Florida, out to a distance of 3 miles, is available for oil and gas leasing except where beaches not owned by the State are located.

The lessor, approximate locations, and outlines of State leases located offshore from the west coast of Florida, acreage contained in each lease, and bonuses and annual rentals paid are shown on figure 3. All leases provide that the State's share of production shall be one-eighth of the value of the oil at the wellhead.

GEOPHYSICS

Summary of geophysical activity in Florida in 1961:

<u>County and company</u>	<u>Method</u>	<u>Total crew weeks</u>
Collier Humble Oil and Refining Co.	Deep core drill	1
Hendry Sinclair Oil and Gas Co.	Experimental seismograph	6 (est.)
Sun Oil Co.	Experimental seismograph	5
Santa Rosa Olin Oil Company	Seismograph	5
Plymouth Oil Company	Seismograph	(latter part 1961)
Texaco Company	Gravity	2 (continued working area in 1962)

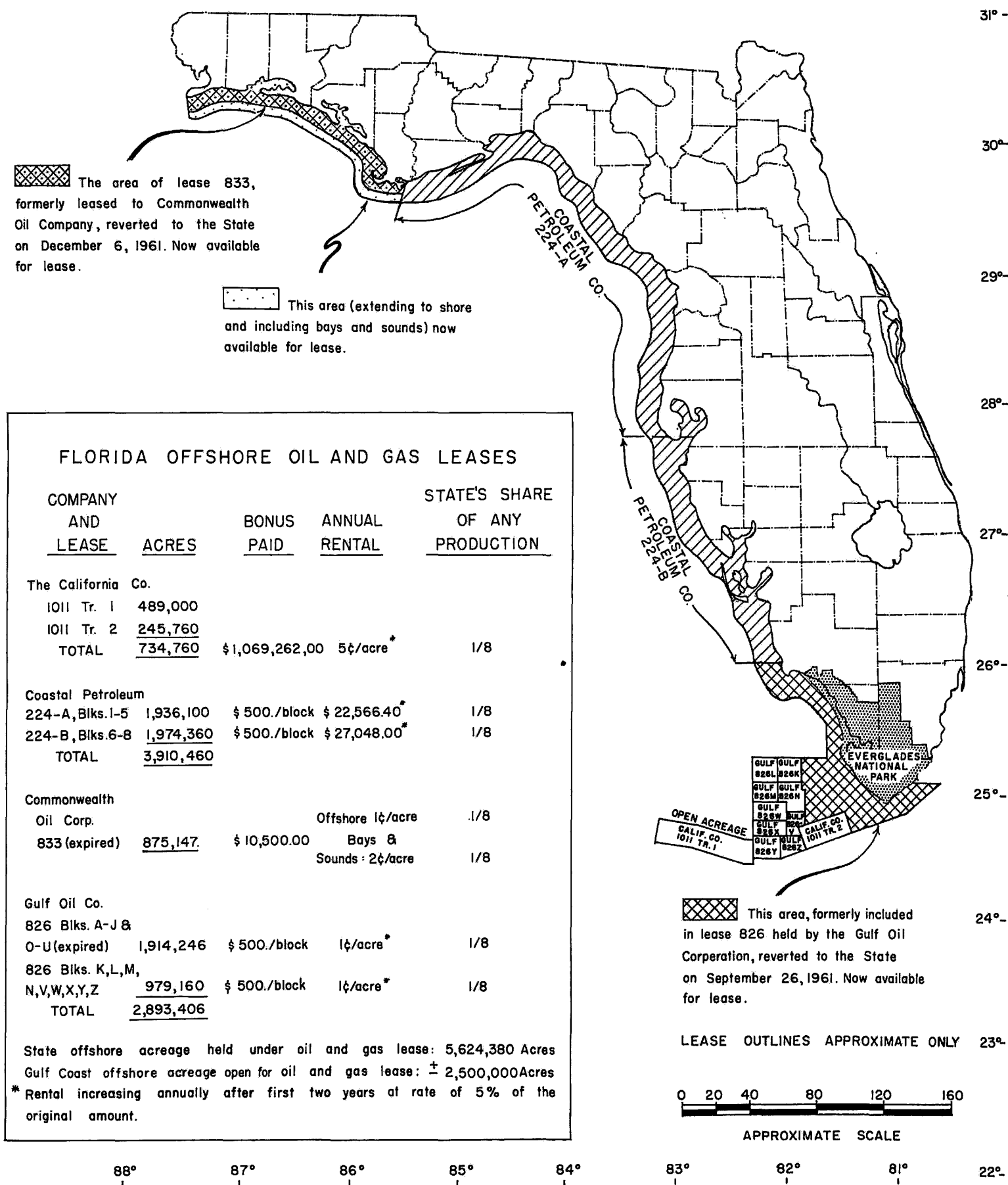


Figure 3. Offshore Florida State leases, December 31, 1962.

There was much more geophysical activity in Florida during the preceding year of 1960, for which period 89 crew weeks are recorded by Vernon and Hendry (1960, p. 7).

Crew weeks of geophysical activity in Florida, by counties, over the 20-year interval, 1941-1960, inclusive, were obtained from the Oil and Gas Year Book pertaining to each of the included years, and are shown in table 1.

Table 1. Crew Weeks of Geophysical Activity in Florida,
1941 to 1960, Inclusive

County	Gravity	Mag.	Air Mag.	Resist.	Core drill	Seismic	Total
Alachua	42	14	0.33			7	63.33
Baker	26.66	16.33	.33				43.32
Bay	60.25	15	1.33		11	18	105.58
Bradford	12.33	3	.33				15.66
Brevard	13.66	4.75				14	32.41
Broward	6	0.5			2	2	10.50
Calhoun	67	3	.33		17	14	101.33
Charlotte	25	3.5		1	13	70	112.50
Citrus	28	10			.5		38.50
Clay	13.33	13.33				3.5	30.16
Collier	33.5	7.5		4	313.5	158	516.50
Columbia	41.5	5			3	7.16	56.66
Dade	21	4.25				53	78.25
DeSoto	31	1.5			17	60	109.50
Dixie	31.5	19.5			71	12	134.00
Duval	17.5	17.66				3.25	38.41
Escambia	64	11	3		95	62	235.00
Flagler	28	4				2	34.00
Franklin	26.33		.33		12	31	69.66
Gadsden	37.5	17	.33		27	21	102.83
Gilchrist	26.5	4.5	.33				31.33
Glades	25	2.5			16	27	70.50
Gulf	60.75	8	.33		12	61	142.08
Hamilton	20.83	4	.33		18		43.16
Hardee	42.5	3			35.5	19	100.00
Hendry	21	1.5			63	68	153.50
Hernando	33.5	13.25			46.5		93.25
Highlands	38.5	6.25			16	56	116.75
Hillsborough	59	2			16	21	98.00
Indian River	9	2.33				29	40.33
Holmes	67.83	29	1			47	144.83
Jackson	73.33	27	.33		52	31	183.66
Jefferson	38.33	15	.33				53.66
Lafayette	35.5	6.5	.33		43	12	97.33
Lake	34.33	9.25				6	49.58

Table 1. (Continued)

County	Gravity	Mag.	Air Mag.	Resist.	Core drill	Seismic	Total
Lee	11	3.5		2	27	54	97.50
Leon	45	13.75	0.33		6		65.08
Levy	45	22.91	.33		14.5		82.74
Liberty	30.33	10	.33		6	16	62.66
Madison	49	10	.33		6	3	68.33
Manatee	23	9				40	72.00
Marion	36	28.25				2	66.25
Martin	4	1.33			3	10	18.33
Monroe	69.5	17.25				116	202.75
Nassau	15.5	13.66				4	33.16
Okaloosa	77.3	14	5		26	22	144.30
Okeechobee	25	6.25			30	60	121.25
Orange	17.83	8.75			23	1	50.58
Osceola	23.5	7.33			28.5	45	104.33
Palm Beach	41	10			20	45	116.00
Pasco	58	4			60		122.00
Pinellas	18.5	1					19.50
Polk	100.5	12			66.5	17	196.00
Putnam	14.66	10.5					25.16
Santa Rosa	82.5	11	6		167	104	370.50
St. Johns	20	6.5				2	28.50
St. Lucie	6	6.75				20	32.75
Sarasota	12	5.5			28	13	58.50
Seminole	18	4.75					22.75
Sumter	18	6.75					24.75
Suwannee	46.33	6.66	.33		46	1.5	100.82
Taylor	53	7	.33		31		91.33
Union	12	7					19.00
Volusia	29.33	2					31.33
Wakulla	23.66	4	.33			6	33.99
Walton	100.83	22	4		58	112	296.83
Washington	72	23.5	2.33	4	16.5	34.5	152.83
Total	2410.23	621.79	28.93	11.00	1563.00	1642.91	6277.86
Activity not broken down by counties, for 1951, '52, '53, and '58 (with percent of Grand Total)	82(3%)				250(14%)	1214(42%)	1546(20%)
Grand Total	2492.23	621.79	28.93	11.00	1813.00	2856.91	7823.86

In 1959 there was an additional 17 crew weeks of seismic activity over water bottom acreage which lies beyond the jurisdiction of the State of Florida (further offshore than 3 leagues or 10.36 statute miles).

RULES AND REGULATIONS

The rules and regulations by which Florida's oil and gas law (Florida Statutes, chapter 377, 1961) is administered, are implemented by the twelve 1-page forms listed below which are self-explanatory:

Form

- 1 - Organization Report
- 2 - Notice of Intention to Drill or Deepen
- 3 - Bond for Plugging a Single Well
- 4 - Blanket Bond for Plugging
- 5 - Notice of Intention to Abandon and Plug Well
- 6 - Monthly Producer's Report
- 7 - Producer's Report of Condensate . . .
- 8 - Monthly Producer's Natural Gas Report
- 9 - Well record
- 10 - First Production or Retest Report
- 11 - Producer's Certificate of Compliance and Authorization to Transport Oil
from Lease
- 12 - Affidavit on Plugging Completion

The following forms are given special consideration:

Form 2 - Notice of Intention to Drill or Deepen: To obtain a permit to drill, this form, accompanied by a fee of \$50.00, shall be presented to the Administrator, Oil and Gas Section, State Board of Conservation, P.O. Box 631, Tallahassee, Florida.

To obtain a permit to deepen, the same procedure is followed, but the \$50.00 fee is not required. No permit is required for workover operations as long as the well remains completed in the same reservoir.

Form 5 - Notice of Intention to Abandon and Plug Well: To obtain a permit to abandon, this form, accompanied by a fee of \$15.00, shall be presented to the Administrator, Oil and Gas Section, who may elect to send a representative to supervise the plugging of the well. All abandoned wells shall be plugged within 30 days of abandonment.

A primary objective of regulations regarding the plugging of oil tests is to avoid contamination of fresh water supplies.

Form 9 - Well Record: This form ". . . shall describe progressively the strata, water, oil or gas encountered in drilling a well with such

additional information as to gas volumes, pressures, rate of fill-up, water depths, caving strata, casing record, shooting, perforating, chemical treatment, etc., as are usually recorded in the normal procedure of drilling. Any electrical logging or surveying of the well shall also be recorded. . . ."

It is stipulated that the operator supply the Oil and Gas Section, Division of Geology, the following items within the time limit (following completion of the well) specified:

<u>Item</u>	<u>Time limit</u>
Form 9	30 days
Well samples	90 days
Electrical logs (or other surveys)	6 months

Florida's oil and gas law is administered in accordance with the rules and regulations set out in a pamphlet designated as "General Rules and Regulations Governing the Conservation of Oil and Gas in Florida." The law, the rules and regulations pamphlet, and oil and gas forms 1 through 12 (discussed previously) conform closely with the pattern suggested by the Interstate Oil Compact Commission. This material may be obtained without charge by writing to the following:

Administrator, Oil and Gas Section
Division of Geology
P. O. Box 631
Tallahassee, Florida

PRODUCTION

Florida's only current production is from the Sunniland oil field, which is located in Collier County in southern Florida. The locations of specific wells in the field, as well as of the 15 dry outposts to the field, are shown on figure 4.

The field was discovered in September 1943 by the Humble Oil and Refining Company. The discovery well, the Gulf Coast Realties Corporation No. 1, was drilled on the strength of core-drill information supported by a seismic and gravity anomaly. The field now produces from 11 wells, all pumpers. It has had 13 productive wells, most of which flowed initially. The oil lifting cost in the field is low because an efficient water drive permits the wells to be pumped from a depth of only 3,500 to 4,000 feet. Most of the wells are open-hole completions.

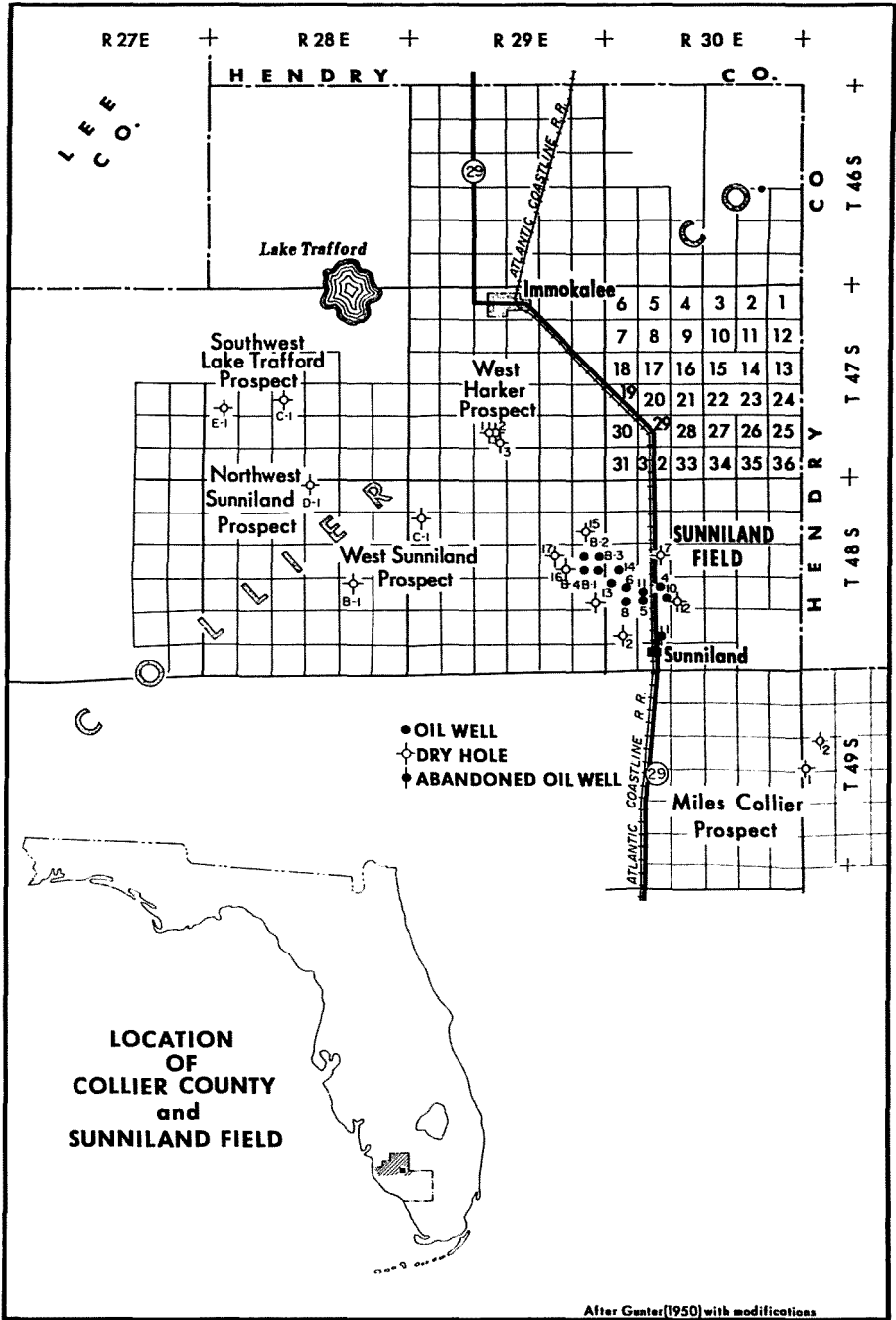


Figure 4. Sunniland oil field and nearby prospects, Collier County, Florida.

Completion data on the 20 Sunniland field wells, including dry as well as productive tests, are shown in table 2.

At the present time the Sunniland field produces about 1,000 barrels of oil per day. Production figures for 1961 are:

Month	Barrels
January	33,324
February	29,977
March	32,093
April	29,513
May	30,550
June	29,359
July	30,195
August	30,400
September	31,718
October	28,520
November	30,719
December	37,872
Total	374,240

The cumulative production of the field during its 18-year history to January 1, 1962, is 6,852,620 barrels of oil. The monthly production of oil and water for the field during its 18-year life is shown as a graph in figure 5.

The best wells in the Sunniland field are the Gulf Coast Realities Corporation No. 6 and No. 13, which, up to January 1, 1960, produced 1,148,792 and 731,883 barrels, respectively (Banks, 1960, p. 1738).

The Sunniland crude oil is black and medium in weight (19°-26° API [American Petroleum Institute] gravity; table 2). It is associated with little gas (gas-oil ratios are about 100 to 1; table 2). This crude oil is suitable principally for fuel products. According to Schweyer (1949, p. 12, 13) it is a mixed base oil possessing properties intermediate between those of the "paraffinic" base oils of Pennsylvania and those of the "naphtenic" base oils of Texas; the Sunniland crude oil is comparable to the high sulphur asphaltic crude oils from California.

DISTRIBUTION

At the present time Sunniland crude oil sells for \$2.39½ per barrel at the wellhead. It is moved by tank trucks from the field to Port Everglades just south of Fort Lauderdale, where tankers ship it to the refinery located at Bay Way, New Jersey.

Table 2. Completion Data on Humble Oil & Refining Company Wells, Sunniland Field, Collier County, Florida
(Modified after Gunter, 1950, p. 5)

Farm and No.	Present Status	Initial Production	Choke	Completion Date	Total Depth	Producing Zone	Elev. (D. F.)	Tubing Pressure	Casing Pressure	Gravity API	Gas-Oil Ratio 1949 ²	Remarks
GCRC #1 ¹		97 BOPD & 425 bbls. SW	Pump	11-16-43	11,626	Open hole 11,600-11,626	34'			20.8		Discovery well converted into SW disposal well
GCRC #2	P & A	Dry		11- 9-44	13,512		34'					Deepest well in field
GCRC #4	P & A	257 BOPD On pump	Pump	6-24-45	11,597	Open hole 11,560-11,597	34'			19.2		
GCRC #5	Pumper	518 BOPD Flowing	$\frac{1}{4}$ "	5-24-47	11,578	Open hole 11,560-11,578	31'	380	265	25	136 to 1	Pumped since June, 1948
GCRC #6	Pumper	225 BOPD Flowing	5/32"	5- 1-47	11,578	Open hole 11,556-11,578	31'	350	Sealed	25.6	67 to 1	Pumped since August, 1950
GCRC #7	P & A	Dry		10-21-45	11,842	Core of 11,782-11,791: Porous limestone with slight show of dead oil.						
GCRC #8	Pumper	527 BOPD Flowing	$\frac{1}{4}$ "	9-15-46	11,576	Perforations 11,564-11,569	29'	350	410	24.5	138 to 1	
GCRC #9	P & A	Dry		4-29-48	11,595	Promising shows, but every attempt to make a producer failed.						
GCRC #10	Pumper	175 BOPD Flowing	$\frac{1}{4}$ "	1- 8-48	11,574	Open hole 11,566-11,574	30'	72		24.8	100 to 1	Pumped since June, 1949
GCRC #11	Pumper	120 BOPD	$\frac{1}{4}$ "	10-14-47	11,573	Open hole 11,550-11,573	30'	35	60	25.4	90 to 1	Pumped since April, 1949

Table 2. (Continued)

Farm and No.	Present Status	Initial Production	Choke	Completion Date	Total Depth	Producing zone	Elev. (D. F.)	Tubing Pressure	Casing Pressure	Gravity API	Gas-Oil Ratio 1949	Remarks
GCRC #12	P & A	Dry		4-21-48	11,709	Oil shows in cores of 9,783-9,900, 11,591-11,592, and others						
GCRC #13	Pumper	395 BOPD Flowing	$\frac{1}{4}$ "	12-25-48	11,572	Open hole 11,519-11,572	39'	260	200	25.6	125 to 1	Pumped since June, 1950
GCRC #14	Pumper	190 BOPD Flowing	$\frac{1}{4}$ "	6- 1-49	11,579	Open hole 11,534-11,579	33'	120	0	25.5	85 to 1	Pumped since August, 1950
GCRC #15	P & A	Dry										
GCRC #16	P & A	Dry				Oil shows in cores of 11,570-11,580, 11,731-11,733, 11,737-11,745 and intervals between.						
GCRC #17	P & A	Dry										
LTCLC ³ B-1	Pumper	137 BOPD Flowing	5/16"	9-22-48	11,588	Open hole 11,568-11,588	39'	40	75	24.4	105 to 1	Pumped since September, 1949
LTCLC B-2	Pumper	519 BOPD Flowing	$\frac{1}{4}$ "	3-25-49	11,585	Open hole 11,564-11,585	40'	370	270	26.4	100 to 1	Pumped since June, 1950
LTCLC B-3	Pumper	447 BOPD Flowing	$\frac{1}{4}$ "	6-13-49	11,579	Open hole 11,541-11,579	34'	270	170	25	85 to 1	Pumped since May, 1950
LTCLC B-4	Pumper	437 BOPD Flowing	5/32"	12-28-49	11,576	Open hole 11,535-11,576	32'	730	565	25.3	105 to 1	

¹GCRC is Gulf Coast Realities Corporation.²Gas-Oil ratios have not been measured in recent years. However, due to the level of pressure maintenance, it is believed to have remained essentially constant at about 100 cf per bbl.³LTCLC is Lee Tidewater Cypress Lumber Company.

RESERVOIR

Geologically, the Sunniland structure is a northwest-southeast dome about 2 miles wide and $4\frac{1}{2}$ miles long. Puri's and Banks' paper of 1959 showed that the domal structure has a maximum vertical relief of about 154 feet, but that tilting to the northeast has reduced vertical closure to about 36 feet. An unpublished master's thesis submitted to the graduate faculty of Florida State University in 1954 by Albert C. Raasch, Jr., page 3 (written after 13 oil wells and 7 dry holes had been drilled in the Sunniland field) stated that the field was estimated to contain 2,356 productive acres. Also, Raasch (1954, p. 30) stated that the oil-water contact occurred at a subsea depth of approximately 11,555 feet.

There are two adjoining Sunniland pay zones and they are in Lower Cretaceous limestone of Glen Rose Age. The more productive of the two zones is the lower one which consists of a porous Chamid or rudistid reef. It is probable that the two Sunniland pay zones form a single reservoir. They have a combined thickness in the Sunniland field ranging from 5 to 45 feet, and are found at an approximate depth of 11,550 feet. A description of the reservoir rock in the Humble Oil and Refining Company, Gulf Coast Realities Corporation No. 2 well, used as the type section of the Sunniland field, is quoted from Raasch (1954, p. 29,30), with underlining by the present writer for emphasis:

"Two zones of porosity in the upper part of the middle member of the Sunniland formation produce all the oil at Sunniland. These are in the 'upper producing' zone and the underlying 'Chamid' zone. The upper zone . . . is composed of a maximum of fifteen feet of light to dark brown, hard, dense to porous, microfossiliferous limestone. Porosity ranges from 5 per cent to 22 per cent with an average porosity of 10 per cent.

"The main production is located in the top part of the 'Chamid' zone just below the 'upper producing' zone. The 'Chamid' zone at Sunniland is made up of fossil fragments (caprinids) and chalky cement When both the cement and the caprinids are recrystallized, the resulting inter-crystalline porosity is at its highest with little remaining of the original shell fragments except brown outlines from which minute calcite crystals project.

"The main producing zone has a maximum thickness of thirty feet Porosity ranges from 11 to 33 per cent with an average porosity of 18 per cent.

"Permeability determinations are not available on all wells in the field because of poor core recovery. Permeability is very poor, both horizontally and vertically, in the south and southeast parts of the field. In the northwestern part of the field, the permeability is considerably better, but the porosity is not as good."

Pressler (1947, p. 1862) stated that the producing zone in the Sunniland field has an average permeability of 312 millidarcys parallel with the bedding and 84 millidarcys perpendicular to the bedding.

Sunniland has had a low decline rate, the production of 1960 being less than that of 1950 by about 25 percent. The essential absence of free gas, low gas-oil ratios, small decrease in bottom-hole pressures, and the general pattern of continued increase in water production show that reservoir energy is primarily from water drive. A summary of reservoir data is provided in appendix 2, which itemizes specific information on the following reservoir parameters: bottom-hole reservoir pressure, present producing pressure differentials, and gas-oil ratios. Production statistics, by months, for the field during its 18-year life are shown on figure 5.

In an endeavor to estimate the additional oil which may be produced from the Sunniland field, consideration must be given to the following three factors:

(1) Figure 5 shows that over the past 7 years there has been a gradual increase in the percentage of salt water production as compared to oil production. At the present time the field produces slightly more than 60 percent salt water, whereas early in 1955 it produced only about 50 percent salt water. Figure 5 also shows that in 1956 and 1957 the percentage of salt water production as compared to total production fell sharply to about 43 percent. Beginning with January 1958, however, the salt water percentage returned to about the value which would have been expected had there been no decline in 1956 and 1957. The decline may have been due to some production practice which has been discontinued. It is not known what policy relative to salt water control the operator plans to follow in the future.

(2) During the last 10 years the annual percentage of production decline for the field has been in the neighborhood of 5 to 10 percent. Within this approximate range it has fluctuated rather sharply (determined from the production statistics shown in figure 5).

(3) At the present time the Division of Geology has no information on the production figure at which the economic limit of the field will be reached. The element of lifting cost, however, should not be unduly high since an efficient water drive permits the wells to be pumped from a depth of only 3,500 to 4,000 feet.

MONTHLY PRODUCTION IN BARRELS

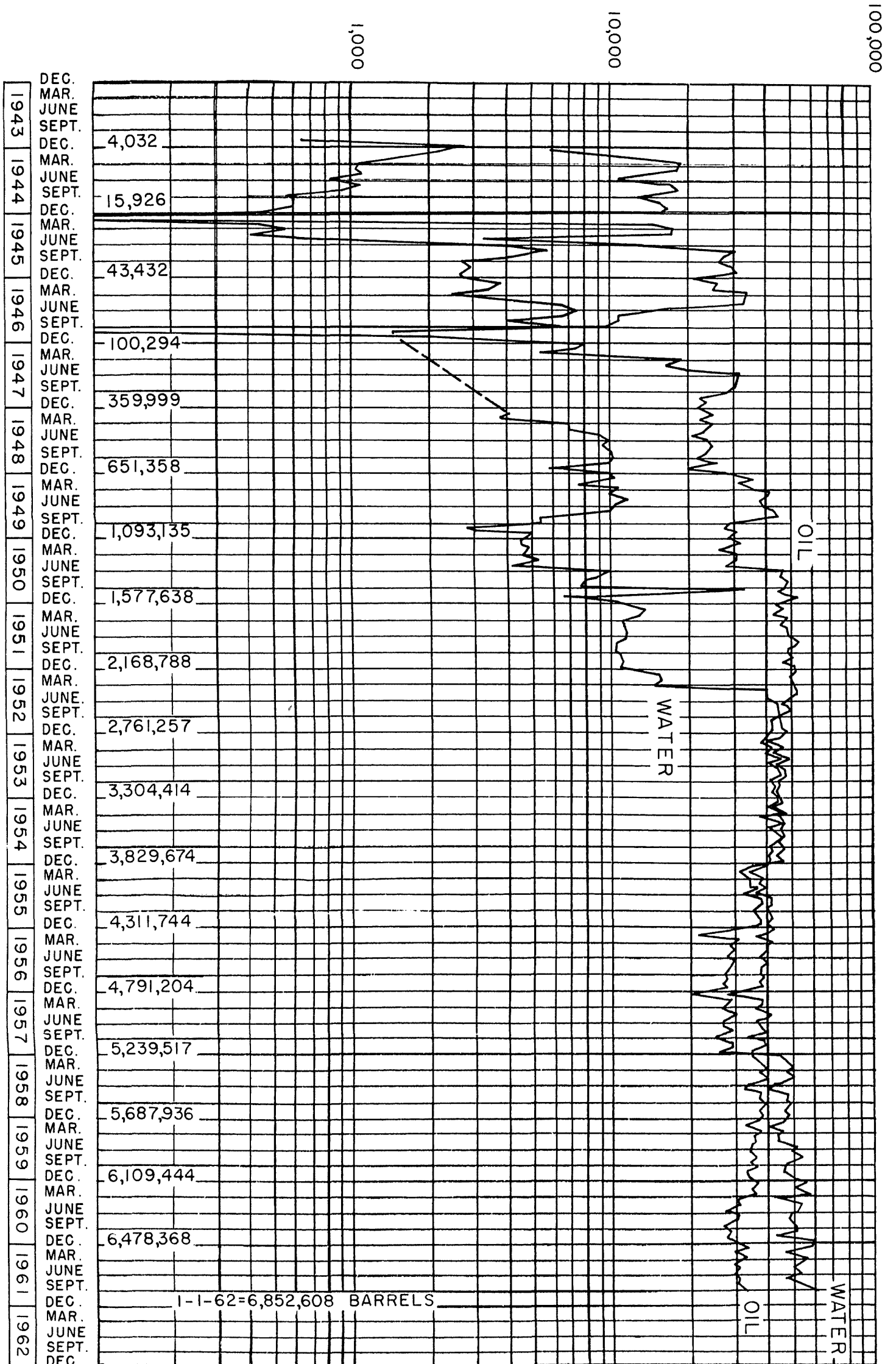


Figure 5. Production statistics, Sunniland oil field, Collier County, Florida.

In view of these considerations, a close estimate of the additional economically recoverable reserves of the field is not ventured. However, it appears reasonable to assume that the field has a good chance of being commercially exploitable for another 20 years, even though salt water incursion probably will have become very advanced within that period of time. If the Sunniland field produces another 20 years, and the percentage of production decline is about 5 to 10 percent per year, about 3 to 4½ million additional barrels of oil will be produced.

DRILLING PRACTICES

The casing program used in drilling the Sunniland field wells was described by Pressler (1947, p. 1862) as follows:

"Typical drilling procedure at Sunniland is to start with a 24-inch hole that is drilled to approximately 80 feet in depth where 20-inch conductor pipe is set. A 17¼-inch hole is carried to approximately 1,000 feet where 13 3/8-inch casing is set and cemented to the surface. This setting cases off the surface sand, gravel, and sandy limestone, and protects the Ocala limestone water zone from contamination. From this depth, a 12¼-inch hole is drilled to the total depth of 5,700 feet. Between the depths of 1,600 and 3,000 feet, complete circulation is lost in the cavernous limestones and dolomites of the middle and lower Eocene. At 5,700 feet, or near the top of the Upper Cretaceous chalky limestone, 9 5/8-inch casing is set. This setting restores circulation, and the wells are completed with 8 5/8-inch bits."

Most of the Sunniland wells were drilled with water to a depth of several hundred feet above the producing horizons, at which point drilling mud was added to prevent blowouts (Raasch, 1954, p. 31).

Raasch (1954, p. 31) stated that the time required to drill the Sunniland wells "... to a total depth of approximately 11,600 feet ranged from over seven months for the first well drilled (in 1943) to slightly over two months for the last well drilled (in 1949)"

BRINE

The Humble Oil and Refining Company, Gulf Coast Realities Corporation No. 1, which was the discovery well for the Sunniland field, was converted to a salt water disposal well in 1947. This well originally was completed December 2, 1943, at a total depth of 11,626 feet. Since it was unable to flow, pumping equipment was installed. Production

during the test conducted December 6, 1943, was 111 barrels of oil and 475 barrels of salt water. The well was operated until June 16, 1946, at which time the oil production had decreased to 10 barrels per day and the salt water had increased to 600 barrels per day. The well produced a cumulative total of 20,550 barrels of oil prior to being converted to salt water disposal.

The chemical analyses of the brine from the Sunniland field indicates it might be commercially exploited. Two analyses of brine produced from the Gulf Coast Realties Corporation No. 1 well are presented:

Table 3. Analyses of Brines from the Humble Oil and Refining Company, Gulf Coast Realties Corporation No. 1, the Discovery Well for the Sunniland Field

Radicals	Florida State Chemist Laboratory (milligrams per liter)	U. S. Bureau of Mines (milligrams per liter)
Silica (SiO_2)	30.0	0.0
Iron (Fe)	75.0 (+Al)	.0
Calcium (Ca)	28,100.0	25,204.0
Magnesium (Mg)	4,000.0	3,110.0
Sodium (Na)	51,000.0 (est.)	58,491.0
Fluoride (F)	.0	.0
Potassium (K)	4,700.0	Not tested
Carbonate radical (CO_3)	.0	.0
Bicarbonate radical (HCO_3)	.0	146.0
Sulphate radical (SO_4)	260.0	275.0
Chloride radical (Cl)	145,000.0	143,601.0
Nitrate (NO_3)	.0	.0
Bromide radical (Br_2)	600.0	Not tested
Iodide radical (I)	.0	.0
Hydrogen sulphide (H_2S)	.0	.0
Total hardness as (CaCO_3)	.0	.0
Specific conductance ($\text{K}\times 10.5$ at $25^\circ\text{C}.$)	.0	.0
Total dissolved solids	240,600.0 (at 180°C)	230,827.0
Suspended matter	20.0	---
Specific gravity	1.159	1.162

By calculation, the radicals determined by the Florida State Chemist Laboratory would form the quantities of salt compounds shown below:

	Compounds formed from Sunniland brine (milligrams per liter)
NaSO_4KCl	897
KCl	
NaCl	137,453
NaBr	
$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	
CaCl_2	77,817
CaCO_3	
MgSO_4	328
MgCl_2	15,398
Fe_2O_3	
	231,893

Comparison of the Sunniland brine with sea water, as analysed by Igelsrud (1932, p. 188) indicates that the brine contains nine times more bromine, almost three times more magnesium, and six times more total salts.

Of the elements contained in this brine, most are commercially extracted from sea water, or from salt such as that present in the Permian Basin of southeastern New Mexico. Two elements, however, are produced to an important extent from salt wells. Information on these two elements is:

(1) *Bromine*: The Michigan Chemical Corporation recovers bromine from *oil well brines* at El Dorado, Arkansas, and in 1960 this company expanded its El Dorado facilities. Also Arkansas Chemicals, Incorporated, a new company formed by the Great Lakes Chemical Corporation and the Houston Chemical Corporation, plans to extract bromine from well brines at a new plant to be constructed near El Dorado. (Information source: Stipp and Roman, Minerals Yearbook, 1960, p. 283-284.)

Bromine is also extracted from brine produced from wells in Michigan and West Virginia. (Information source: Stipp and Roman, op.cit., p. 283.)

(2) *Magnesium*: Of the magnesium produced in the United States 70 percent comes from brines. The source of these brines is specified as "well brines, raw sea water, and sea water bitterns." (Comstock and Baker, Minerals Yearbook, 1960, p. 749-750.)

The Sunniland brine could be delivered to an extraction plant from the oil separator at relatively low cost. There are few oil field brines as saline as the Sunniland brine, which is concentrated sufficiently to cause some of the dissolved solids to precipitate upon standing.

It appears that these brines might be commercially exploitable for their high bromine and magnesium content; also, the extraction of other radicals may be feasible. It is interesting to note that, according to the Geological and Economic Survey of the State of West Virginia, a large chemical plant in South Charleston, West Virginia, has operated on a brine containing about 9 percent sodium chloride and 12 percent total salt. For comparison, the Sunniland brine contains calculated percentages of 13.7 percent sodium chloride and 23.2 percent total salt. In 1960 the Sunniland field produced 619,000 barrels of brine, or about 1,700 barrels per day. This brine production is the equivalent of about 80 tons of total salts daily.

PROSPECTS

The subsurface axis of the Florida Peninsula (and of the Florida Plateau) is the Peninsular Arch (Applin, 1951, p. 3). Information from wells showed that on the pre-Mesozoic surface the crest of this feature is in the center of northern peninsular Florida, in Columbia County, and that on this surface the feature has a south-southeast trend which extends from southeastern Georgia into central Florida with a regional southeasterly dip of about 50 feet per mile (Applin, 1951, fig.2). Furthermore, the structural configuration and trend of Upper Cretaceous rocks at the base of beds of Austin Age, according to the Tectonic Map of 1961 (U.S. Geological Survey and American Association of Petroleum Geologists), on which the area of Florida was contoured by Paul L. Applin, is very similar to that of the pre-Mesozoic surface. Regional gravity control (Lyons, 1950) indicates, however, the existence of extensive gravity anomalies with predominantly northeast-southwest trend approximately at right angles to the pre-Mesozoic and Upper Cretaceous Peninsular Arch. Some of these gravity anomalies may reflect uplifted Ordovician and Silurian lithology deposited in a northeast-southwest trending Early Paleozoic "basin" as tentatively interpreted by Applin (1951, p. 12, fig. 5; p. 17). These gravity anomalies in some cases also may reflect certain Tertiary features of northeast-southwest alignment as contoured by Vernon (1951, pl. 2) from close well control on

top of the Inglis Formation of the Ocala Group of Eocene Jackson Age. In the general area of the Peninsular Arch 25 wells penetrated Upper or Lower Cretaceous beds overlying Early Ordovician sandstone and quartzite (Puri and Vernon, 1959, pl. 1). These are the oldest rocks to be drilled in the State, and lie at depths from 2,813 feet, in the Sun Oil Company, Ruth M. Bishop No. 1 well, located in central Columbia County, to 7,720 feet, in the Ohio Oil Company, Hernasco Corporation No. 1 well, located in southwestern Hernando County.

These Early Ordovician rocks were laid down on a continental shelf under shallow water marine conditions (Gunter and Vernon, 1954). In general, similar conditions of deposition have controlled the character of sediments laid down subsequently.

Sedimentary rocks of the Cenozoic, Mesozoic, and Paleozoic eras, with a cumulative thickness of 18,000+ feet, underlie Florida (Roberts and Vernon, 1961). This column is relatively thin over the Peninsular Arch, and thick in southern Florida and in the Florida Panhandle. The upper part of this column, consisting of rocks of Tertiary and Cretaceous ages, has a thickness as great as 15,000+ feet. These sediments underlie the entire State and are primarily carbonates and evaporates in southern Florida and clastics in western Florida. In general, the limestones spread northward in successively younger stages and encroach upon the clastics (Applin, 1944, p. 1679, 1680).

The limestones and sands of the Cretaceous System are important as oil and gas prospects. On the Florida mainland they vary in thickness from 1,000 to about 10,000 feet. In the Florida Panhandle, the Upper Cretaceous stratigraphy (exclusive of that laid down in Taylor time) has been described in cross sections, maps, and text by Applin and Applin (1947). For the eastern part of the Florida Panhandle, as well as the remainder of the State, Upper and Lower Cretaceous stratigraphy has been published in a series of cross sections designated as "Mesozoic Cross Sections A-A', B-B', C-C', D-D', and E-E'," prepared by the Southeastern Geological Society (1949).

Florida contains about 40 million mainland acres underlain by thick sequences of sedimentary rocks. Only 369 oil tests have been drilled but not more than three-fourths of these wells were deep enough to reach the Cretaceous horizons which present information indicates are the primary oil objectives.

The oil and gas provinces of Florida, as discussed in this report, are outlined on figure 6. The Offshore Province encompasses the area extending from shore to a water depth of 200 feet, mostly off the west coast of Florida. The Osceola Low Intermediate Province, in which postulated pinchout of deeper Lower Cretaceous sands against basement rocks is the most attractive possibility, mainly is delineated to conform with the possible outline of a basement feature as indicated by regional gravity control. The other provinces are based primarily on stratigraphy, and are intended to enclose depositional areas in which the conditions of oil and gas occurrence and exploration would be similar. Accordingly, the South Florida Embayment Province is outlined as it probably existed during Trinity Age when Lower Cretaceous reservoir and oil source rocks were deposited. Similarly, other province outlines for the remainder of the State are shown as they probably existed during important parts of the Eagle Ford-Woodbine (or Eutaw-Tuscaloosa) Age when Upper Cretaceous rocks were laid down.

A tabulation by province of depths and thicknesses of important sections, and approximate number of wells deep enough to test them, is presented in table 4.

OFFSHORE PROVINCE

Water bottom acreage under various depths of water from shore to 200 feet (considered the economic limit of water depth for commercial drilling operations on the basis of information presented in appendix 3) is shown on figure 6. This province provides an area for prospective offshore drilling slightly greater than that of the Florida mainland.

Of the 11 offshore wells which were probably deep enough to have reached Lower Cretaceous beds, 5 are located in the Marquesas area. Data on these wells are shown on figure 2. On the Sunniland marker, the Marquesas area lies at a structural elevation about 800 feet lower than that of the Sunniland field, located 130 miles to the north-northeast. Also, the Lower Cretaceous section down to the Sunniland marker is about 1,800 feet thicker in the Marquesas area than it is in the Sunniland field.

In general, seismic records of southern Florida contain much background interference making interpretations difficult. It would be helpful in interpretations if seismic records over water bottom acreage were found to have a relatively minor amount of background interference.

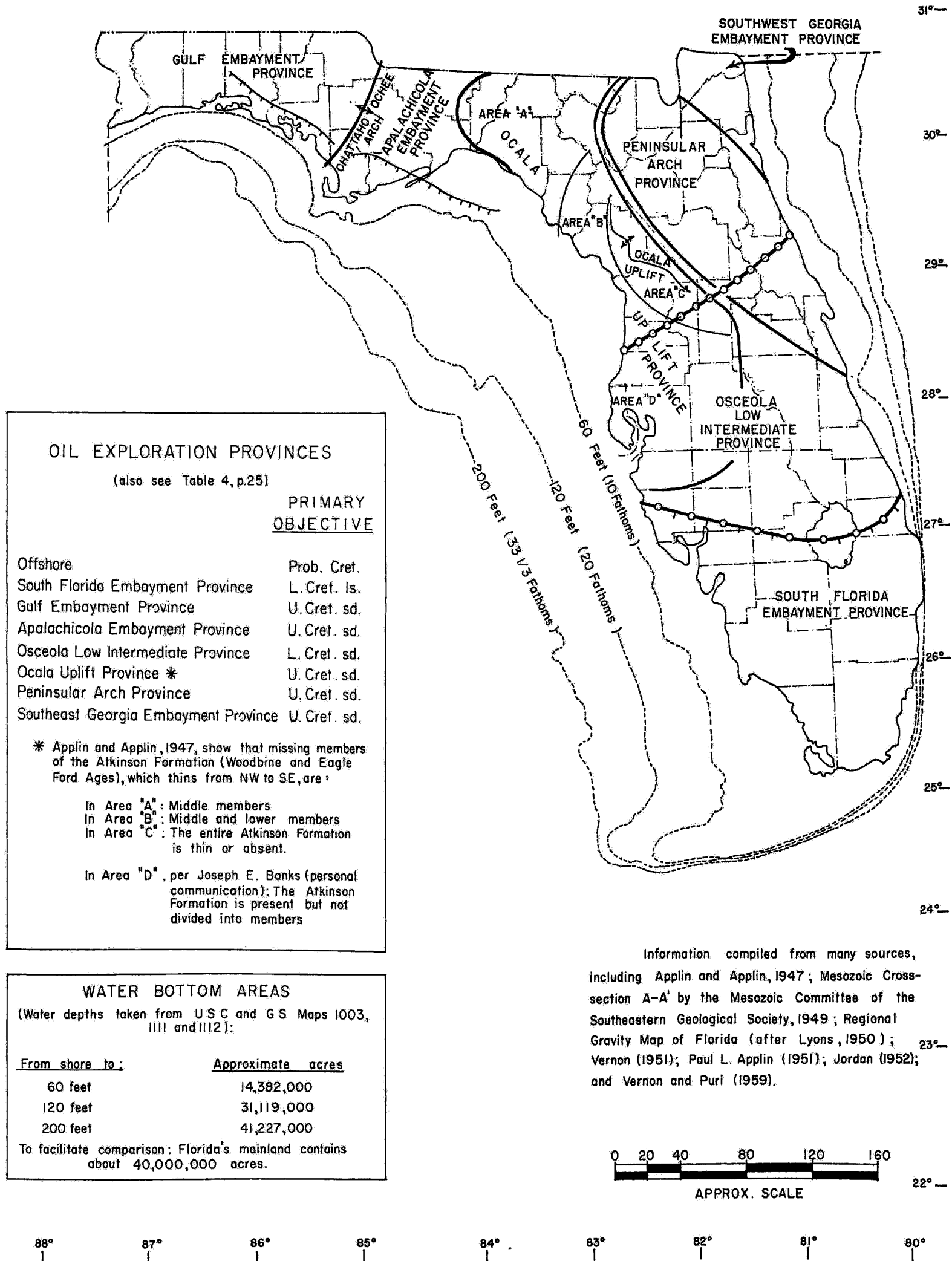


Figure 6. Oil and gas provinces of Florida.

Table 4. A Tabulation by Provinces of Depths and Thicknesses of Important Sections, and Probable Number of Wells Deep Enough to Test Them

Florida province	Important sections			
	Sections arranged in order of merit per present well information	Depths over most of the Province (bracketed if for one well only)	Total thickness (bracketed if for one well only)	Approx. no. of wells deep enough to test
Offshore	?	---	---	11
South Florida Embayment	L. Cret. Sunniland fm.	10,000-12,400	250	
			Pay zones: 77	
			Net pay: 5-45	57
	L. Cret. Fred. Ls.	±9,800 in Sunniland field	±1,000	
	Deeper L. Cret. sd.	^a (12,200)	418	57+
Gulf Embayment	U. Cret. beds	2,100-3,300	^b 1,500-3,000	100
	L. Cret. Rodess Fm.	^c (10,218) and ^d (12,120)	^c (1,100)	2
	Deeper L. Cret. Hosston Fm.	^c (11,290)	^c (1,235)	1
Apalachicola Embayment	U. Cret. beds	2,100-3,500	^b 1,500	26
	L. Cret. Sd. (Rodessa Fm.?)	^e (7,580)	^e (2,430+)	1
Osceola Low Intermediate	Deeper L. Cret. sd.	^f (6,360)- ^a (12,200)	^f (1,340)- ^a (418)	14
Ocala Uplift	U. Cret. beds	1,700-5,200	^b 1,500-2,750	35
Peninsular High	U. Cret. beds	2,000-3,000	^b 1,000-2,200	20
Southeast Georgia Embayment	U. Cret. Beds	^g (2,985)+	^g (1,655)+	1

^aHumble, C. C. Carlton No. 1 (southwestern Highlands County)

^bIsopach by Jordan, 1954

^cSocony, St. Regis No. 1 (northwestern Santa Rosa County)

^dZach Brooks, Caldwell No. 1 (southern Escambia County)

^eGulf Coast Drilling and Exploration Co., U. S. A. Forest Service No. 1 (southwestern Liberty County)

^fOhio, Hernasco No. 1 (southwestern Hernando County)

^gSt. Mary's River Oil Corporation, Hilliards Turpentine Company No. 1 (northwestern Nassau County)

TESTS AND SHOWS IN THE FLORIDA KEYS

The Gulf Oil Corporation, State Lease 826-Y well, the most northward and eastward of the Marquesas area wells, recovered from the calcareous Lower Cretaceous Sunniland interval 14.1 barrels of black salt water with strong sulphur odor, and 15 barrels of oil (fig. 2). This well probably could have been developed as a producer if it had been located on land and the oil present at shallow depth.

A deeper section initially appeared promising in the State Lease 826-Y well; core recovery from this section revealed good staining. Results of a drill stem test of this interval, which occurs below the top of the Lower Cretaceous massive anhydrite, were negative, as shown:

Depth	: 14,642-14,702 feet
Chokes	: 1-inch bottom and ¼-inch top
Duration	: 5 hours 18 minutes
Recovery	: 106 barrels salt water 21.3 barrels sea water cushion No show
Pressures	: Packers were stuck in the hole, and the pressure recorders could not be recovered

A section of alternating carbonates and anhydrites below the top of the Lower Cretaceous massive anhydrite also contained shows in another Gulf Oil Corporation test, State Lease 373 (Big Pine Key), which was located about 44 miles east of the State Lease 826-Y well. This test was structurally about 1,700 feet the higher of the two wells on the top of the Sunniland marker. In the test a 2-foot recovery from a cored interval of 5 feet (12,752 to 12,757 feet) had slight intermittent oil staining in hard limestone. Cores of a deeper calcareous and anhydritic section 224 feet thick (14,470 to 14,694 feet) had several zones of slight porosity and very slight oil stain. Apparently none of the shows were tested.

SOUTH FLORIDA EMBAYMENT PROVINCE

The South Florida Embayment, as contoured by J. E. Banks (1960) on an anhydrite near the Sunniland pay interval, is a large basin, has a gentle regional southwest dip of about 20 feet per mile, and has low relief features (Banks, 1960, p. 1743). The contoured anhydrite lies unconformably beneath about 10,000 to 12,400 feet of sediment.

The Sunniland formation extends north of the South Florida Embayment Province perhaps halfway into the Osceola Low Intermediate Province. The boundary which separates these provinces, as they are delineated on figure 6, is based on well control; it also conforms in general with the alignment of a broad regionally high trend depicted on gravity maps. Generally the area north of this boundary contains dense carbonate development in the stratigraphic equivalent of the section of Trinity Age, whereas to the south the Trinity section is characterized by the more favorable Chamid reefal development. This accounts for the fact that north of this boundary few oil and gas shows have been reported from the Sunniland pay interval, whereas to the south most of the 57 wells drilled deep enough to test this zone have recorded good shows.

Though well control in the South Florida Embayment Province has revealed that oil occurrence is common, it is inadequate to supply more than very regional structural information. Furthermore, geophysical techniques have been unsuccessful in providing detailed information on structures. The difficulties connected with reflection seismology were summarized in 1946 by John D. Todd, who stated:

"The seismograph . . . has encountered almost overwhelming difficulties in this province (South Florida). The cavernous surface, ground roll, absence of deeper reflection changes, (and) acute lateral velocity variations . . . have combined to hold reliable reflection seismograph results to a bare minimum."

Despite its limited effectiveness, Todd (1946) concluded:

". . . by using a shallow reflection, the Petty Company was able to do mapping in the southern part of the state. And by refractions the position of the basement can be located, and the top of the Selma often can be mapped." (Editor's note: The Selma Group comprises the uppermost of the beds of Upper Cretaceous Age in peninsular Florida, according to Puri and Vernon, 1959, fig. 3.)

During the past year the Seismograph Service Corporation has been working in areas of Hendry and Collier counties using the new vibration system in connection with their seismic prospecting. Operations are particularly difficult here. Because the subsurface sediments consist predominantly of carbonates, there are relatively few deep refraction and reflection changes. Furthermore, the sandy crust in parts of the area tends to obscure the record. However, the vibration system, which produces continuous vibrations, should yield more conclusive and characteristic records than the isolated tremors produced by dynamite, and there should

be less distortion on records made by the vibration system than on those made by dynamite.

There are large regional and many untested local gravity anomalies in southern Florida. It is unlikely that these are due entirely to lithology changes, and some structures must be present, although wells in Florida are too sparse to verify this.

THE MIDDLE MEMBER OF THE SUNNILAND FORMATION

The most prospective horizon in this province is the middle member of the Sunniland formation, of Lower Cretaceous (Trinity Glen Rose) Age, as defined in Raasch's type section (1954, p. 11). This member is 250 feet thick and consists predominantly of limestone. Its top occurs at the base of a prominent anhydrite that produces a characteristic electrical log marker. There are two pay zones in this member. The "upper producing" zone, the production of which is of secondary importance, occurs at the very top of the member and consists of 36 feet of hard limestone interbedded with anhydrite and dolomite. Immediately underlying this is a more productive zone which consists of 41 feet of Chamid reefal carbonates.

A third zone, occurring from 109 to 131 feet below the Chamid reef, was productive on test in the Commonwealth Oil Company, et al., M. B. Wisheart and State Board of Education No. 1 well, located in western Dade County in the abandoned Forty Mile Bend field. This zone was acidized through perforations (11,464 to 11,486 feet) and during a pumping test it yielded 20 barrels of oil per day plus considerable salt water.

In the areas that have been productive, the Sunniland pay zones contain dolomite. In some Sunniland field wells, production is obtained from a dolomitic section as thin as 5 feet, occurring somewhere within the interval of the upper two pay zones described above. Completion operations must be handled with great care and precision to avoid salt water incursion.

The middle member of the Sunniland formation is reached near the northern boundary of the province at about 10,000 feet; in the Sunniland field at about 11,550 feet, and offshore to the south in the Marquesas Keys area, which is in the deepest part of the basin drilled to date, at about 12,400 feet.

The Sunniland pay zones are the source of all of the oil produced in the approximately 10-million barrel Sunniland field, already described in this report under "Production." Structurally, the Sunniland field lies in a saddle between two gravity maxima, with seismic, gravity, and core drill results contributing to its discovery (Baum, 1953, p. 351).

All of the production of the 2-well Forty Mile Bend field, amounting to 33,888 barrels of oil before the field was abandoned for technical reasons, also is from the Sunniland pay zones. Figure 1 locates this field about 48 miles southeast of the Sunniland field. In the Forty Mile Bend area there is overwhelming evidence that petroleum source beds are present in the part of J.E. Banks' cyclothem (1960) which corresponds to the middle member of Raasch's (1954, p. 11) Sunniland formation. Banks (1960, p. 1743) stated that ". . . more than 15,000 barrels per acre of solid bitumen and 5,000 barrels of petroleum are indicated by physical and chemical tests of limestone cores." The discovery well for the field was the Commonwealth Oil Company, M. B. Wisehart State Board of Education No. 1, which was acidized through perforations 11,322 to 11,339 feet), and during a pumping test yielded 60 barrels of oil and 90 barrels of salt water. The Chamid reef of the Sunniland pay section in most south Florida producing wells was not present in the discovery well of the Forty Mile Bend field (Banks, 1960, p. 1740, fig. 3). In this well the producing zone was a thin dolomite with 19 to 22 millidarcys of permeability and 19 percent porosity, which produced 14,742 barrels of oil during about 15 months in 1954 and 1955 (Banks, 1960, p. 1741, 1742).

An analysis is presented in table 5 of the 10 dry outpost wells located from 4½ to 11½ miles from Sunniland field production. In these wells the top of the middle member of the Sunniland formation is compared with the oil-water contact of the Sunniland field, which stood in 1954 at a datum of -11,555 feet according to Raasch (1954, p. 30). This comparison shows that the datum in nine of these outposts ranged from 0 to 261 feet lower than the oil-water contact specified. Included in this group is the Humble Oil and Refining Company, Miles Collier No. 1 well, completed in 1961, in which the Sunniland marker occurs at the same structural elevation as the 1954 oil-water contact of the Sunniland field. This test had an excellent oil show from Sunniland reservoir rock and, according to the Microlog, good porosity. Only one of the dry outpost wells was structurally high on the basis described. This well is the Humble Oil and Refining Company, Collier Corporation B-1, which was 75 feet higher than the 1954 oil-water contact; large fluid recovery from

Table 5. Sunniland Field Outpost Wells¹

Wells	Comment
LTCL Co. No. 3 (West Harker Prospect) Sec. 28, T. 47 S., R. 29 E. -4½ mi. NW of production	69' low. Completed in 1947. T. D. 11,943'.
LTCL Co. No. C-1 (West Sunniland Prospect) Sec. 7, T. 48 S., R. 29 E. -5 mi. W of production	261' low. Completed in 1949. T. D. 11,894'.
GCRC No. B-1 (West Sunniland Prospect) Sec. 23, T. 48 S., R. 28 E. -7 mi. W of production	152' low. Completed in 1948. T. D. 12,220'.
GCRC No. D-1 (NW Sunniland Prospect) Sec. 3, T. 48 S., R. 28 E. -8½ mi. WNW of production	264' low. Completed in 1949. T. D. 11,900'.
GCRC No. C-1 (SW L. Trafford Prospect) Sec. 21, T. 47 S., R. 28 E. -10 mi. WNW of production	167' low. Completed in 1948. T. D. 12,120'.
GCRC No. E-1 (SW L. Trafford Prospect) Sec. 19, T. 47 S., R. 28 E. -11½ mi. WNW of production	178' low. Completed in 1949. T. D. 12,210'. It is understood that this well had a good test. The Division of Geology has no record of it, however.
Curry No. 1 (West Lake Trafford Prospect) Sec. 8, T. 47 S., R. 29 E. -8 mi. NW of production	12' low. Completed in 1955. T. D. 11,937'. DST in Sunniland pay interval recovered salt water (150,000 ppm.), no oil.
Collier Corporation B-1 (NE Sunniland Prospect) Sec. 14, T. 47 S., R. 31 E. -11½ mi. NE of production	75' high. Completed in 1952. T. D. 11,796'. DST: 11,549-585' Choke: 5/8" Duration: 7 hrs. 40 min. Recovery: 10,205' salt water

Table 5. (Continued)

Wells	Comment
Miles Collier No. 2 (SE Sunniland Prospect) Sec. 18, T. 49 S., R. 31 E. -6 mi. SE of production	0' low. Test: 11,745-757' Choke: $\frac{1}{4}$ " Duration: 2 hrs. 28 min. Recovery: 1 pint. oil, 9 gal. water Pressures: BHF, 415 pounds BHSI, 485 pounds According to the Microlog, this test was made in the upper 5 feet of a 90-foot interval of good porosity.
Miles Collier No. 1 ² (SE Sunniland Prospect) Sec. 18, T. 49 S., R. 31 E. -6 mi. SE of production	0' low. The Sunniland formation was drill stem tested in the open hole as follows: Depth: 11,631-11,636' Choke: $\frac{1}{4}$ " Duration: 3 hrs. 53 min. Recovery: 4 bbls. oil 41 bbls. water (156,000 ppm.) Pressures: BHF, 2,740 pounds BHSI, 5,165 pounds

¹ A brief summary of structural and drilling data for the 10 dry outpost wells located at distances ranging from $4\frac{1}{2}$ to $11\frac{1}{2}$ miles from Sunniland field production, and all drilled by the Humble Oil and Refining Company. Structural data at the base of an anhydrite immediately overlying the Sunniland pay interval in the dry wells are compared with Raasch's 1954 oil-water contact in the Sunniland field of -11,555 feet.

² Several swabbing tests are reported to have recovered a total of about 50 barrels of oil and 3,000 barrels of salt water.

A comparison of the drill stem test recovery with the reported total recovery of the swabbing tests shows that whereas the oil-to-water ratio in the drill stem test was 1 to 4, it was 1 to 60 in the swabbing tests. This unsuccessful completion is considered to be the most promising oil show in the past few years.

the Sunniland pay zones, though consisting entirely of salt water, indicated the presence of good porosity and permeability.

A similar analysis of the five dry outpost wells of the Forty Mile Bend field is summarized in table 6. The McCord Oil Company, Damoco No. 1 well is very low on Trinity Age Lower Cretaceous horizons as compared with all of the other wells in the Forty Mile Bend area. Correlating on the top of Banks' Lower Cretaceous Comanche interval Dade Unit D-4, this well is 270 feet lower than the Gulf Oil Corporation, State Lease 340 No. 1 producer. In the McCord Oil Company, Damoco No. 1 well the Sunniland Chamid reef appears to be absent. The remainder of the dry outposts to the Forty Mile Bend field ranged from 3 feet to about 54 feet low on the top of the middle member of the Sunniland formation as compared with the Gulf State Lease 340 No. 1 producer.

A paper by Roberts and Vernon (1961) stated that there is a trend of porosity in the Sunniland pay interval about 200 miles long and 30 to 50 miles wide trending through Sarasota, Charlotte, Lee, Hendry, Collier, Broward and Dade counties. Probably several factors contributed to the formation of porosity traps. There are cases in which porosity in carbonates is formed where shoal areas pinchout against the denser carbonates and anhydrites that were deposited in deeper waters) Roberts and Vernon, 1961). Banks (1958, p. 7) stated that the pay section which trends across Florida is a very porous reef limestone that abuts against dense anhydrite on one side and is covered by anhydrite. Also, according to Gunter and Vernon (1954) "Much of the porosity . . . is formed as biostrome and bioherm reefs, with porosity pinchouts in the inner reef areas and where pores have been filled with secondary anhydrite."

Porosity in carbonate rocks also might result from wave action over shallow areas during regressions and transgressions of the sea, whereby the fine rock particles are removed and the coarser particles remain as conglomerates. Regressions could produce "summit" conglomerates at the top of a formation just as naturally as transgressions could produce basal conglomerates at the base of a formation (Banks, 1958, p. 7). "Summit" conglomerates especially would occur at the top of a marine cycle when wave energy had a chance to act on reefs or other carbonate rocks. According to Banks, such conglomerates are present in the Sunniland pay interval.

OTHER POSSIBLE PAYS

Both above and below the middle member of the Sunniland formation, porous limestones and dolomites have carried shows of oil which occasionally have been tested.

Table 6. Forty Mile Bend Field Outpost Wells,¹

Wells	Comment
Commonwealth, et al. State Lease 1055 No. 1 Sec. 11, T. 54 S., R. 35 E. (About 2 mi. NE of production)	Low (54'?). Completed in 1959. T. D. 11,676'. DST: 11,395-456' Choke: 5/8" Duration: 1 hr. 45 min. Recovery: 6 bbls. mud and salt water Pressures: BHF, 3,212 pounds BHSl, 5,220 pounds
McCord Oil Company Damoco No. 1 Sec. 31, T. 53 S., R. 35 E. (About 4 mi. NW of production)	About 270' low. The reef does not appear to be developed in this well. Completed in 1951. Corr. T.D. 11,690'.
Gulf Oil Corporation State Lease 340 No. 2 Sec. 19, T. 54 S., R. 36 E. (About 1 mi. S of production)	5' low. The reef is probably present, but poorly developed in this well. Microlog not legible above salt water level. Completed in 1954. T. D. 11,597'.
Gulf Oil Corporation State Lease 340 No. 3 Sec. 19, T. 54 S., R. 36 E. (About 3/4 mi. S of production)	3' low. The reef is probably present but poorly developed in this well. Completed in 1955. T. D. 11,625'. DST: 11,342-346' Chokes: 3/8" and 1/4" Duration: 9 hrs. Recovery: 30' oil and 2,370' salt water Pressures: BHF, 221 pounds
Humble Oil & Refining Co. State Lease No. 1 Sec. 30, T. 55 S., R. 36 E. (About 8 mi. S of production)	3' low. Completed in 1945. T. D. 11,794'.

¹A brief summary of the five dry outpost wells located within an 8-mile radius of the field. Structural elevation of the electrical log marker occurring at the base of an anhydrite immediately overlying the Sunniland pay interval in the dry wells are compared with the datum of this marker (-11,312 feet) in the Gulf Oil Corporation, et al., State Lease 340 No. 1 producer (sec. 19, T. 54 S., R. 36 E., Dade County).

Relatively few shows have been reported from the Tertiary section. A show was encountered in the Coastal Petroleum Company, John Tiedtke No. 1 well, located in southeastern Glades County and in the northern part of the province, at a depth from 3,567 to 3,587 feet. This is in the upper part of the Cedar Keys Limestone of Paleocene Midway Age (the interval of the show in the Tiedtke well is porous dolomite with thin interbedded black shale). The rate of penetration through this interval was 1 to 2 minutes per foot. A layer of stratified anhydrite, 28 feet thick, lies upon the dolomite. The show is described by the Coastal Petroleum Company as "orange brown, sticky hydrocarbon spotted in porosity. Black shale is oily. Good cut with CCl_4 ." Throughout the province, porosity is well developed above the Cedar Keys Limestone in the Oldsmar Limestone of Lower Eocene and Upper Paleocene Wilcox Age. In fact, much of the Oldsmar Limestone is a zone of "lost circulation" which must be cased off before drilling to deeper depths; unfortunately, this zone is commonly flooded with salt water.

The Upper Cretaceous section in most wells in the South Florida Embayment Province has contained no sand. A few wells have had from 10 to 20 feet of very calcareous, tight, shaly sand with glauconite inclusions in the lowermost part of the Upper Cretaceous section.

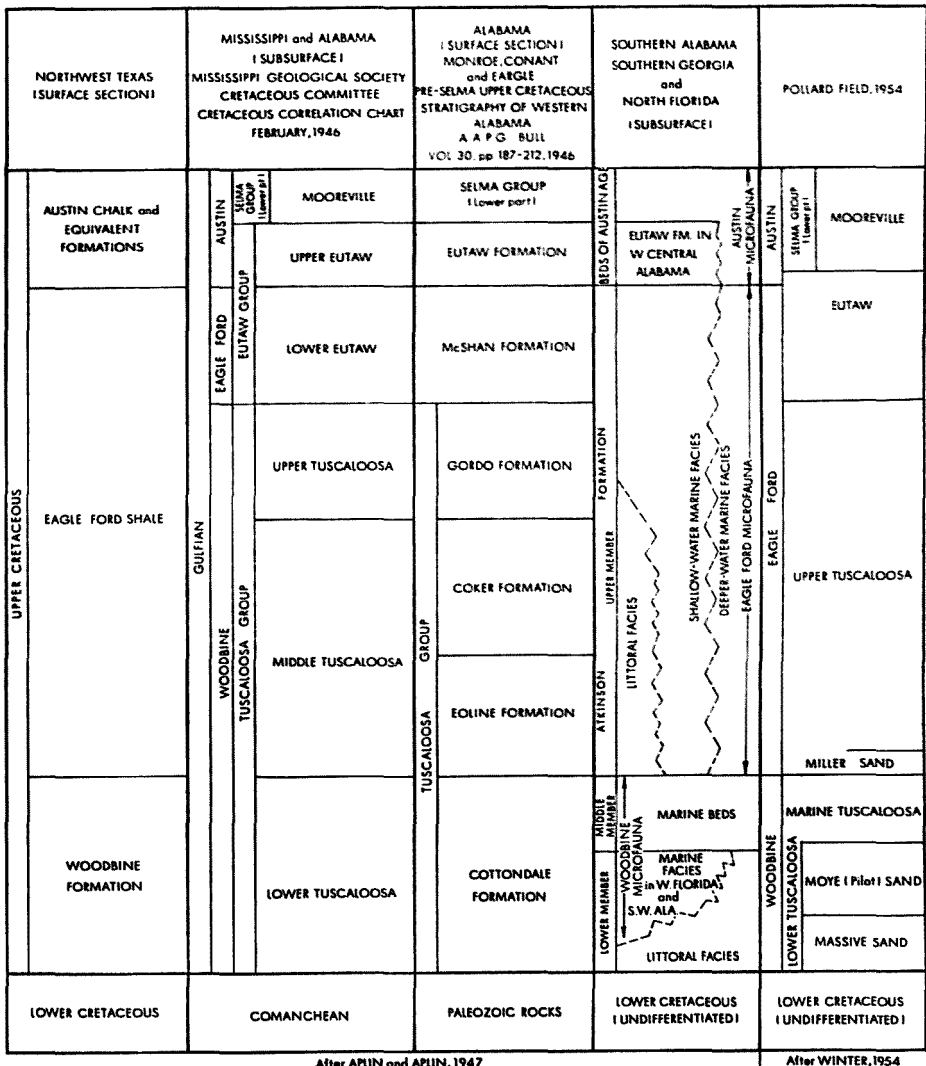
Oil shows are persistently reported in the Fredericksburg Limestone of Lower Cretaceous Age, which is penetrated at a depth of about 9,800 feet in the Sunniland field. Contours by Paul L. Applin of the top of Lower Cretaceous beds of Washita Age are shown on the Tectonic Map of 1961 (U. S. Geological Survey and the American Association of Petroleum Geologists) to enclose a basin which is generally similar in configuration to a deeper basin contoured by Banks (1960, p. 1739) on an anhydrite near the Sunniland pay zone. As compared with the stratigraphically deeper basin, the upper basin is somewhat shallower, the main part of the basin plunges to the west rather than to the southwest, and its axis is about 40 miles further north. The structural markers used to define these two basins are separated by an interval of 3,200 feet in the Sunniland field; the top of the Fredericksburg Limestone is approximately midway between these markers.

GULF EMBAYMENT PROVINCE

This province consists of the Florida Panhandle westward from the Chattahoochee Arch, and includes the structural depression known as the Apalachicola Basin, a syncline that widens and plunges to the southwest (Gunter, 1944), off the flank of the Chattahoochee Arch.

UPPER CRETACEOUS

The age and stratigraphic correlation of the Atkinson Formation (mainly with the Tuscaloosa Group of Mississippi and Alabama), which is an important Upper Cretaceous target in this province as well as in other provinces dealt with in this report, are shown in figure 7, a correlation chart.



As proposed by the Applins in 1947, the Atkinson Formation is divided into three members which are lithologically and ecologically distinctive over extensive areas of northern Florida. In Panhandle Florida the upper member contains deposits designated as shallow-water marine (updip) and deeper-water marine (downdip); whereas the middle member contains marine beds (Applin and Applin, 1947). The lower member grades southward from the unfossiliferous littoral deposits of Alabama and Georgia into a fossiliferous marine facies (Esther R. Applin, 1955, p. 187). Joseph E. Banks (personal communication) thinks that oil may be present in this lower member in areas where there is a gradation from a littoral to a marine facies. Exploration concentrated on the marine-littoral gradational trend of this lower member may find oil in northwestern Florida.

The validity, significance, and usefulness of the division of the Atkinson Formation into three members were not nullified nor questioned when Esther R. Applin (1955, p. 187), in order "To clarify the correlation of the Atkinson formation of the subsurface in the southeastern Gulf region with the Eagle Ford and Woodbine formations of Texas," redefined the Atkinson Formation "to consist of two members, an upper member of Eagle Ford age as formerly used, and a lower member of Woodbine age consisting of the former lower and middle members."

Applin and Applin in 1947 considered the lower sediments of their Atkinson Formation, which they designated as belonging to the Woodbine Stage, to have been deposited in the early part of the Upper Cretaceous Epoch (fig. 7). This assignment of an Upper Cretaceous Age to these sediments received support in 1952 from Cobban and Reeside (chart 10b, facing p. 1011) who would include the Woodbine Stage of the Gulf Coastal Plain, as well as the upper part of the underlying Washita Stage, in the Upper Cretaceous Series. These Cretaceous correlations by Cobban and Reeside are followed by the U. S. Geological Survey (1959, Wilson, et al., p. 410, 422). It should be noted, however, that the Mesozoic Cross Section Committee of 1949 of the Southeastern Geological Society considered the lower part of the Atkinson Formation to be of Lower Cretaceous Age.

It is possible that the correlations shown on figure 7 need further study, since Loeblich and Tappan (1961, p. 263) stated that planktonic and benthonic Foraminifera point to an Eagle Ford Age for a part of the section which Esther R. Applin (1955, p. 187) considered to be of Woodbine Age. The fossils cited by Loeblich and Tappan are a part

of the "Barlow fauna" described by Esther R. Applin (1955, p. 190), which occurs below the upper member of the Atkinson Formation in sections ranging from 3 to 60 feet in thickness in 13 wells located in Florida, Georgia, and Alabama.

In the Gulf Embayment Province the most prospected horizon to date consists of the Atkinson Formation, which is shown to have a thickness from about 800 to 1,400 feet in Applin and Applin's Cross Sections C-C' and D-D'.

The sands of the middle and lower members of the Atkinson Formation make up the productive intervals in the Pollard field, located just 4 miles north of the Florida State line in Escambia County, Alabama.

The Pollard field was discovered in 1952 by the Humble Oil and Refining Company. The cumulative production of this field up to January 1, 1961, was 6,665,531 barrels of 26° to 29° gravity oil. In 1960, a total of 35 wells produced in the field, all by artificial lift (Oil and Gas Year Book of 1961, pt. 2, p. 22). The petroleum accumulation is controlled by closure against a northwest-southeast fault, downthrown to the northeast. A paper by C. Victor Winter (1954, p. 121) showed that production is from the Miller sand of the Upper Tuscaloosa Formation (Eagle Ford Age) on the downthrown side of the fault, and from the Moya (Pilot) and Massive sands of the Lower Tuscaloosa Formation (Woodbine Age) on the upthrown side. Depths to production from these sections range from 5,624 to 5,905 feet. Thicknesses, porosities, and permeabilities of productive sands in the Pollard field are shown in table 7.

The Miller sand is included in the lowest part of the upper member, and the Moya (Pilot), which is the most prolific section in the Pollard field, and Massive sands are included in the lower member of the Atkinson Formation as defined by Applin and Applin (1947; correlation based especially on well No. 23 of Cross Section D-D').

The Oil and Gas Year Book of 1961 (pt. 2, p. 22) showed that the Pollard field also produced from the "Eagle Ford" sand, which is reached at an average depth of 5,196 feet and had an average thickness of 6 feet. No permeability or porosity figures are given for this sand.

Exploration with the core drill appears to have contributed to the discovery of the Pollard field (Baum, 1953, p. 355).

Table 7. Thicknesses, Porosities, and Permeabilities of Productive Sands in the Pollard Field

Sand	Thickness (feet) ¹				Permeabilities ² (millidarcys)	Porosities ² (percent)
	Gross		Net			
	Av.	Rge.	Max.	Av.		
Miller	--	15-30	18	13	600	32
Moye (Pilot)	91	--	40	--	--	30
Massive	240	--	23	--	495	29

¹ Winter, 1954² Oil and Gas Year Book of 1961, pt. 2, p. 22

Two additional Alabama fields which produce from Upper Cretaceous sands are present in this province. They are South Carlton (13 wells pumping from the Lower Tuscaloosa section), and Gilbertown (59 wells pumping from the Selma Chalk and Eutaw sections), located 50 to 85 miles, respectively, northwest of the Pollard field.

LOWER CRETACEOUS PROSPECTS

In this province the stratigraphic column also contains the sands of the Rodessa-Pine Island section of Glen Rose Age, which produce in the Citronelle field of Mobile County, Alabama, located about 36 miles west of the Florida Panhandle. The Citronelle field was discovered in October 1955, and to January 1, 1961, 254 wells had been drilled in the field and cumulative production was 21,072,619 barrels of 40° to 45° (API) oil. Depths to the tops of producing formations range from 10,870 to 11,399 feet, with all wells producing by artificial lift. In the Citronelle field the productive structure is anticlinal, and production is from a sand of 19 millidarcys permeability and an estimated porosity of 13 percent (Oil and Gas Year Book of 1961, pt. 2, p. 22).

In the Gulf Embayment Province of Florida only two tests definitely have reached the Rodessa Formation. These wells were the Socony,

St. Regis No. 1 well in northwestern Santa Rosa County, and the Zach Brooks, Caldwell No. 1 well in southern Escambia County. Depths to the top of this formation in these wells were 10,218 and 12,120 feet, respectively. The Rodessa Formation as drilled in the St. Regis well was 1,072 feet thick, but no porosity logs are available to the Division of Geology on this well. A Microlog over a 390-foot interval (12,120-12,510 feet) occurring in the upper part of the Rodessa Formation in the Caldwell well indicates that the interval is relatively tight. According to a Hycalog, no oil or gas shows were found in this 390-foot section.

The Hosston Formation of Lower Cretaceous Age was reached at a depth of 11,290 feet in the Socony, St. Regis well, and the well was terminated in these sediments at 12,525 feet.

Both the St. Regis and Caldwell wells were about normal to the regional strike, based on the top of both the Selma Formation and the Eutaw Formation of Upper Cretaceous Age. Several oil companies are known to be studying the possibility of further testing of the Rodessa-Pine Island and Hosston sections.

STRUCTURES

Structures in the Gulf Embayment Province are considered to be narrow, limited, and hard to find. Some of the gravity maxima, however, may be caused by faults (Todd, 1946).

Four probably related, essentially northwest-southeast faults cut beds of Upper Cretaceous Age and extend a distance of possibly 40 miles or more from the area of Pollard field, Alabama, into the northern half of Santa Rosa County, Florida. Included in this group of faults is a regional graben; this structurally negative feature embraces several subordinate essentially northwest-southeast faults, all downthrown to the northeast, one of which is the Pollard Fault which traps the oil accumulated in the Pollard field. With the exception of the area embraced by this graben, the major regional faults which belong to this system in Florida are downthrown to the southwest. The more eastwardly of these movements appear to be almost strike faults, whereas the most southwestwardly fault cuts the strike of Upper Cretaceous beds at almost 45° . In Florida, this fault system has produced as much as 470 feet of vertical displacement (between the Sunniland Contracting Company, T. J. Nicholas No. 1 well, and the Gulf Oil Corporation,

Cleveland H. Bray, et al., unit No. 1 well. Both of these wells are located in northern Santa Rosa County, with the second well being 1 1/3 miles northeast of the first) in Upper Cretaceous beds on top of a high resistivity curve in the Eutaw Formation. Distorted Upper Cretaceous beds, as contoured from relatively close well control in Florida, indicates that there has been some horizontal fault movement whereby blocks originally in Florida have moved in the direction of Alabama (Puri and Vernon, 1959, p. 22, fig. 6; Winter, 1954, p. 128, fig. 4).

DRILLING COSTS

Drilling costs over most of this province are low, and for this reason quite a lot of the drilling has been done by independents. Between 8 and 13 rock bits will usually cut an average hole to test lower Upper Cretaceous sands (Jeffreys, 1953). Gunter and Vernon (1953) reported that at the date of their writing it cost from \$18,000 to \$150,000 to drill a well in the Florida Panhandle.

APALACHICOLA EMBAYMENT PROVINCE

This province is bounded on the west by the Chattahoochee Arch, a gentle regional uplift on the flanks of which oil may be trapped. On the east the Apalachicola Embayment Province is bounded by the eastward limit of the middle member of the Atkinson Formation of Upper Cretaceous Age as drawn by the Applins (1947, map 2,3). This eastern boundary lies about 5 to 40 miles east of the synclinal axis of the Suwannee strait as contoured by the Applins. In its southerly part the Applins depict the Suwannee strait as widening and becoming fanlike so that it covers a large part of the lower half of the province. As this feature widens and deepens toward the south it progressively loses much of its identity and significance as a strait, until it becomes an embayment.

The Suwannee strait appears to have an important bearing on the petroleum prospects of this area. Paul L. Applin (1952, p. 1162) stated that this feature is ". . . probably partly structural and partly topographic in origin." Hull (1962, p. 120) suggested that it may have been formed as an area of nondeposition. In any event, the late Upper Cretaceous beds of Navarro Age and the upper part of the underlying beds of Taylor Age (Paul L. Applin, 1952, p. 1162) are not present. Hull (1962, p. 119) recorded that the strait is as narrow as 20 to 30 miles, is more

than 200 miles long, and has relief on top of the Cretaceous of more than 800 feet. In Pressler's Florida Cross Section A-B (1947, p. 1855, fig. 2), the general area in which the Suwannee strait is located is shown to lie at a depth of 3,000 feet, as referred to the top of the Selma Formation of Upper Cretaceous Age. The Suwannee strait is the boundary between two distinct facies of Upper Cretaceous rocks. Hull (1962, p. 119) noted that, "North of the strait is a sandy calcareous shale of the coastal plain. Just south of the strait are the Florida reef and bank deposits of the Florida Peninsula."

UPPER CRETACEOUS

In the Apalachicola Embayment province there are a variety of Upper Cretaceous prospects. Thinning of the middle member of the Atkinson Formation may produce an updip stratigraphic porosity pinchout. Unconformities which overlies sections from which Upper Cretaceous rock sequences are missing may serve as oil traps. The relationships of clastic to carbonate facies, which characterizes beds of Upper Cretaceous Age may produce traps. Oil accumulation may be present in the Upper Cretaceous carbonate reef which, according to Hull, is present just south of the Suwannee strait. If the Suwannee strait is partly structural in origin, as suggested by Paul L. Applin, structural traps may be present.

To date the Upper Cretaceous sediments of the Atkinson Formation (Eagle Ford and Woodbine ages) have been the most highly regarded section in the Apalachicola Embayment Province. The combined thickness of the Applins' upper and middle members of this formation over most of the province ranges from about 400 to 630 feet (Applin and Applin, 1947, map 3). Inclusion of the lower member, the base of which is very difficult to pick, increases the above thickness figures by about one-third (Applin and Applin, 1947, Cross Section D-D', wells 46 and 50).

The J. R. Sealy, Fee No. 1 well, located in southwestern Decatur County, Georgia, and in the northwestern part of the Apalachicola Embayment Province about 5 miles north of Florida, recovered gas (and salt water) from the Eutaw section at 3,005 feet. A sample of the gas analyzed by the U. S. Bureau of Mines contained 74 percent methane. Wellhead pressure was above 30 pounds per square inch, and was probably due to water pressure primarily. R. O. Vernon (personal communication) is of the opinion that storable quantities of gas such as were present in this show are commonly associated with, and can be separated from, subterranean salt water.

Robert B. Campbell (1940, p. 3) stated that the Central Florida Oil and Gas Company, G. W. Rhodes No. 1 well, located in southern Leon County, was reported to have a good show in the Selma Chalk Formation of Upper Cretaceous Age from depths beginning at 3,000 feet. The well drilled through the Selma Chalk Formation at 3,465 feet. At a total depth of 3,755 feet, at which point the well was abandoned (probably still in Upper Cretaceous sediments), considerable free oil was reported to have been bailed from the hole, but this report has never been substantiated.

OTHER POSSIBLE PAYS

The files of the Division of Geology record reports of shows in the Tertiary section which were even better than those described above. These were recorded by promoters and associates as being present in the Bonheur Development Company, B. M. Cates No. 1 well, located in northeastern Wakulla County, about 8 miles south-southwest of the Rhodes well. The Cates well is structurally 85 feet higher than the Rhodes well on top of the *Lituonella* zone, as correlated on the basis of a paleontological examination by Paul L. Applin. The Cates well was reported to have encountered a 32-foot section of oil sand at 2,137 feet continuing to the total depth of the well at 2,169 feet. The interval in which the shows occurred is included in the Avon Park *Lituonella* zone of Eocene Claiborne Age. Subsequently, a third well, the Revlin-Brown Trustees, Phillips No. 1, located about 2 miles east of the Rhodes well, was drilled to a sufficient depth to test the zones in which oil shows were reported in the Rhodes and the Cates wells. The Phillips well was a dry hole and was plugged and abandoned when the shows reported in the Rhodes and Cates wells were not encountered.

"Possible first red Rodessa sand" (early Glen Rose age) was found in the Gulf Coast Drilling and Exploration Company, U.S.A. Forest Service No. 1 well, located in the southwestern part of the Apalachicola Embayment Province and in southwestern Liberty County. The top of this formation was reached at 7,580 feet in this well, and from this point to the total depth at 10,010 feet the section is predominantly arenaceous. Seven sidewall cores taken at depths of 8,486, 8,880, 8,986, 9,058, 9,252, 9,263, and 9,510 feet, respectively, recovered primarily reddish brown sand, with occasional silty and slightly micaceous, or glauconitic sands; no shows were reported. These sands, though cored, were not tested and they appear to carry salt water. According to the Microlog, the 2,430-foot interval from 7,580 to 10,010 feet

contains 55 zones of good porosity (calculated porosity of a typical interval, 9,414 to 9,418 feet, is 24 percent) varying from 3 to 42 feet in thickness and having a combined thickness of about 584 feet. This well is regionally about normal on both the Selma and Eutaw formations of Upper Cretaceous Age. These seemingly porous "possible first red Rodessa sands" could be made to produce if they carried hydrocarbons further updip, or on structure.

BASEMENT

LeGrand (1961, p. 1558, fig. 2) using the Tectonic Map of the United States (1961), showed that "basement" in the northeastern corner of the province lies at about 6,000 to 7,000 feet, and probably dips rather steeply toward the southwest.

PROBABLE JURASSIC

A core taken at 10,324½ feet in the California Company and Coastal Petroleum Company, State Lease 224-A, No. 2 well, located about 13 miles offshore from Carrabelle, contains pollen of probable Jurassic Age. This well is located in an area which regional gravity and magnetic control shows to be high.

DRILLING PROBLEMS

J. E. Banks (1950) stated that "East and south of Tallahassee. . . unusual drilling problems start at the surface and continue until the widespread zone of lost circulation or water flow is completely penetrated and cased."

OSCEOLA LOW INTERMEDIATE PROVINCE

This is designed as an intermediate province because both the Tertiary and Cretaceous sediments grade into sediments that characterize the adjoining provinces.

The postulated pinchout of Lower Cretaceous clastics against the pre-Cretaceous basement appears to be the most attractive possibility in this province. Therefore, the province boundaries are drawn to conform with the possible configuration of a large, generally negative

basement feature as indicated by gravity control. The boundaries also enclose the locations of wells in which questionable pre-Cambrian (Applin, 1951, p. 2, fig. 1) crystalline rocks were penetrated by wells drilled on structural highs, including uplifted fault blocks (Vernon, 1951, pl. 2). These relatively high structural areas lie in the north-eastern part of the province. The quantity of disseminated particles of igneous material variously described as arkose and feldspar increases in the direction of these highs, which thus are indicated to have served as a source area of the Lower Cretaceous clastics. This material is especially prevalent in the Humble Oil and Refining Company, N. Ray Carroll No. 1 well, located in northeastern Osceola County, which reached weathered granite at the relatively shallow depth of 8,030 feet.

The Lower Cretaceous clastic section is comparatively thin in the southern part of the province, where it occurs at greatest depth, and appears to be farthest from the source areas of the clastics probably toward the north. The clastic sediments thicken in the northwestern part of the province where they are penetrated at comparatively shallow depths, and appear to have been deposited near a source area. The depth to the top of this Lower Cretaceous clastic section, and its thickness, in selected wells are presented in table 8.

Table 8. Depth and Thickness to Lower Cretaceous Clastic Section in the Osceola Low Intermediate Province

Well	Depth to top of section	Thickness of section
Humble C. C. Carlton No. 1 (Southwestern Highlands County)	12,200	485
Amerada Swenson No. 1 (Western Okeechobee County)	10,550	200
Humble N. Ray Carroll No. 1 (Northeastern Osceola County)	7,525	505
Ohio Hernasco No. 1 (Southwestern Hernando County)	6,360	1,340

In the Osceola Low Intermediate Province the Lower Cretaceous clastic section consists of terrestrial-marine clastics and red and green terrestrial clastics interbedded with evaporites.

E. H. Rainwater, in a well study made in 1946, designated these Lower Cretaceous rocks as "possible" Hosston sediments (Coahuilan Series) in the Humble Oil and Refining Company, C. C. Carlton No. 1 well, located near the southern boundary of the province. The Lower Cretaceous sediments in this well carried salt water and the section was not tested. However, a Microlog of a correlative section in the Continental Oil Company, C. C. Carlton, et al., No. 1 well, located 1½ miles to the west-northwest, indicates fair porosity. Rainwater has stated, also in the 1946 well study, that the sediments in the Carlton well that underlie the Lower Cretaceous section are of "possible" Jurassic Age. Lewis (1932, p. 537) is of the opinion that the Jurassic section of Cuba is the source of most of the oil and asphalt that occurs in the seeps and pools of Cuba.

The Hosston Formation is productive in Mississippi, Louisiana, Arkansas, and Texas (Murray, 1957, p. 112). According to Jordan (1954, p. 375) oil shows have been found in the Hosston Formation in southern Florida. Dead oil stains in the Lower Cretaceous section from 8,110 to 8,150 feet were found in the Humble Oil and Refining Company, Hayman No. 1 well, located in southern Osceola County.

OTHER SECTIONS

The Upper Cretaceous section contains relatively little quartz sand in most of the province, but it becomes more arenaceous to the west and northwest. The prospects in this area will be discussed in the part of this report devoted to the Ocala Uplift Province, which overlaps the western portion of the Osceola Low Intermediate Province.

The interval corresponding to the Sunniland field pay zone of Lower Cretaceous (Glen Rose) Age changes characteristics almost entirely in this province. Dense carbonates, with the percentage of dolomite increasing toward the north, replace the Chamid reefal development which occurs further to the south in the South Florida Embayment Province.

OCALA UPLIFT PROVINCE

Deposition of the Atkinson Formation of Upper Cretaceous Age, appears to be incomplete in all parts of the Ocala Uplift Province as delineated on figure 6. This condition prevails in Area A, Area B, and Area C (after Applin and Applin, 1947, map 3, 6), which embrace most of the province. It also appears to exist in the southern part of the province, designated as Area D on figure 6, in which the thinness of the Atkinson Formation suggests deposition of only part of the section. In Area D the Atkinson Formation, though present, has not been divided into members (Joseph E. Banks, personal communication).

The Ocala Uplift Province includes most of the structures referred to the Ocala Uplift, which was formed in Tertiary beds, probably during Early Miocene Age (Vernon, 1951, p. 53). Vertical dip slip faults paralleling the crest of the Ocala Uplift have flattened its crest and lengthened its cross section (Vernon, 1951, p. 56). Small domes also give gentle reversal of dip (Vernon, 1951, fig. 13, section C-C'). This information is based on control which extends into the Avon Park Limestone of Eocene Claiborne Age. Such control is a better guide to Tertiary petroleum prospects than is the shallower control of the extensively outcropping and eroded Ocala Group of Upper Eocene Age, which in the past was widely used as a structural key. It is unlikely, however, that Tertiary structures reflect, in most cases, the deeper highs. In connection with this, Vernon (1951, p. 53) stated that ". . . on the crest of the Ocala Uplift . . . Tertiary beds which are structurally high overlie Mesozoic beds which are structurally low. . . ."

UPPER CRETACEOUS

Drilling experience to date has shown that the sands of the Atkinson Formation (Eagle Ford and Woodbine ages) provide the most promising section in this province. These sands thin from north to the south in this province, as shown by the thicknesses tabulated for selected wells in table 9.

All of the Atkinson section is considered prospective, and areas of pinchout are especially interesting. See Area A, Area B, Area C (after Applin and Applin, 1947, map 3, 6), and Area D, all drawn on figure 6.

Table 9. Thicknesses of the Atkinson Formation
in the Ocala Uplift Province

Well	Thickness of the Atkinson Formation	Thickness of individual members of the formation		
		Upper	Middle	Lower
Stanolind St. Joe Paper Co. No. 1 (Leon County)	790'	378'		412'
Coastal Larsh No. 1 (Jefferson County)	420'	200'		220'
Stanolind-Sun Perpetual Forest No. 1 (Dixie County)	190'			190'
Coastal Wright No. 1 (Pinellas County)	70'	Not differentiated		
Socony Manatee No. 1 (Pinellas County)	10'	Not differentiated		

The basal shales of Austin Age which overlies the Atkinson Formation or that lie upon eroded Paleozoic rocks, are reported by Jordan (1954) often to have a petroliferous odor in the area of the Peninsular Arch.

All of the exposed sediments in this province, the oldest being the Avon Park Limestone, carry fresh water.

Gas shows were reported in the Eutaw (?) Formation of Eagle Ford Age at -3,672 feet in the Florida Oil and Gas Company, Cedar Keys No. 2 well, located near the west coast in Levy County (Todd, 1946). This gas was similar to that produced in Georgia by J. R. Sealy and was separated from flowing, gas-saturated, salt water.

OTHER SECTIONS

The Lower Cretaceous clastics penetrated at depth in the Ocala Uplift Province are generally red to variegated, calcareous sandstones. To the south the upper third of the section, which is included in the Comanche Series, is a tight dolomite with thin beds of limestone and anhydrite.

In the Ohio Oil Company, Hernasco No. 1 well, located in southwestern Hernando County and toward the southern part of the Ocala Uplift Province, Lower Cretaceous terrestrial-marine clastics and red and green terrestrial clastics are interbedded with evaporites.

The investigation of the prospects of these Lower Cretaceous rocks was presented in the preceding section which dealt with the Osceola Low Intermediate Province, the western part of which overlaps the Ocala Uplift Province.

A thickness of 2,285 feet of Paleozoic sediments, which appear to be mostly quartzitic sandstone, was drilled in the Stanolind Oil and Gas Company, Perpetual Forest No. 1 well, located in western Dixie County. This test bottomed in Paleozoic sandstone at a depth of 7,510 feet but no porosity log is available.

OTHER PROVINCES

The two remaining provinces of Florida are considered to be of secondary significance as oil and gas prospects at the present time. They are designated as the Peninsular Arch Province and the Southeast Georgia Embayment Province. The primary targets in both were the sands of Upper Cretaceous Age. These provinces lie on the eastern flank of the Peninsular Arch as contoured by Jordan (1952, fig. 8) on the base of the Upper Cretaceous section. The northwestern boundary of the Peninsular Arch Province, as shown on figure 6, encompasses an area, covering a large part of the province, in which the Upper Cretaceous section rests upon Paleozoics (Jordan's dashed area, 1954). The boundary between these two remaining provinces mainly is based on subsurface information from one well (St. Mary's River Oil Corporation, Hilliard Turpentine Company No. 1, located in northwestern Nassau County), and hence is very indefinite, especially to the south and away from the control well.

PENINSULAR ARCH PROVINCE

A well with an encouraging Upper Cretaceous interval is the Sun Oil Company, Powell Land Company No. 1 well, located in northern Volusia County, which cored 140 feet of Atkinson clastics. Core recovery revealed this clastic section to contain thick sequences of black shale. The upper 35 feet of this section, penetrated at a depth of 4,955 feet, is a fine grained, glauconitic sand or silt, with associated shale, about 8 feet from the top of which, according to the operator's core description, occurs 2 feet of "green, glauconitic, salt and pepper sand with black shale partings (and) kerosene odor."

The Lower Cretaceous sediments deposited to the south within the province immediately downflank from the Paleozoic subcrop into Upper Cretaceous rocks is a red sandstone of the Comanche Series. Further to the southeast in the province and toward the east coast, the Lower Cretaceous section thickens to a maximum of about 700 feet, and the upper two-thirds of the section becomes an alternating sequence of limestone, dolomite, and anhydrite.

Pre-Cretaceous sediments or igneous rocks of undetermined ages for the most part lie at depths ranging from about 3,000 to 6,000 feet, with the column being thickest toward the south.

Much of the sediment of the Peninsular Arch Province are saturated with fresh water which may have flushed out oil accumulations. Baker County, located in the north central part of the province, is saturated with fresh water to depths of about 3,000 feet (Gunter and Vernon, 1954). The Hunt Oil Company, H. L. Hunt No. 1 well, which bottomed at 3,349 feet, and which is selected as representative of the subsurface section of Baker County, reached the tops of the formations underlying this area at the following depths: Taylor (late Upper Cretaceous age) 2,393 feet; Austin (late Upper Cretaceous age) 3,038 feet; and Paleozoics, 3,339 feet.

SOUTHEAST GEORGIA EMBAYMENT PROVINCE

Only one deep well has been drilled in this province, and therefore little can be said about its petroleum prospects. The stratigraphic column here should be somewhat thicker than it is in the westwardly adjoining Peninsular Arch Province.

The sole deep well drilled here is the St. Mary's River Oil Corporation, Hilliard Turpentine Company No. 1, located in the northwestern part of the province in Nassau County. The total depth of this test was 4,824 feet. The Cretaceous and pre-Cretaceous sections drilled in this well, according to Mesozoic Cross Section D-D' prepared by the Southeastern Geological Society in 1949, are:

	Thickness (feet)
Navarro-Taylor-Austin	1,505
Atkinson	305
Comanche	30
Paleozoic	210
Basic igneous	24

Campbell (1940, p. 7) stated that he and R. S. Bassler considered the Paleozoics in the St. Mary's well to be of Chattanooga (Lower Mississippian) Age. Bassler's opinion is based on the presence in these sediments, which include black shales, of an ostracod cf. *Amphissites* (Campbell, 1940, p. 7). This specimen was lost after identification and cannot be checked. Bridge and Berdan (1950, fig. 6) show this material to be of Silurian or Ordovician Age.

W. Storrs Cole (1944, p. 94) is of the opinion that the St. Mary's well bottomed in 16 feet of igneous dike, which he tentatively classified as Triassic in age. Bridge and Berdan (1950, fig. 6) stated that this well terminated in "diabase," which was post-Paleozoic, and probably Triassic, in age.

In most of this province Upper Cretaceous prospects probably lie below the zone of fresh water saturation. The section in Duval County, which is located in the middle of the province as drawn on figure 6, is saturated with fresh water to a depth of about 2,400 feet (Gunter and Vernon, 1954). The top of sediments of Upper Cretaceous Navarro Age in the St. Mary's well, according to Mesozoic Cross Section D-D', lies at a depth of 2,750 feet.

CONCLUSIONS

Florida's oil and gas prospects primarily are in Cretaceous rocks. In northern Florida the Upper Cretaceous is the most promising section, whereas in southern Florida the Lower Cretaceous section is the most attractive.

In figure 6, Florida is divided into seven provinces intended to enclose depositional areas in which conditions of oil and gas occurrences and exploration would be similar. On the basis of present information, the most promising provinces appear to be the South Florida Embayment Province, the Gulf Embayment Province, and the Apalachicola Embayment Province. The Offshore Province, though as yet hardly tested, contains a thick sedimentary section and provides an area slightly larger than mainland Florida for prospective drilling. In table 4 is a tabulation by provinces of the depths and thicknesses of important sections, and probable number of wells deep enough to test them.

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APPENDIX I

EXPLORATORY WELL INFORMATION, 1961

COLLIER COUNTY

58

Permit no.	FGS no.	Company or owner	Well name	Location	Well data
288	W-5558	Humble Oil and Refining Co.	Miles Collier #1 About 7 miles SE of Sunniland field production.	SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 18 T. 49 S., R. 31 E.	Elev. - 35' Comp. - 1961 T.D. - Original hole, 11,737'; sidetrack hole, 11,646' (in Trinity)

REMARKS: (1) Fredericksburg Formation of late Lower Cretaceous Age was swabbed at 9,812'-9,822'; only salt water recovered (117,000 ppm).

(2) Sunniland formation of Lower Cretaceous (Glen Rose) Age was drill stem tested in the open hole as follows:

Depth : 11,631'-11,636'
 Choke : $\frac{1}{4}$ "
 Duration : 3 hrs. 53 min.
 Recovery : 4 bbls. oil, 41 bbls.
 water (156,000 ppm).
 Pressures: : BHF, 2,740 lbs.;
 BHSI, 5,165 lbs.

(3) Several swabbing tests are reported to have recovered a total of about 50 barrels of oil and 3,000 barrels of salt water.

(4) This was a seismic location.

(5) Logs: Condensed driller's log; Microlog; Induction - electrical log.

COLLIER COUNTY

Permit no.	FGS no.	Company or owner	Well name	Location	Well data
291	W-5692	Humble Oil and Refining Co.	Miles Collier #2 Located slightly less than 1 mile NE of Miles Collier #1	NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 49 S., R. 31 E.	Elev. - 35' Comp. - 1961 T.D. - 12,961' (in Trinity)

REMARKS: (1) The Sunniland limestone of Lower Cretaceous (Glen Rose) Age was tested as follows:

Depth : 11,745'-11,757'
 Choke : $\frac{1}{4}$ "
 Duration : 2 hrs. 28 min.
 Recovery : 1 pint oil, 9 gallons water
 Pressures : BHF, 415 lbs.
 BHSL, 485 lbs.

- (2) The oil zone tested occurs about 107 feet lower in the Sunniland pay interval in the Miles Collier No. 2 than in the Miles Collier No. 1, and the two zones are separate and distinct. The No. 2 is about flat with the No. 1, and these wells lie at about the same structural elevation as do the typical wells in the Sunniland field.
- (3) Encountered high pressure artesian water from 2,962'-3,134'.
- (4) This was a seismic location.
- (5) Logs: Condensed driller's log; Induction - electrical log.

COLUMBIA COUNTY

Permit no.	FGS no.	Company or owner	Well name	Location	Well data
285		Barton, S. W., Strahan, J. G., and Anderson, A. A.	W. M. Davidson #1	SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 29, T. 7 S., R. 17 E.	Elev. - 62' Comp. - 1961 T. D. - 160' (in Eocene)

- REMARKS: (1) It was proposed that this test be drilled to 3,000 feet to test the updip pinchout of Tuscaloosa sands on the west side of the Peninsular Arch.
- (2) The highest portion of the Peninsular Arch is found in east central Columbia County, near where this well is located (per Louise Jordan, p. 370, Oil and Gas Journal, November 15, 1954).
- (3) Wells in the vicinity of this well found Early Ordovician (Beckmantown) sands, shales, and quartzites at about 3,000 feet.
- (4) This was a subsurface location.
- (5) Logs: Condensed driller's log.

ESCAMBIA COUNTY

Permit no.	FGS no.	Company or owner	Well name	Location	Well data
294	W-5715	Emmett F. Gathright, Florida State Lease 833	Barnes Estate #1	202' W. of Florida State Highway 10A and 902' NE of S. line of sec. 2, T. 2 S., R. 29 W. about 10 miles NE of City of Pensacola	Elev. - 48.28' (ground) Comp. - Jan. 21, 1961 T.D. - 7,043' (in Lower Cretaceous).

REMARKS: (1) Though this well was permitted for 12,500 feet (which probably would have tested the deeper Lower Cretaceous section), it is reported that the intention was to abandon this well after testing the Lower Tuscaloosa section if the well was normal.

(2) This was a gravity location.

FRANKLIN COUNTY-OFFSHORE

Permit no.	FGS no.	Company or owner	Well name	Location	Well data
293	W-5654	California Company - Coastal Petroleum Company	State Lease 224-A No. 2	Lat. 29°47'03" Long. 84°22'51" (South Shoal area) about 13 miles off- shore from Carra- belle	Elev. - 25+ below MLW Comp. - 1961 T.D. - 10,566' (in probable Jurassic)

- REMARKS: (1) This general area is high according to regional gravity and magnetics.
- (2) Core at 10,324½' contained coal with pollen inclusions of Jurassic Age. It has long been postulated that part of Florida, and probably most of it, was underlain by Jurassic rocks which extend northward from the known Jurassic section of Cuba. Furthermore, since the Jurassic rock in Cuba is oil-saturated, it was hypothesized that this condition might prevail in Florida also.
- (3) This was a seismic location.
- (4) Condensed driller's log; Induction - electrical log; Microlog; Temperature log.

LEE COUNTY - OFFSHORE

Permit no.	FGS no.	Company or owner	Well name	Location	Well data
297	W-5785	California Company - Coastal Petroleum Company	State Lease 224-B No. 2	Lat. 26°43'06" N Long. 82°17'12" W (Boca Grande area) 2 mi. W of Useppa Island, about 3 mi. NE of same operator's State Lease 224-B #1, 14,000' dry hole.	Elev. - Comp. - 1961 T.D. - 12,600' (in Coahuila?)

- REMARKS:
- (1) Casing program: 13-3/8" to 651'; 9-5/8" to 4,394' with 650 sacks.
 - (2) Various intervals were cored. No recovery information available.
 - (3) The Woodbine Formation of lower Upper Cretaceous Age was drill stem tested as follows:

Depth	: 8,212'-8,232'	Recovery	: 2,439' salt water (135,000 ppm)
Chokes	: 5/8" bottom and 1/4" top.	Pressures:	BHF, 153-1,176 lbs.
	No water cushion.		BHSI, 2,949 lbs.
Blow	: Good to no blow.		Hydrostatic, 3,700 lbs.
 - (4) Tops: Cedar Keys - 3,336'; Upper Cretaceous - 5,379'; Lower Cretaceous - 8,350'; Fredericksburg - 9,450'; Sunniland - 11,330'; Mass Anhy. 11,566'.
 - (5) The Sunniland limestone of Lower Cretaceous (Glen Rose) Age was drill stem tested as follows:

Depth	: 11,285'-11,355'	Recovery:	744' drilling fluid, 8,534 salt water (260,000 ppm)
Choke	: 5/8" bottom and 1/4" top.	Pressure:	BHF, 3,465-4,830 lbs.
	No water cushion.		BHSI, 5,200 lbs.
Blow:	: Fair, increasing to strong blow for 30 minutes. Died after 3 hours.		Hydrostatic, 5,485 lbs.
 - (6) This was a subsurface location.
 - (7) Logs: Condensed driller's log; Induction - electrical log.

MONROE COUNTY - OFFSHORE

Permit no.	FGS no.	Company or owner	Well name	Location	Well data
290	W-5714	The California Company	OCS 0672 Block 44 #1	Lat. 24°25'17" N Long. 82°36'02" W Fla. Coordinates: x = -32,583.86 y = +35,072.20 (Marquesas area)	Elev. - 60' below MLW Comp. - 1961 T.D. - 4,687' (in Eocene)

REMARKS: (1) Proposed depth: 7,500 feet. Drilling was discontinued, however, at the inconclusive depth of 4,687 feet when the drill pipe twisted off and could not be recovered.

Control from other Marquesas area wells indicates that the proposed depth probably would have been sufficient to reveal the top of the Lower Cretaceous.

(2) Logs: Condensed driller's log; Electrical log; Gamma Ray log.

MONROE COUNTY-OFFSHORE

Permit no.	FGS no.	Company or owner	Well name	Location	Well data
295	W-	The Gulf Oil Corporation - California Company	OCS Block 46 #1	Lat. 24°26'10" N Long. 82°29'37" W (Marquesas area)	Elev. - Comp. - 1961 T.D. - 7,871'
REMARKS: Proposed depth: 13,000 feet. Drilling was discontinued, however, when the drill pipe twisted off. Despite the fact that the fish was recovered, drilling was never resumed. The well penetrated sediments of Upper Cretaceous Age.					
292	W-5713	The California Company	State Lease 1011 #2	Lat. 24°32'10" Long. 82°06'40" (Marquesas area)	Elev. - 18'-24' below MLW Comp. - 1961 T.D. - 7,723'
REMARKS: (1) Proposed depth: 8,000 feet. (2) Logs: Electrical log; Gamma Ray log.					
298	W-	The California Company	State Lease 1011 #3 15 mi. SW of Key West, 8 mi. SE of Marquesas Keys. Located 790 feet SE of same operator's State Lease 1011 #2	Lat. 24°32'1.143" N Long. 82°06'31.168" W	Elev. - Comp. - Jan. 13, 1962 T. D. - 12,850'

REMARKS: Proposed depth: 12,800 feet, planned as a Lower Cretaceous test.

APPENDIX II

SUMMARY OF RESERVOIR DATA

SUNNILAND FIELD, COLLIER COUNTY, FLORIDA

SUMMARY OF RESERVOIR DATA
SUNNILAND FIELD, COLLIER COUNTY FLORIDA

Structural trap: NW-SE dome (2 miles wide and $4\frac{1}{2}$ miles long) with a maximum vertical relief of about 154 feet, but which has been tilted to the NE so that vertical closure is reduced to about 36 feet.¹

Oil-water contact: About -11,555² feet.

Productive area: Estimated to be 2,356 acres.²

Producing formation: Though they probably form a single reservoir, there are two adjoining pay zones which occur in Lower Cretaceous limestone of Glen Rose Age. The main pay zone is a Chamid or rudistid reef.

The total thickness of the producing interval ranges from 5 to 45 feet. Average porosities range from 18 percent, for the reefal limestone,² to 10 percent for that which is nonreefal.² The average permeability is 312 millidarcys parallel with the bedding and 84 millidarcys perpendicular to the bedding.³ In the northwestern part of the field the permeability is considerably better, but the porosity is not as good.²

Production: During its approximately 18-year life the field has produced 6,852,620 barrels of oil (up to January 1, 1962). There has been initial production from 13 wells, most of which flowed initially. The field now produces about 1,000 barrels per day from 11 pumping wells. The 1960 production was less than that of 1950 by about 25 percent.

In 1961 salt water production has been slightly more than 60 percent of total production. Early in 1955, or about 7 years ago, the field produced only 50 percent salt water.

Crude: 19°-26° API, high sulphur asphaltic base.

Drive: Water drive.

Bottom hole pressures: In March 1958, the reservoir pressure, at a depth of reference of -11,548 feet, was 4,638 PSIG (pounds per square inch per gauge), and had declined an average of 654 PSIG from its original value (5,292 PSIG).

Present producing pressure differential: Since all of the Sunniland wells are pumpers, there is no specific information on this point. However, in March 1958, production tests on these pumpers showed that the difference between shutin pressures and the estimated bottom hole flowing pressures, at a depth of reference of -11,548 feet, ranged from 58 to 1,533 PSIG.

Gas-oil ratios: Gas-oil ratios have not been measured in recent years. However, due to the level of pressure maintenance it is believed to have

¹Puri and Banks, 1959.

²Unpublished thesis by Albert C. Raasch, Jr., 1954

³Pressler, 1947.

remained essentially constant at about 100 cubic feet per barrel. Thus it appears that the reservoir has not suffered a loss of gas energy since the discovery of the field.

The Division of Geology estimates that if Sunniland produces another 20 years, and the percentage of production decline is about 5 to 10 percent per year, about 3,000,000 to 4,500,000 additional barrels of oil will be produced.

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APPENDIX III

OFFSHORE DRILLING

OFFSHORE DRILLING

WATER AND DRILLING DEPTHS

(A presentation of several points of information,
with sources to indicate present capacities.)

A. OF IMMEDIATE ECONOMIC INTEREST:

(1) Atwater, Gordon I., *Geology and Petroleum Development of the Continental Shelf of the Gulf of Mexico*, 1959, sec. 1, paper 21, of the 1959 Fifth World Congress, p. 6, states:

"A maximum water depth of 200 feet is considered as marking the limit of economic accessibility for petroleum exploration of the continental shelf under present conditions of production costs and product prices."

This quotation applies to the water bottom acreage offshore from Florida.

(2) "Big Stride in the Gulf," *Service* (a publication of the Cities Service Oil Company), October 1961, p. 6, states:

"The latest big stride in the march from shore was a drilling effort in water 180 feet deep and at the farthest offshore site - 70 miles out - in the history of drilling off Louisiana. The structure designed for this type of exploration is as tall, from Gulf bottom to derrick top, as a 33-story building. This unique platform represents a technological breakthrough in offshore drilling, and its different design prepares the way for operations in deeper and deeper water."

(3) Wilson, Howard, "Giant Sale Should Guarantee Offshore Activity in Gulf for 5 years," *The Oil and Gas Journal*, January 22, 1962, v. 60, no. 4, p. 36, states:

"... this week Shell is starting to drill (one of the tracts in the south extensions of Grand Isle and South Timbalier areas, located offshore from Louisiana). It will use a floating drilling barge operating in 287 ft. of water, the deepest ever tried in the Gulf of Mexico."

This article also states (p. 34) that, as a result of the March 16, 1962, sale of acreage offshore from Louisiana, there will be an "increased (d) demand for floating drilling equipment. Many of the tracts are in waters deeper than 200 ft. and some are close to 600 ft."

B. OF SCIENTIFIC INTEREST PRIMARILY

(1) Bascom, Willard, *A Hole in the Bottom of the Sea*, 1961 (the story of the Mohole project to date), page 15, states, in effect, that:

The Mohole will be drilled 31,000 feet beneath the sea, and in water about 13,000 feet deep.

(2) Riedel, W. R., Ladd, H. D., Tracey, J. I., Jr., and Bramlette, M. N., "Preliminary Drilling Phase of Mohole Project (II. Summary of Coring Operations)," AAPG, v. 45, no. 11, p. 1793-1798, discloses, in effect that:

Experimental Mohole 7 drilled in water 11,706 feet deep and recovered a basalt core from a depth of 595 feet.

GLOSSARY OF OPERATING TERMS AND PHRASES USED IN THE OIL INDUSTRY (from Ira Rinehart's and others)

A

<i>A/</i> , acidized with	<i>btm ch</i> , bottom choke
<i>A</i> , Abstract (example: A-10)	<i>BW</i> , barrels water
<i>abnd</i> , abandoned	<i>BWPD</i> , barrels water per day
<i>ac</i> , acres	<i>BWPH</i> , barrels water per hour
<i>addl</i> , additional	<i>C</i> , center
<i>alg</i> , along	<i>C/</i> , contractor (example: C/John Doe)
<i>amt</i> , amount	<i>calc</i> , calcareous
<i>AOF</i> , absolute open flow	<i>CD</i> , contract depth
<i>AW</i> , acid water	<i>CFG</i> , cubic feet gas
<i>B/</i> , base	<i>CFGPD</i> , cubic feet gas per day
<i>BAW</i> , barrels of acid water	<i>ch</i> , choke
<i>bbl</i> , barrel	<i>CHG</i> , choke
<i>BCPD</i> , barrels of condensate per day	<i>cht</i> , chert
<i>BCPH</i> , barrels of condensate per hour	<i>circ</i> , circulate or circulation
<i>BDPD</i> , barrels of distillate per day	<i>clng</i> , cleaning
<i>BDPH</i> , barrels of distillate per hour	<i>cmt (ed)</i> , cement (ed)
<i>BFPH</i> , barrels of fluid per hour	<i>CO</i> , cleaning or cleaned out
<i>BHC</i> , bottom hole choke	<i>COF</i> , calculated open flow
<i>BHFP</i> , bottom hole flowing pressure	<i>comb</i> , combination
<i>BHP</i> , bottom hole pressure	<i>comp</i> , completed or completion
<i>BHSIP</i> , bottom hole shutin pressure	<i>cond</i> , condensate
<i>bld</i> , bailed	<i>conn</i> , connection
<i>bldg</i> , building	<i>cor</i> , corner
<i>blg</i> , bailing	<i>corr</i> , corrected
<i>Blk</i> , Block	<i>C&P</i> , cellar and pits
<i>BLO</i> , barrels of load oil	<i>CP</i> , casing pressure
<i>blr</i> , bailer	<i>CPSI</i> , casing pressure shut in
<i>BNO</i> , barrels of new oil	<i>crd</i> , cored
<i>BO</i> , barrels oil	<i>crg</i> , coring
<i>BOPD</i> , barrels oil per day	<i>crk</i> , creek
<i>BOPH</i> , barrels oil per hour	<i>csg</i> , casing
<i>BP</i> , back pressure	<i>cse gr</i> , coarse grained
<i>BPD</i> , barrels per day	<i>CSL</i> , County School Lands
<i>BPH</i> , barrels per hour	<i>CT</i> , cable tools
<i>brkn</i> , broken	<i>D&A</i> , dry and abandoned
<i>BS&W</i> , basic sediment and water	<i>DC</i> , drill collar
<i>btm</i> , bottom	<i>DD</i> , drilling (ed) deeper

<i>decr</i> , decrease or decreasing	<i>frac</i> , fractured, used for Hydrafrac, Sandfrac, Stratafrac
<i>deg</i> , degrees	<i>fract</i> , fractures
DF , derrick floor	<i>fsg</i> , fishing
<i>dim</i> , diminish or diminishing	<i>ft</i> or <i>'</i> , foot or feet
<i>displ</i> , displaced or displacement	GA , gallons acid
<i>dist</i> , distillate	<i>gal</i> (<i>s</i>), gallon or gallons
DO , drilled out	GC , gas cut
DP , drill pipe	GCM , gas cut mud
D/P , drill plug or drill(ed)(ing) plug	GCR , gas condensate ratio
DPM , drill pipe measurement	<i>gd o&t</i> , good odor and taste
<i>drk</i> , derrick	GDR , gas distillate ratio
<i>drld</i> , drilled	GLR , gas liquid ratio
<i>drlg</i> , drilling	<i>ggd</i> , gauged
DRLR , <i>Drlr</i> , driller	<i>gge</i> , gauge
DST , drill stem test	G&O , gas and oil
DT , drillers tops	G&OCM , gas and oil cut mud
E , east	GO , gas odor
EL , electric log	GOR , gas-oil ratio
ELEV , elevation	<i>grad</i> , gradual or gradually
EL/T , electric log tops	<i>grd</i> , ground
Est , estate	<i>grn</i> , green
<i>est</i> , estimate or estimated	<i>grav</i> , gravity
<i>et al</i> , "and others"	<i>hd</i> , hard
<i>et ux</i> , "and wife"	HFO , hole full oil
<i>et vir</i> , "and husband"	HFW , hole full water
E/BL , East boundary line	HGOR , high gas oil ratio
E of W/L , east of west line	HO&GCM , heavily oil and gas-cut mud
FEL , from east line	HP , hydrostatic pressure
FNL , from north line	<i>hr</i> (<i>s</i>), hour or hours
FSL , from south line	<i>hvly</i> , heavily
FWL , from west line	<i>hvy oil</i> , heavy oil
FNEL , from northeast line	<i>incl</i> , included or inclusions
FNWL , from northwest line	<i>irr sec</i> , irregular section
FSEL , from southeast line	IP , initial production or initial potential
FSWL , from southwest line	IPF , initial potential flowed
FS & WLs , from south and west lines	IPP , initial potential pumped
<i>f-gr</i> , fine gained	J&A , junked and abandoned
FIH , fluid in hole	KB , kelly bushing
<i>fld</i> , field	KO , kicked off
<i>fluor</i> , fluorescence	L , line
<i>flw</i> (<i>d</i>) (<i>g</i>), flowed or flc	Lab , Labor
<i>foss</i> , fossiliferous	lam , laminated
FP , flowing pressure	
FQG , frosted quartz gra	
<i>fr</i> , from	

ld (s), land or lands
Lge, League
li, lime or limestone
loc, location or located
lse, lease
MCF, thousand cubic feet
med gr, medium grained
mi, miles
MI, moving in
mic, micaceous
MICT, moving in cable tools
MID, moving in derrick
MIM, moving in materials
min, minutes
MIR, moving in rig
MIRT, moving in rotary tools
MIST, moving in standard tools
MIT, moving in tools
mld, milled
mlg, milling
MO, moving out
N, north
nat, natural
NCT, non-contiguous tract
NE, northeast
NF, no fluorescence

OAW, old abandoned well
OC, oil cut
OCM, oil cut mud
OF, open flow
O&G, oil and gas
O&GCM, oil and gas cut mud
OH, open hole
OIH, oil in hole
OO, oil odor
op, open (ed)
orig, originally
O sd, oil sand
OS&W, oil and salt water
OTD, old total depth
OWDD, old well drilled (ing) deeper
OWPB, old well plugged back

OWWO, old well worked over
P&A, plugged and abandoned
PB, plugged back
PBTD, plugged back total depth
PD, per day
perf, perforated (example: perf 23/2900
 -20', means perforated with 23
 shots from 2900-2920')

perf csg, perforated casing
perm, permeable or permeability
pk, packer
PL, pipeline
pld, pulled
plg, pulling
PLO, pipeline oil
POP, putting on pump
Porc, Porcion
por, ~~porosity~~ or porous
pot'l, potential
P/, pumped
ppp, pinpoint porosity
prep, preparing
press, pressure
prod, produced or producing
PSI, pounds per square inch
PSIG, pounds per square inch
 per gauge
PSL, Public School Lands
PT, potential test
qts, quarts
R, range
RA, right angles
RB, rotary bushing
rds, roads
rec, recovered
redrld, redrilled
rep, repairs or repairing
ret, retainer
rng, reaming
rng, running
RP, rock pressure
RT, rotary tools; or rotary table
 when used after elevation

<i>RU</i> , rigging up	<i>S/T</i> , sample top
<i>RUCT</i> , rigging up cable tools	<i>stds</i> , stands
<i>RUP</i> , rigging up pump	<i>stdy</i> , steady
<i>RUR</i> , rigging up rotary	<i>STH</i> , sidetracked hole
<i>RUST</i> , rigging up standard tools	<i>stk</i> , stuck
<i>S</i> , south	<i>strks</i> , streaks
<i>sat</i> , saturated or saturation	<i>strgr</i> , stringer
<i>SC</i> , show condensate	<i>subd</i> , subdivision
<i>SCHL</i> , Schlumberger	<i>sul</i> , sulphur
<i>SD</i> , shut down	<i>sul wtr</i> , sulphur water
<i>SDO</i> , shut down for orders	<i>Sur</i> , survey
<i>SDR</i> , shut down for repairs	<i>surf</i> , surface
<i>SE</i> , southeast	<i>SW</i> , salt water or southwest
<i>Sec</i> , section	<i>swb (d) (g)</i> , swabbed or swabbing
<i>SG</i> , show gas	<i>SWC</i> , sidewall cores
<i>SG&C</i> , show gas and condensate	<i>SWS</i> , sidewall samples
<i>SG&D</i> , show gas and distillate	<i>sx</i> , sacks
<i>sh</i> , shale	<i>T/</i> , top
<i>shly</i> , shaley	<i>T-</i> , township (example: T-4 S)
<i>shls</i> , shells	<i>T-A</i> , Temporarily Abandoned
<i>SI</i> , shut in	<i>TC</i> , top choke
<i>SIBHP</i> , shut in bottom hole pressure	<i>tbg</i> , tubing
<i>SICP</i> , shut in casing pressure	<i>tbg ch</i> , tubing choke
<i>SIP</i> , shut in pressure	<i>TD</i> , total depth
<i>SITP</i> , shut in tubing pressure	<i>temp</i> , temporary
<i>sli</i> , slight	<i>th</i> , thence
<i>sly OCM</i> , slightly oil cut mud	<i>TP</i> , tubing pressure
<i>SLM</i> , steel line measurement	<i>TOP</i> , testing on pump
<i>sd</i> , sand or sandstone	<i>/"T/"B</i> , top and bottom choke measurement
<i>sdv</i> , sandy	
<i>sd w/SG</i> , sand with shows gas	<i>T/pay</i> , top pay
<i>sd w/SO</i> , sand with show oil	<i>TPSI</i> , tubing pressure shut in
<i>SLM</i> , steel line measurement	<i>tr</i> , tract, trace
<i>slls</i> , siltstone	<i>T/sd</i> , top sand
<i>SMPL</i> , <i>smpl</i> , sample	<i>tstg</i> , testing
<i>SO</i> , show oil	<i>twp</i> , township
<i>SO&G</i> , show oil and gas	<i>U/</i> , upper (i.e., U/Laramie)
<i>SO&W</i> , show oil and water	<i>U/rmg</i> , underreaming
<i>spud</i> , spudded	<i>vert</i> , vertical
<i>sqzd</i> , squeezed	<i>VHOCM</i> , very heavily oil cut mud
<i>SSG</i> , slight show gas	<i>W</i> , west
<i>SSO</i> , slight show oil	<i>w/</i> , with
	<i>WB</i> , water blanket

WC , wildcat or water cushion when used in DST	WOR , waiting on rig
W'y , westerly	WORT , waiting on rotary tools
WI , washing in	WOST , waiting on standard tools
WO , waiting on, work over	WOT , waiting on test
WOC , waiting on cement	WP , working pressure
WOCT , waiting on cable tools	WS , whipstock
WOO , waiting on orders	wtr , water
WOPT , waiting on potential test	WW , wash water
	Xln , crystalline

SYMBOLS:

@ . . . at, seated

¢ . . . core

' . . . feet after number (or minutes when used in giving directions: S 45°30' W)

" . . . inches after number (or seconds when used in giving directions:
S 45°30'22" W)

° . . . degrees

. . . pounds after a number (and stands for number before a number, i.e., #1)

5½''-5779'/800 sx . . . means 5½'' casing cemented at 5779 feet with 800
sacks of cement.

gW . . . salt water

