The Comanche Series and Associated Rocks in the Subsurface in Central and South Florida

GEOLOGICAL SURVEY PROFESSIONAL PAPER 447

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By PAUL L. APPLIN *and* ESTHER R. APPLIN

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The stratigraphy and geologic structure of deeply buried Mesozoic rocks and of the Coastal Plain floor

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THE COMANCHE SERIES AND ASSOCIATED ROCKS IN THE SUBSURFACE IN CENTRAL AND SOUTH FLORIDA

By Paul L. Applin and Esther R. Applin

ABSTRACT

The stratigraphy, structure, micropaleontology, and oil possibilities of a part of the Mesozoic sedimentary section in the subsurface of an area of more than 30,000 square miles in central and south Florida have been studied from the data provided by oil test wells drilled in the area. Microscopic examination of cores and samples of drill cuttings provide the basic stratigraphic data for this report. Electric logs aid in the correlation of the data. The primary purpose of the report is the integration of the data from the scattered test wells and the development from them of an interpretation of the regional geology.

The Coastal Plain floor in the central and northern parts of the Florida peninsula is the truncated surface of a wide variety of igneous and sedimentary rocks that are chiefly Precambrian(?) and early Paleozoic in age. In the northern part of the peninsula, rocks of Late Triassic(?) age are evidently a part of the truncated floor. Highly altered igneous rocks of uncertain age have been penetrated only in a single well on the southeast coast of the peninsula. The depth below sea level to the Coastal Plain floor ranges from about 2,600 feet in northern Florida to more than 12,500 feet near Lake Okeechobee in the south-central part of the State. Oil test wells in south Florida have not been drilled sufficiently deep to penetrate the pre-Coastal Plain rocks.

In south Florida, a stratigraphic unit of Late Jurassic(?) or earliest Cretaceous(?) age, the Fort Pierce Formation, is the oldest unit of the Coastal Plain rocks. The Fort Pierce Formation, the overlying units of the Comanche Series, and the basal rocks of the Gulf Series compose the part of the Coastal Plain rocks described in this report. This section of Mesozoic age forms a wedgelike mass that pinches out around an irregular-shaped area of lower Paleozoic strata in northern Florida and thickens gradually southeastward, southward, and southwestward toward the coast. On the Florida Keys about 8,000 feet of the section was penetrated in a well that stopped in the Fort Pierce Formation. The depth below sea level at the top of the Comanche rocks ranges from about 4,000 feet in central Florida to 8,582 feet in a well in Collier County on the southwest coast. The Comanche rocks in central Florida overlie with profound unconformity the truncated surface of the Coastal Plain floor. Most wells in south Florida terminated in the Comanche rocks, although six wells penetrated the underlying Fort Pierce Formation, the thickness and areal extent of which are largely unknown. Throughout the central and south parts of the peninsula, the Atkinson Formation of early Gulf age overlies the Comanche rocks.

Irregularly interbedded carbonate rocks, evaporites, and a few thin lenses of dark shale compose the generally similar lithologic sequence of the Comanche rocks and of the underlying Fort Pierce Formation in the southern part of the peninsula. The carbonate rocks are separated into four major stratigraphic units, chiefly on the basis of distinctive microfaunas. The new Fort Pierce Formation contains a new and undescribed microfaunal assemblage and is given the indefinite age assignment of Late Jurassic(?) or Early Cretaceous(?) because the faunal data are, as yet, inconclusive. Three major units of the Comanche rocks in Florida, which are roughly correlated with the groups of the Comanche Series in Texas, are classified, from oldest to youngest, as beds of Trinity, Fredericksburg, and Washita age. Faunal and lithologic units have not been differentiated within the beds of Fredericksburg and Washita age, but the beds of Trinity age can be separated into a unit of early Trinity age and a unit of late Trinity age on the basis of their lithologic and faunal characteristics. A new name, Punta Gorda Anhydrite, is applied to a thick sequence of evaporites in the upper part of the beds of early Trinity age. The Sunniland Limestone is applied in this report to the basal unit of the beds of late Trinity age that contains the oil-productive porous limestone in the Sunniland field, Collier County, and in the abandoned Forty Mile Bend field, Dade County. In most wells, the Sunniland Limestone rests on the Punta Gorda Anhydrite and underlies a stratigraphic unit of late Trinity age, informally known as the upper anhydrite, which is composed chiefly of interbedded anhydrite and carbonate rocks.

The sediments composing the Fort Pierce Formation and the Comanche Series were deposited in a transgressing sea whose margin moved northward over the peninsula in response to the nearly continuous progressive subsidence of the Coastal Plain floor. By a series of onlaps, the Fort Pierce Formation and the units of the Comanche Series transgress northward and wedge out against the ancient rocks. The carbonate-evaporite lithofacies that prevails in south Florida changes significantly in the central part of the peninsula. The carbonate-evaporite facies of each stratigraphic unit thins progressively northward and grades laterally into a mixed facies composed of interbedded argillaceous and arenaceous limestone and dolomite, neritic clastic rocks, and some evaporites. The mixed facies, in turn, changes shoreward into an unfossiliferous clastic facies composed of irregularly interlensing beds of mudstone, siltstone, poorly sorted fine- to coarse-grained sandstone, and red, green, and varicolored shale. This marginal clastic facies rests unconformably on the Coastal Plain floor, and, like the carbonate facies and the mixed facies, ranges in age from Late Jurassic(?) or earliest Cretaceous(?) to Washita.

A unique feature in the Comanche rocks is a starved basin that apparently occupied a part of south Florida during Sunniland time. The position of the Sunniland oil field on a shelf bordering the starved basin is of considerable significance in the search for oil in south Florida.

In south Florida, a bed of distinctive green shale of marine origin, ranging in thickness from a few inches to a few feet, lies between the carbonate-evaporite facies of the beds of Washita age at its base and the predominantly carbonate rocks at the

base of the Atkinson Formation above. Whether the age classification of the green shale is Comanche or Gulf is indeterminate.

The basal beds of the lower member of the Atkinson Formation are composed of three laterally intergrading calcareous lithofacies that cross central and southern Florida in roughly parallel belts. From north to south they are, respectively, the oolitic limestone facies, the sandy chalk facies, and the dense gray limestone facies. The facies are believed to be contemporaneous and represent different depositional conditions with respect to depth of water and distance from shore. Each lithofacies contains a characteristic microfauna. Glauconitic sandstone and conglomerate that characterize the base of the Atkinson Formation that is penetrated by wells in the northern third of the peninsula suggest that the calcareous lithofacies grade gradually shoreward into clastic rocks.

Structure contour maps and isopach maps of the different stratigraphic units indicate four major structural features in the Comanche rocks of central and south Florida. These features are (a) the southeastern part of the Peninsular arch that trends about S. 35° E. from south-central Georgia to the vicinity of Lake Okeechobee; (b) the south Florida embayment that trends about N. 65° W. from the east end of Florida Bay across the southern tip of the peninsula and plunges toward the Gulf of Mexico; (c) the south Florida shelf that trends about S. 45° E. across the peninsula from Charlotte County on the west coast to Key Largo on the east coast; and (d) the Broward syncline, a southeastward-plunging syncline in Palm Beach and Broward Counties on the southeast coast of Florida. Stratigraphic and structure cross sections show the effect of the structural features on the distribution, thickness, lithologic facies changes, and biostratigraphy of the stratigraphic units.

In contrast to the prevailing northwestward trend of the four major structural features, several minor poorly defined, southwestward-trending fold axes are present in the Comanche units. These minor folds probably reflect structural or topographic features in the pre-Coastal Plain rocks.

An example of the structure in a localized area is provided by structure contour maps and isopach maps of the different units of the Comanche Series in the Sunniland oil field, Florida's only producing field. The productive area is along the somewhat flattened crest of a west-northwestward-trending asymmetrical anticline, the dip of which is steeper on the northeast side. This steep dip suggests that a fault bounds the anticline on the northeast. Structural closure on the anticline is estimated at 60 to 100 feet. Progressive growth of the anticline during Comanche time is suggested by (a) relatively sharp folding in the Sunniland Limestone in contrast to broad folds of low relief in the younger units; (b) thinning over the crest of the anticline in each stratigraphic unit above the Sunniland Limestone; and (c) progressive basinward shift of the anticlinal axis in the post-Sunniland stratigraphic units.

The relatively mild tectonic movements that formed the present-day regional structure of the Coastal Plain rocks in the Florida peninsula apparently began early in the Mesozoic and continued through the later Mesozoic and Cenozoic. Early in the Mesozoic, the peninsula was a truncated and eroded surface of ancient rocks that stood a little above sea level. Downwarping of this surface at the south end of the peninsula progressed northward with the passage of time and was accompanied by the gradual encroachment of a shallow sea. In this northward-transgressing sea, the Coastal Plain sediments of the Fort Pierce Formation, the Comanche Series, and the basal beds of the Atkinson Formation were deposited in a series of onlaps that wedge out against the Coastal Plain floor. From early in the Mesozoic until the end of Comanche time, at least, the north-central part of the peninsula was a stable area in contrast to the gradually subsiding southern and central parts. Beginning with the beds of middle Late Cretaceous age, the successively younger units of the Gulf Series and the units of Cenozoic age were deposited over most of the peninsula.

INTRODUCTION

Sedimentary rocks of the Coastal Plain, ranging in age from Late Jurassic(?) or earliest Cretaceous(?) to Recent, are present in the Florida peninsula, but rocks older than late middle Eocene are known only from the subsurface. The thickness of the Coastal Plain rocks is less than 3,000 feet in an area in the northern part of the peninsula but increases southward to at least 15,455 feet where it was measured in an oil test well near Key West. Beneath the Coastal Plain cover in the northern two-thirds of the peninsula, deep wells drilled in the search for oil penetrated an ancient truncated surface composed of a patchwork of different kinds of igneous and sedimentary rocks that, for the most part, are tentatively classified as early Paleozoic and Precambrian, but some of which are probably Triassic. The oldest known rocks in south Florida, however, are Coastal Plain sedimentary rocks of Late Jurassic(?) or earliest Cretaceous(?) age. This report presents a description of the older rocks of the Coastal Plain floor, followed by a discussion of the stratigraphy, structural features, micropaleontology, and oil possibilities of the Upper Jurassic(?) or Lower Cretaceous(?) rocks, the overlying rocks of the Comanche Series, and the basal rocks of the Gulf Series in an area of more than 30,000 square miles in central and south Florida (fig. 1). Carbonate rocks and evaporites that are dominant in the Comanche Series and in the Upper Jurassic(?) or Lower Cretaceous(?) unit in south Florida grade northward in central Florida into red and varicolored marginal clastic rocks (fig. 2). The basal beds of the Atkinson Formation, likewise, change gradually northward from dense marine limestone into brackish water and lagoonal deposits. Some of the published reports on the geology of the Florida peninsula contain information about the general relations of the Comanche Series and associated rocks, but relatively few articles contain descriptions of the faunal and lithologic criteria that differentiate the stratigraphic units of the Comanche Series, the older unit of Late Jurassic(?) or Early Cretaceous(?) age, and the younger rocks at the base of the Gulf Series.

During the last half century, porous limestone of Comanche age has yielded large quantities of oil and gas from many fields in the Gulf Coast region of Texas and Mexico, and in recent years the Comanche limestones in south Florida have been an objective in the oil

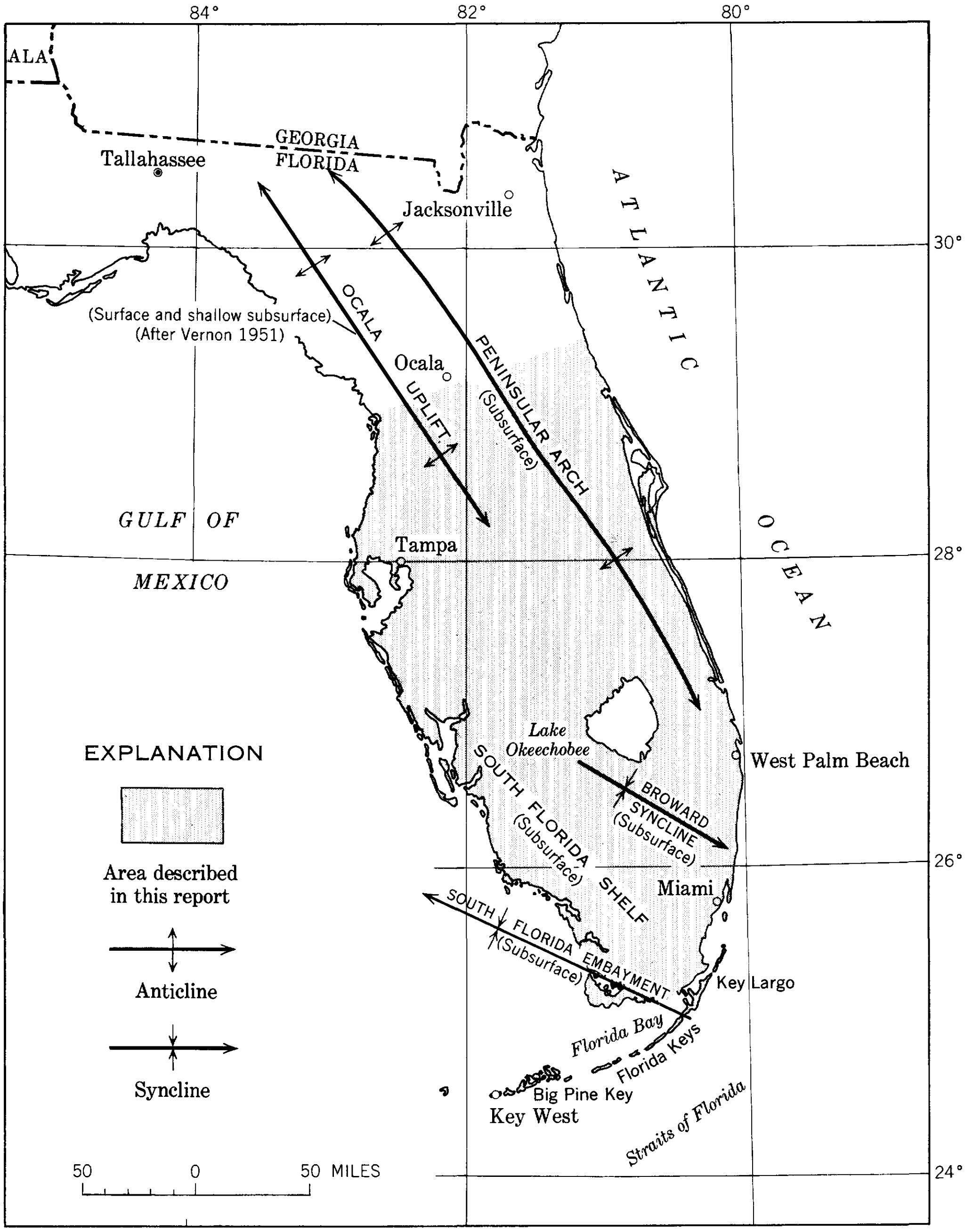

FIGURE 1.—Index map of the Florida peninsula showing the major structural features and area described in this report.

industry's search for potential reservoirs of accumulation. In 1943, oil was discovered in a limestone of Trinity (Comanche) age which was penetrated by the Humble Oil & Refining Co. Gulf Coast Realties Corp. 1, near Sunniland, Collier County, Fla. In the years following the discovery of the Sunniland field, 70 test wells (table 1) in central and south Florida penetrated the Comanche Series, and 19 of them penetrated older rocks. Twenty wells are in the Sunniland field, and the others are more or less widely scattered throughout the area shown in figure 1, average density being 1 well to bout 400 square miles. The range in depth of the wells is from 4,637 feet to 15,455 feet. Samples from the wells were made available to the public by the oil companies, and microscopic examination of hundreds of cores and cutting samples from 34 wells provide the basic data relating to the part of the stratigraphic section discussed in the present report. The

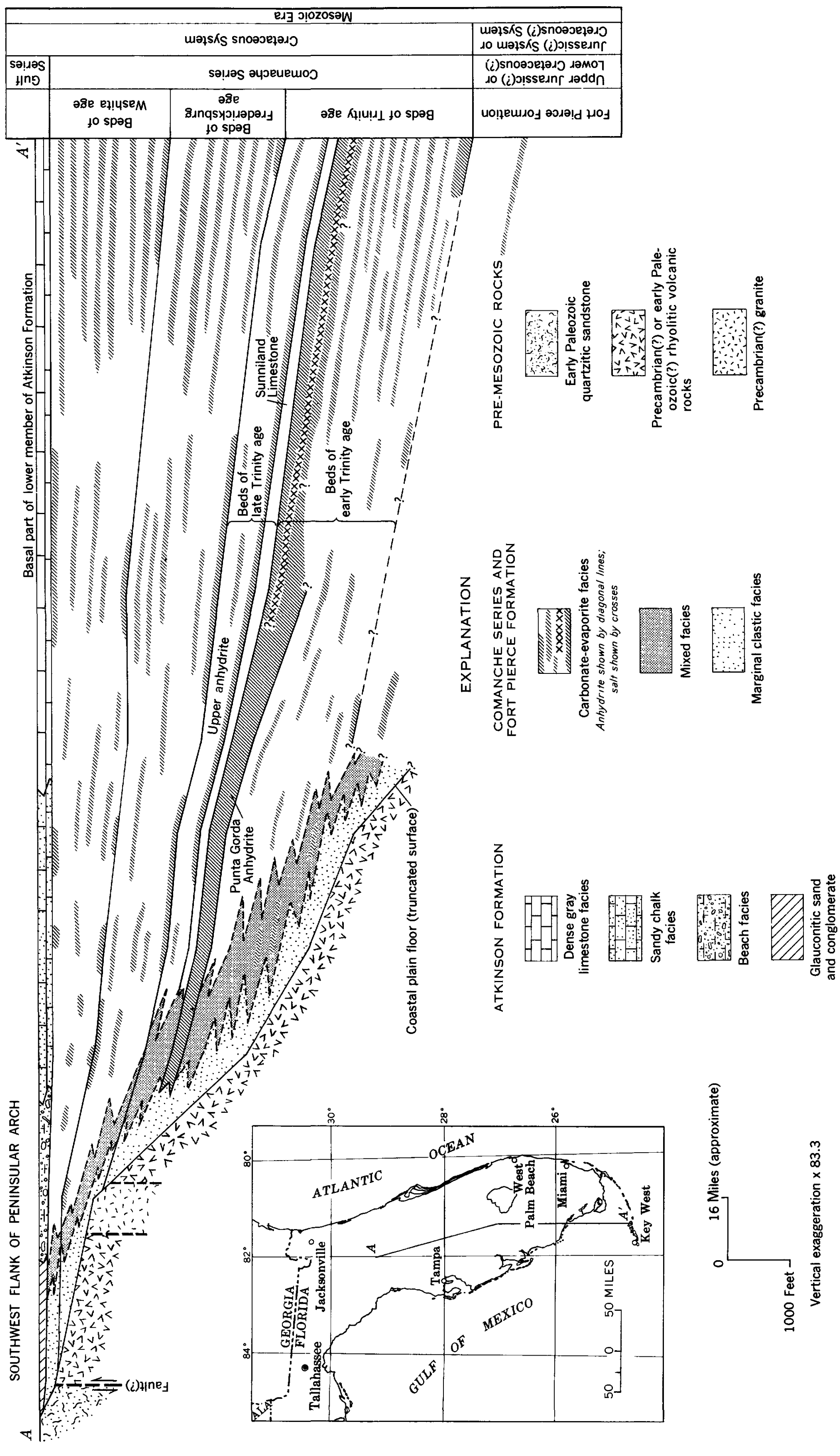

Figure 2.—Diagrammatic cross section of the Comanche Series and associated rocks in central and south Florida showing the relations of the rocks of the Coastal Plain floor and the correlation of the Mesozoic rocks discussed in this report.

thickness of this section ranges from about 125 feet in a well in Marion County near the north boundary of the area, to 8,000 feet in a well near Key West.

Faunal and lithologic variations as judged from cuttings, cores, and electric logs are the basis for the correlations from well to well. The fossils are, chiefly, accumulations of microfossils, generally accompanied by varying quantities of macrofossil debris, occurring in calcareous oolitic rocks and fine-grained calcium carbonate silt. In the oolitic lenses, the microfossil tests frequently form the nuclei of oolities, but may occur, less commonly, in the interoolitic spaces. The fossil accumulations in the silt are uneven in density and irregularly distributed. Owing to recrystallization of the host rocks, the faunal elements are generally firmly embedded. Some specimens of larger arenaceous Foraminifera were successfuly removed from their matrix, but as a rule, the microfossils could be studied only in thin sections and polished rock fragments. Fragments of limestone cuttings were moistened with water containing a little hydrochloric acid to reveal textural and faunal details not otherwise visible. A binocular microscope with a magnification 30–40 × was customarily used.

The primary purpose of this report is the integration of the subsurface data and the development from them of an interpretation of the regional geology. As is true of most papers dealing with regional subsurface investigations, this paper is a report of progress. The continuing search for oil in Florida and the subsurface studies being carried on by commercial geologists will expand our knowledge of the buried rocks and will call for reappraisal of the data we now possess. It is hoped that this paper will aid in further investigations of the stratigraphy, structure, and micropaleontology of the buried sedimentary rocks of the Florida peninsula.

ACKNOWLEDGMENTS

We are greatly indebted to many geologists who helped in various ways to facilitate the preparation of this report. Particular mention should be made of Dr. Herman Gunter, former Director, and Dr. R. O. Vernon, Director of the Florida Geological Survey, for the many courtesies extended to us and for the assistance rendered during the progress of the study.

The excellent sets of samples from many oil test wells, which were made available to us by oil-company geologists, provided the basic data for the report. For this valuable service, sincere appreciation is expressed to D. J. Munroe, Sun Oil Co., and Dr. Louise Jordan, formerly with the Sun Oil Co.; E. A. Murchison, A. C. Raasch, Jr., and E. T. Caldwell, Humble Oil & Refining Co.; J. A. Tierney and M. F. Kirby, Gulf Oil Corp.; E. H. Rainwater and Jules Braunstein, Shell Oil Co.; E. M. Ross and E. J. Henderson, Amerada Petroleum Corp.; J. L. Martin, Jr., Sinclair Oil & Gas Co.; H. G. Walter, The Ohio Oil Co.; J. E. Banks, Coastal Petroleum Co.; R. J. Alexander, The California Co.; and the late R. B. Campbell.

Thanks are due Prof. R. E. Peck, University of Missouri, for his helpful reports on Charaphytes, and Prof. J. H. Johnson, Colorado School of Mines, for his excellent descriptions of algal lenses in the Comanche rocks.

By arrangement with the Chief of Engineers, U.S. Army, and the Chief of the Concrete Research Division, Waterways Experiment Station, Corps of Engineers, McRaven, Miss., Mrs. K. K. Mather, Chief, Petrography Section, conducted petrographic studies and provided a report on 100 rock samples selected by us from cores of carbonate rocks from many wells in central and south Florida. Unless otherwise noted, most of the petrographic descriptions are based on her work. We are pleased to acknowledge Mrs. Mather's valuable contribution to the study of the carbonate rocks and express our appreciation for her gracious cooperation.

We take pleasure in acknowledging the technical assistance rendered by members of the U.S. Geological Survey. C. Wythe Cooke, R. W. Imlay, the late J. B. Reeside, Jr., I. G. Sohn, L. W. Stephenson, and Curt Teichert reported on fossils having a critical bearing on the subsurface geology of Florida. C. S. Ross reported on the petrography of cores of igneous rocks from an oil test well in St. Lucie County, Fla. H. A. Tourtelot made a detailed petrographic analysis of two characteristic core samples of carbonate rocks and contributed the theoretical account of their diagenesis that is included in the report. Photomicrographs of thin sections were prepared by H. N. Shupe, D. A. Myers, and H. A. Tourtelot. Figured specimens of *Nummoloculina heimi* Bonet and all thin sections used in making the photomicrographs that illustrate this report are temporarily deposited in the Jackson, Miss., office of the U.S. Geological Survey and will eventually be transferred to the U.S. National Museum.

HISTORICAL SKETCH

The following account of the earlier investigations relating to the Comanche Series and associated rocks in central and south Florida is based on published articles and on our personal acquaintance with some of the significant events that have lead to the development of the present knowledge of the subsurface geology of the area.

PUBLISHED LITERATURE

The earliest report of supposed Lower Cretaceous rocks in the Florida peninsula was by Cushman (1919). The fossils on which this report was based were later correctly identified as early middle Eocene in age. The

TABLE 1.—*Location, date of completion, and*

[Stratigraphic data for each well show the depth and

Well	County	Name and location of well	Date of completion	Elevation of well (feet)	Comanche Series							
					Beds of Washita Age undifferentiated		Beds of Fredericksburg Age undifferentiated		Beds of Trinity Age			
									Beds of late Trinity Age			
					Depth to top (feet)	Thickness (feet)	Depth to top (feet)	Thickness (feet)	Depth to top of rocks of late Trinity Age (feet)	Sunniland Limestone: Depth to top (feet)	Sunniland Limestone: Thickness (feet)	Thickness of rocks of late Trinity Age (feet)
1	Charlotte	Gulf Oil Corp. W. H. and A. G. Vanderbilt well 1, sec. 35, T. 41 S., R. 21 E.	Mar. 14, 1954	22	8,450	930	9,380	1,365	10,745	11,255	250	760
2	do	Humble Oil & Refining Co. Lowndes Treadwell well 1A, sec. 17, T. 42 S., R. 23 E.	Dec. 29, 1945	20	8,550	980	9,530	1,400	10,930	11,505	185	760
3	Collier	Humble Oil & Refining Co. Collier Corp. well 1, sec. 27, T. 50 S., R. 26 E.	Aug. 27, 1951	25	8,607	1,283	9,890	1,615	11,505	12,359	69	923
4	do	Humble Oil & Refining Co. J. A. Curry well 1, sec. 8, T. 47 S., R. 29 E.	July 6, 1955	45	8,540	1,160	9,700	1,445	11,145	11,620	260	735
5	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 1, sec. 29, T. 48 S., R. 30 E.	Sept. 26, 1943	34	8,410	1,230	9,640	1,445	11,085	11,598		
6	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 2, sec. 30, T. 48 S., R. 30 E.	Nov. 9, 1944	34	8,420	1,210	9,630	1,460	11,090	11,600	275	785
7	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 4, sec. 20, T. 48 S., R. 30 E.	June 24, 1945	34	8,410	1,210	9,620	1,430	11,050	11,550		
8	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 5, sec. 20, T. 48 S., R. 30 E.	May 24, 1947	31	8,395	1,210	9,605	1,445	11,050	11,555		
9	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 6, sec. 19, T. 48 S., R. 30 E.	May 1, 1946	31	8,400	1,210	9,610	1,440	11,050	11,555		
10	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 7, sec. 17, T. 48 S., R. 30 E.	Oct. 21, 1945	34	8,510	1,225	9,735	1,445	11,180	11,700		
11	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 8, sec. 19, T. 48 S., R. 30 E.	Sept. 15, 1946	29	8,400	1,210	9,610	1,445	11,055	11,555		
12	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 9, sec. 24, T. 48 S., R. 29 E.	Apr. 29, 1948	29	8,400	1,205	9,605	1,450	11,055	11,575		
13	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 10, sec. 20, T. 48 S., R. 30 E.	Jan. 8, 1948	30	8,400	1,220	9,620	1,430	11,050	11,557		
14	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 11, sec. 20, T. 48 S., R. 30 E.	Oct. 14, 1947	30	8,390	1,210	9,600	1,430	11,030	11,531		
15	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 12, sec. 21, T. 48 S., R. 30 E.	Apr. 21, 1948	37	8,420	1,210	9,630	1,440	11,070	11,582		
16	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 13, sec. 19, T. 48 S., R. 30 E.	Dec. 25, 1948	39	8,405	1,200	9,605	1,437	11,042	11,545		
17	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 14, sec. 18, T. 48 S., R. 30 E.	June 1, 1949	33	8,400	1,205	9,605	1,440	11,045	11,540		
18	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 15, sec. 12, T. 48 S., R. 29 E.	Oct. 25, 1949	34	8,495	1,215	9,710	1,450	11,160	11,670		
19	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 16, sec. 14, T. 48 S., R. 29 E.	Mar. 29, 1950	33	8,405	1,215	9,620	1,445	11,065	11,585	250	770
20	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. well 17, sec. 14, T. 48 S., R. 29 E.	June 15, 1950	34	8,430	1,210	9,640	1,440	11,080	11,600		
21	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. "B" well 1, sec. 23, T. 48 S., R. 28 E.	May 5, 1948	32	8,470	1,225	9,695	1,465	11,160	11,745	225	810
22	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. "C" well 1, sec. 21, T. 47 S., R. 28 E.	Oct. 23, 1948	37	8,520	1,180	9,700	1,460	11,160	11,760	180	780

See footnote at end of table.

elevation of 73 wells in central and south Florida

thickness of units of the Comanche Series and older rocks]

Comanche Series—Continued							Pre-Mesozoic rocks		Total depth of well (feet)	Oldest rocks penetrated	Stratigraphic data from samples (S) or electric log (E)	Remarks
Beds of Trinity Age—Continued				Thickness of Comanche Series (feet)	Upper Jurassic(?) or Lower Cretaceous(?), Fort Pierce Formation							
Beds of early Trinity Age			Thickness of beds of Trinity Age (feet)									
Depth to top of rocks of early Trinity Age (feet)[1]	Thickness of Punta Gorda Anhydrite (feet)	Thickness of rocks of early Trinity Age (feet)			Depth to top (feet)	Thickness (T) or depth of penetration (P) (feet)	Depth to top (feet)	Depth of penetration (feet)				
11,505	440								12,722	Rocks of early Trinity Age.	E	
11,690	467								13,304	do	S, E	
12,428									12,600	Punta Gorda Anhydrite.	S, E	
11,880									11,937	do	E	
									11,626	Sunniland Limestone.	E	Discovery well Sunniland oil field. Production abandoned May 1947.
11,875	630								13,512	Rocks of early Trinity Age.	S, E	Deepest test in Sunniland oil field.
									11,597	Sunniland Limestone.	E	Second productive well in Sunniland oil field. Production abandoned August 1954.
									11,578	do	E	Fifth productive well in Sunniland oil field.
									11,578	do	E	Third productive well in Sunniland oil field.
									11,842	do	E	In Sunniland oil field.
									11,576	do	E	Fourth productive well in Sunniland oil field.
									11,595	do	E	In Sunniland oil field.
									11,582	do	E	Seventh productive well in Sunniland oil field.
									11,573	do	E	Sixth productive well in Sunniland oil field.
									11,709	do	S, E	In Sunniland oil field.
									11,572	do	E	Ninth productive well in Sunniland oil field.
									11,579	do	E	Eleventh productive well in Sunniland oil field.
									11,797	do	E	In Sunniland oil field.
11,835									11,875	Punta Gorda Anhydrite.	E	In Sunniland oil field.
									11,658	Sunniland Limestone.	E	Do.
11,970									12,220	Punta Gorda Anhydrite.	E	
11,940									12,120	do	S, E	

TABLE 1.—*Location, date of completion, and elevation*

[Stratigraphic data for each well show the depth and

Well	County	Name and location of well	Date of completion	Elevation of well (feet)	Comanche Series							
					Beds of Washita Age undifferentiated		Beds of Fredericksburg Age undifferentiated		Beds of Trinity Age — Beds of late Trinity Age			
					Depth to top (feet)	Thickness (feet)	Depth to top (feet)	Thickness (feet)	Depth to top of rocks of late Trinity Age (feet)	Sunniland Limestone: Depth to top (feet)	Sunniland Limestone: Thickness (feet)	Thickness of rocks of late Trinity Age (feet)
23	Collier	Humble Oil & Refining Co. Gulf Coast Realties Corp. "D" well 1, sec. 3, T. 48 S., R. 28 E.	Mar. 15, 1949	37	8,555	1,210	9,765	1,470	11,235	11,855		
24	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. "E" well 1, sec. 19, T. 47 S., R. 28 E.	July 27, 1949	31	8,510	1,190	9,700	1,460	11,160	11,790	160	790
25	do	Humble Oil & Refining Co. Lee Tidewater Cypress Lumber Co. well 3, sec. 28, T. 47 S., R. 29 E.	June 10, 1947	35	8,520	1,195	9,715	1,440	11,155	11,660	270	775
26	do	Humble Oil & Refining Co. Lee Tidewater Cypress Lumber Co. "B" well 1, sec. 13, T. 48 S., R. 29 E.	Sept. 22, 1948	39	8,410	1,205	9,615	1,440	11,055	11,560		
27	do	Humble Oil & Refining Co Lee Tidewater Cypress Lumber Co. "B" well 2, sec. 13, T. 48 S., R. 29 E.	Mar. 25, 1949	40	8,420	1,210	9,630	1,435	11,065	11,565		
28	do	Humble Oil & Refining Co. Lee Tidewater Cypress Lumber Co. "B" well 3, sec. 13, T. 48 S., R. 29 E.	June 13, 1949	34	8,415	1,205	9,620	1,435	11,055	11,552		
29	do	Humble Oil & Refining Co. Lee Tidewater Cypress Lumber Co. "B" well 4, sec. 13, T. 48 S., R. 29 E.	Dec. 28, 1949	32	8,403	1,207	9,610	1,440	11,050	11,552		
30	do	Humble Oil & Refining Co. Lee Tidewater Cypress Lumber Co. "C" well 1, sec. 7, T. 48 S., R. 29 E.	Jan. 4, 1949	32	8,600	1,230	9,830	1,470	11,300	11,850		
31	Dade	Coastal Petroleum Co. State of Florida, Lease 340-A, well 1, sec. 25, T. 55 S., R. 37 E.	Dec. 18, 1949	33	7,322	1,538	8,860	1,330	10,190	10,775	235	820
32	do	Commonwealth Oil Co. M. B. Wiseheart-State Board of Education well 1, sec. 16, T. 54 S., R. 35 E.	Feb. 17, 1954	20	7,735	1,560	9,295	1,355	10,650	11,317	218	885
33	do	Gulf Oil Corp. State of Florida, Lease 340, well 1, sec. 18, T. 54 S., R. 36 E.	Apr. 13, 1954	18	7,750	1,600	9,350	1,355	10,705	11,340		
34	do	Gulf Oil Corp. State of Florida, Lease 340, well 2, sec. 19, T. 54 S., R. 36 E.	Oct. 15, 1954	18	7,745	1,590	9,335	1,365	10,700	11,335	235	870
35	do	Gulf Oil Corp. State of Florida, Lease 340, well 3, sec. 19, T. 54 S., R. 36 E.	Jan. 22, 1955	18	7,750	1,600	9,350	1,355	10,705	11,342	239	876
36	do	Humble Oil & Refining Co. State of Florida well 1, sec. 30, T. 55 S., R. 36 E.	Mar. 6, 1945	15	7,700	1,630	9,330	1,360	10,690	11,350	245	905
37	do	McCord Oil Co. Damoco well 1 (was W. G. Blanchard et al., Everglades well 1) sec. 31, T. 53 S., R. 35 E.	Apr. 3, 1951	18	7,810	1,550	9,360	1,390	10,750 corrected depth.	11,440 corrected depth.	210	900
38	Glades	Coastal Petroleum Co. John Tiedtke and William Shroeder well 1, sec. 25, T. 42 S., R. 33 E.	July 20, 1953	25	8,180	1,215	9,395	1,155	10,550	10,910	108	498
39	Hardee	Humble Oil & Refining Co. B. T. Keen well 1, sec. 23, T. 35 S., R. 23 E.	Jan. 12, 1948	83	7,799	861	8,660	980	9,640	10,020	110	490
40	Hendry	Commonwealth Oil Co. Red Cattle Co. well 3, sec. 25, T. 45 S., R. 28 E.	June 13, 1954	50	8,385	1,145	9,530	1,390	10,920	11,444	199	723
41	do	Humble Oil & Refining Co. Collier Corp. "B" well 1, sec. 14, T. 47 S., R. 31 E.	Feb. 23, 1952	40	8,365	1,235	9,600	1,372	10,972	11,520	190	738
42	do	Humble Oil & Refining Co. Collier Corp. "B" well 2, sec. 17, T. 47 S., R. 31 E.	Nov. 18, 1953	40	8,375							
43	do	Humble Oil & Refining Co. Consolidated Naval Stores well 1 (hole 2), sec. 5, T. 45 S., R. 29 E.	Jan. 7, 1955	40	8,360	1,125	9,485	1,395	10,880	11,380	180	680
44	Hernando	The Ohio Oil Co. Hernasco Corp. well 1, sec. 19, T. 23 S., R. 18 E.	June 23, 1946	47	5,600	195	5,795	770	6,565?	Absent		(?)
45	Highlands	Continental Oil Co. G. C. Carlton et al., well 1, sec. 20, T. 38 S., R. 28 E.	June 1, 1955	88	7,910	980	8,890	970	9,860	10,262	113	515

See footnote at end of table.

of 73 wells in central and south Florida—Continued

thickness of units of the Comanche Series and older rocks]

Comanche Series—Continued							Pre-Mesozoic rocks		Total depth of well (feet)	Oldest rocks penetrated	Stratigraphic data from samples (S) or electric log (E)	Remarks
Beds of Trinity Age—Continued				Thickness of Comanche Series (feet)	Upper Jurassic(?) or Lower Cretaceous(?), Fort Pierce Formation							
Beds of early Trinity Age			Thickness of beds of Trinity Age (feet)									
Depth to top of rocks of early Trinity Age (feet)[1]	Thickness of Punta Gorda Anhydrite (feet)	Thickness of rocks of early Trinity Age (feet)			Depth to top (feet)	Thickness (T) or depth of penetration (P) (feet)	Depth to top (feet)	Depth of penetration (feet)				
									11,900	Sunniland Limestone.	E	
11,950									12,210	Punta Gorda Anhydrite.	E	
11,930									11,943	do.	E	
									11,588	Sunniland Limestone.	E	Eighth productive well in Sunniland oil field.
									11,585	do.	E	Tenth productive well in Sunniland oil field.
									11, 579	do.	E	Twelfth productive well in Sunniland oil field.
									11, 576	do.	E	Thirteenth productive well in Sunniland oil field.
									11, 893	do.	E	
11, 010									11, 520	Punta Gorda Anhydrite.	S, E	
11, 535									11, 557	do.	S, E	Discovery well Forty Mile Bend oil field. Production abandoned Sept. 1955.
									11, 357	Sunniland Limestone.	E	Second productive well in Forty Mile Bend oil field. Production abandoned Sept. 1955.
11, 570									11, 597	Punta Gorda Anhydrite.	E	In Forty Mile Bend oil field.
11, 581									11, 625	do.	E	Do.
11, 595									11, 794	do.	S, E	
11, 650 corrected depth.									11, 690 corrected depth.	do.	S, E	Measured depths corrected for deviation from vertical. Corrected depths from Louise Jordan, consulting geologist, Tallahassee, Fla.
11, 048	342	1, 885	2, 383	4, 753	12, 933	491 P			13, 424	Fort Pierce Formation.	S, E	
10, 130	260	1, 698	2, 188	4, 029	Absent		11, 828	106	11, 934	Pre-Mesozoic volcanic rocks.	S, E	
11, 643									11, 668	Punta Gorda Anhydrite.	E	
11, 710									11, 794	do.	E	
									8, 494	Beds of Washita Age.	E	
11, 560									11, 595	Punta Gorda Anhydrite.	E	
Present?	Absent	(?)	1, 155?	2, 120	Absent		7, 720	752	8, 472	Early Paleozoic sedimentary rocks.	S, E	
10, 375	260	2, 227	2, 742	4, 692	do.		12, 602	28	12, 630	Pre-Mesozoic volcanic rocks.	E	

TABLE 1.—*Location, date of completion, and elevation*

[Stratigraphic data for each well show the depth and

Well	County	Name and location of well	Date of completion	Elevation of well (feet)	Comanche Series							
					Beds of Washita Age undifferentiated		Beds of Fredericksburg Age undifferentiated		Beds of Trinity Age			
									Beds of late Trinity Age			
									Depth to top of rocks of late Trinity Age (feet)	Sunniland Limestone		Thickness of rocks of late Trinity Age (feet)
					Depth to top (feet)	Thickness (feet)	Depth to top (feet)	Thickness (feet)		Depth to top (feet)	Thickness (feet)	
46	Highlands	Humble Oil & Refining Co. G. C. Carlton Estate well 1, sec. 34, T. 38 S., R. 29 E.	Jan. 17, 1946	114	7,870	1,010	8,880	995	9,875	10,265	110	500
47	Hillsborough	Humble Oil & Refining Co. T. S. Jameson well 1, sec. 7, T. 31 S., R. 22 E.	July 6, 1946	112	6,968	642	7,610	804	8,414	Not identified		431
48	Indian River	Amerada Petroleum Corp. Fondren Mitchell well 1, sec. 28, T. 31 S., R. 35 E.	Jan. 6, 1956	60	6,413	917	7,330	940	8,270	do		230?
49	Lake	Oil Development Company of Florida. J. Ray Arnold well 1, sec. 17, T. 24 S., R. 25 E.	1937	120	5,402	219	5,621	482	Beds of Trinity age absent			
50	Lee	Gulf Oil Corp. Consolidated Naval Stores well 1, sec. 27, T. 45 S., R. 26 E.	Oct. 2, 1953	45	8,480	1,090	9,570	1,440	11,010	11,520	254	764
50a	do	Gulf Oil Corp. Consolidated Naval Stores well 2, sec. 22, T. 45 S., R. 26 E.	Nov. 3, 1956	45	8,490	1,085	9,575	1,437	11,012	11,530	241	759
51	do	Humble Oil & Refining Co. W. E. Kirchoff well 1, sec. 23, T. 45 S., R. 24 E.	Sept. 10, 1953	24	8,500	1,065	9,565	1,490	11,055	11,615	245	805
52	Manatee	Magnolia Petroleum Co. Schroeder-Manatee, Inc. well 1, sec. 11, T. 35 S., R. 19 E.	Aug. 2, 1955	70	7,870	882	8,752	1,048	9,800	10,200	170	570
53	Marion	Sun Oil Co. H. N. Camp well 1, sec. 16, T. 16 S., R. 23 E.	May 20, 1947	74	4,122	118	Present?		Beds of Trinity age absent			
54	Monroe	Coastal Petroleum Co. State of Florida, Lease 363, well 1, sec. 32, T. 62 S., R. 38 E. on Plantation Key.	Sept. 30, 1949	15	7,312							
55	do	Gulf Oil Corp. State of Florida, Lease 373, well 1, sec. 2, T. 67 S., R. 29 E. on Big Pine Key.	Apr. 1, 1947	23	7,550	1,990	9,540	1,830	11,370	12,070?	170?	870
56	do	Gulf Oil Corp. State of Flordia, Lease 826–G, well 1, In unsurveyed area in Florida Bay at lat. 25°0′53″ N., long. 81°5′54″ W.	Nov. 14, 1955	21	7,750	1,760	9,510	1,515	11,075	11,730	182	837
57	do	Peninsular Oil & Refining Co. J. W. Cory well 1, sec. 6, T. 55 S., R. 34 E.	May 21, 1939	14	8,106	1,574	9,680	1,310 est				
58	do	Republic Oil Co. O. D. Robinson-State of Florida well 1, sec. 29, T. 59 S., R. 40 E. in Barnes Sound, Key Largo.	June 1, 1946	20	6,930	1,440	8,370	1,260	9,630	10,170	240	780
59	do	Sinclair Oil & Gas Co. H. R. Williams well 1, sec. 24, T. 59 S., R. 40 E. on Key Largo.	Aug. 31, 1953	20	6,840	1,380	8,220	1,240	9,460	9,956	217	713
60	Okeechobee	Amerada Petroleum Corp. Marie Swenson well 1, sec. 5, T. 36 S., R. 34 E.	Sept. 27, 1955	55	7,010	970	7,980	1,060	9,040	Not identified.		405?
61	Orange	Warren Petroleum Co. George Terry well 1, sec. 21, T. 23 S., R. 31 E.	Sept. 13, 1955	100	5,443	412	5,855	465	Absent?	Absent		
62	Osceola	Humble Oil & Refining Co. N. R. Carroll well 1, sec. 10, T. 27 S., R. 34 E.	July 15, 1946	62	5,954	776	6,730	640	do	do		
63	do	Humble Oil & Refining Co. W. P. Hayman well 1, sec. 12, T. 31 S., R. 33 E.	Dec. 26, 1946	86	6,390	800	7,190	766	do	do		
64	do	Hunt Oil Co. Consolidated Naval Stores well 3, sec. 4, T. 27 S., R. 32 E.	Oct. 10, 1948	77	5,880							
65	do	Hunt Oil Co. Peavy-Wilson Lumber Co., Inc. well 2A, sec. 27, T. 25 S., R. 34 E.	Aug. 21, 1948	44	5,830							
66	Palm Beach	Amerada Petroleum Corp. Southern States Land and Timber Co. well 1, sec. 34, T. 41 S., R. 39 E.	Oct. 11, 1955	34	7,373	1,257	8,630	1,160	9,790	10,295	140	645
66a	do	Humble Oil & Refining Co. State of Florida, Lease 1004, well 1, sec. 2, T. 48 S., R. 35 E.	Mar. 13, 1958	31	8,219	1,326	9,545	1,405	10,950	11,445	179	674
67	do	Humble Oil & Refining Co. Tucson Corp. well 1, sec. 35, T. 43 S., R. 40 E.	Aug. 8, 1947	34	7,500	1,300	8,800	1,210	10,010	10,630	127	747

See footnote at end of table.

of 73 wells in central and south Florida—Continued

thickness of units of the Comanche Series and older rocks]

Comanche Series—Continued							Pre-Mesozoic rocks		Total depth of well (feet)	Oldest rocks penetrated	Stratigraphic data from samples (S) or electric log (E)	Remarks
Beds of Trinity Age—Continued				Thickness of Comanche Series (feet)	Upper Jurassic(?) or Lower Cretaceous(?), Fort Pierce Formation							
Beds of early Trinity Age			Thickness of beds of Trinity Age (feet)									
Depth to top of rocks of early Trinity Age (feet)[1]	Thickness of Punta Gorda Anhydrite (feet)	Thickness of rocks of early Trinity Age (feet)			Depth to top (feet)	Thickness (T) or depth of penetration (P) (feet)	Depth to top (feet)	Depth of penetration (feet)				
10,375	285	2,243	2,743	4,748	Absent		12,618	367	12,985	Pre-Mesozoic volcanic rocks.	S, E	Southernmost occurrence of igneous rocks in Florida.
8,845	203	1,165	1,596	3,042	do		10,010	119	10,129	do	S, E	
8,500?*	Absent	910?	1,140	2,997	do		9,410	78	9,488	do	S, E	
Beds of Trinity age absent				701	do		6,103	17	6,120	Granite	S, E	
11,774	556								12,865	Beds of early Trinity age.	E	
11,771									11,800	Punta Gorda Anhydrite.	E	
11,860	570								12,877	Beds of early Trinity age.	E	
10,370	355								11,226	do	S, E	
Beds of Trinity age absent				118	Absent		4,240	397	4,637	Pre-Mesozoic volcanic rocks.	S, E	Paleozoic strata 4,240–4,615 ft. Volcanic rocks 4,615–4,637 ft.
									7,559	Beds of Washita age.	E	
12,240	Base not identified.	2,100	2,970	6,790	14,340	1,115 P			15,455	Fort Pierce Formation.	S, E	Deepest test in Florida.
11,912									12,631	Punta Gorda Anhydrite.	E	
									10,006	Beds of Fredericksburg age.	S, E	
10,410	840	1,468	2,248	4,948	11,878	175 P			12,053	Fort Pierce Formation.	S, E	
10,173	783	1,487	2,200	4,820	11,660	308 P			11,968	do	S, E	
9,455?*	Absent	1,305	1,710	3,740	Absent		10,750	88	10,838	Pre-Mesozoic volcanic rocks.	S, E	
6,320?*	do	230	230	1,107	do		6,550	39	6,589	Granite	S, E	
7,370*	do	665	665	2,081	do		8,035	14	8,049	do	S, E	
7,956*	do	784	784	2,350	do		8,740	58	8,798	Pre-Mesozoic volcanic rocks.	S, E	
									6,510	Beds of Washita age.	S, E	
									5,856	do	S, E	
10,435*	Absent								11,030	Beds of early Trinity age.	S, E	
11,624	(?)								12,810	do	E	Maps accompanying this report show location of well in Broward County.
10,757*	Absent	1,853	2,600	5,110	12,610	765 P			13,375	Fort Pierce Formation.	S, E	

TABLE 1.—*Location, date of completion, and elevation*

[Stratigraphic data for each well show the depth and

Well	County	Name and location of well	Date of completion	Elevation of well (feet)	Comanche Series							
					Beds of Washita Age undifferentiated		Beds of Fredericksburg Age undifferentiated		Beds of Trinity Age			
									Beds of late Trinity Age			
									Depth to top of rocks of late Trinity Age (feet)	Sunniland Limestone		Thickness of rocks of late Trinity Age (feet)
					Depth to top (feet)	Thickness (feet)	Depth to top (feet)	Thickness (feet)		Depth to top (feet)	Thickness (feet)	
68	Pinellas	Coastal Petroleum Co. E. C. Wright well 1, sec. 7, T. 30 S., R. 17 E.	July 2, 1948	13	7,210	715	7,925	845?	8,770?	Not identified		500?
68a	St. Lucie	Amerada Petroleum Corp. Cowles Magazines well 2, sec. 19, T. 36 S., R. 40 E.	July 17, 1957	32	6,791	1,209	8,000	1,010	9,010	Not identified		450?
69	Volusia	Grace Drilling Co. Retail Lumber Co. well, 1, sec. 2, T. 15 S., R. 30 E.	Jan. 30, 1949	44	4,985	165	5,150	253	Beds of Trinity age absent			
70	do	Sun Oil Co. Powell Land Co. well 1, sec. 11, T. 17 S., R. 31 E.	Sept. 14, 1946	48	5,130	242	5,372	350	Absent?	Absent		

[1] The top of the beds of Early Trinity age in most wells in this table is at the top of the Punta Gorda Anhydrite. An asterisk (*) following the depth to the top of the

earliest reference to the occurrence of authenticated Comanche rocks in Florida is that of Campbell (1939) who published an account of the drilling operations in and the rocks penetrated by the Peninsular Oil & Refining Co. J. W. Cory 1, Monroe County. The well, which was unproductive, was completed in 1939 at the depth of 10,006 feet in carbonate rocks and anhydrite of Fredericksburg age, and at the time of completion was the deepest test in the State. Although the first announcement of the occurrence of Comanche rocks in south Florida was in the report on the Cory well, it was pointed out by Campbell (1939; 1940, p. 95–96) and by Applin and Applin (1944, p. 1721–1722) that Comanche limestones had been penetrated earlier, in 1937, in the Oil Development Co. of Florida J. Ray Arnold 1 ("South Lake well"), Lake County. Campbell (1940) brought together for the first time the available subsurface data on several deep wells in Florida. He discussed the subsurface formations and presented a cross section through the wells and a series of eight paleogeographic maps, achieving a creditable interpretation of the regional stratigraphy and structure of the peninsula considering the limited information available at that time. The Cory well furnished material for other important contributions to the subsurface stratigraphy and micropaleontology of south Florida. Among these was a report by Cole (1941, p. 9–53, pls. 1–18) in which he presented studies of samples, classifications of formations, and descriptions and illustrations of many species of Foraminifera.

The depths at which the different geologic formations were penetrated in several deep wells in Florida, and the subsurface stratigraphy of the peninsula are discussed by Schuchert (1943, p. 452–465). The regional subsurface stratigraphy and structure of Florida and southern Georgia, and available data on the Lower Cretaceous and older rocks that had been penetrated in several wells were discussed by Applin and Applin (1944).

Cooke (1945) wrote a report on the geology of Florida, dealing primarily with the stratigraphy and paleontology of surface beds but containing much information of value on the buried rocks.

An important contribution relating to the geology and occurrence of oil in Florida was made by Pressler (1947), who described and named regional structures in Florida and the Coastal Plain of Georgia and presented a map showing the location of these structures and of others in adjacent parts of the Atlantic and Caribbean basins. Geologic sections showed the lithology of the different surface and subsurface units in both north and south Florida. A cross section through Florida, the Straits of Florida, and Cuba presented a profile of the structure and showed the lithologic variations in the subsurface units. The report also described the geology of and the drilling operations in the Sunniland oil field in Collier County.

A set of five cross sections, three of which (*A–A′*, *B–B′*, *C–C′*) are of particular interest in connection with the subsurface geology of central and south Florida, was published in 1949 by the Southeastern Geological Society. These cross sections contributed much to the knowledge concerning the regional structure and Mesozoic stratigraphy of the subsurface in Florida, southern Georgia, and southeastern Alabama.

of 73 wells in central and south Florida—Continued

thickness of units of the Comanche Series and older rocks]

Comanche Series—Continued							Pre-Mesozoic rocks		Total depth of well (feet)	Oldest rocks penetrated	Strati-graphic data from samples (S) or electric log (E)	Remarks
Beds of Trinity Age—Continued				Thick-ness of Coman-che Series (feet)	Upper Jurassic(?) or Lower Cretaceous(?), Fort Pierce Formation							
Beds of early Trinity Age			Thick-ness of beds of Trinity Age (feet)									
Depth to top of rocks of early Trinity Age (feet)[1]	Thickness of Punta Gorda Anhydrite (feet)	Thick-ness of rocks of early Trinity Age (feet)			Depth to top (feet)	Thickness (T) or depth of penetra-tion (P) (feet)	Depth to top (feet)	Depth of penetra-tion (feet)				
9,270?	230?								11,507	Beds of early Trinity age.	S, E	
9,460?*	Absent	1,000?	1,450	3,669	10,460	2,220 T	12,680	68	12,748	Pre-Mesozoic metamorphosed igneous intrusive rocks.	S, E	
Beds of Trinity age absent				418	Absent		5,403	21	5,424	Pre-Mesozoic volcanic rocks.	S, E	
5,722?*	Absent	188	188	780	do		5,910	48	5,958	Hornblende diorite.	S, E	

beds of Early Trinity age indicates that the Punta Gorda Anhydrite is absent, and the top of the beds of Early Trinity age is at the top of older beds of Trinity age.

The tectonic and stratigraphic relations of the Florida peninsula and adjacent areas in the southeastern States have been discussed by King (1950, p. 656–658; 1951, p. 166) and by Eardley (1951, p. 559–561).

The available data relating to the buried pre-Mesozoic rocks in Florida and the adjacent States, and the transgressive overlaps of the Comanche rocks on the Coastal Plain floor in central Florida are discussed by Applin (1951a). Applin (1951b) also described the regional subsurface stratigraphy and structure of Florida.

The geographic distribution of evaporites in the different geologic systems within the United States is discussed by Krumbein (1951). He classified the evaporite occurrences, including those of the Comanche rocks in Florida, on the basis of their broad stratigraphic aspects. From the lithologic associations of evaporites, he inferred the environmental and tectonic conditions related to their origin.

Applin (1952) presented isopach maps which are the basis for his estimates of the volume of Comanche and Gulf sediments in Florida and Georgia.

Jordan (1952) discussed the stratigraphy of the Mesozoic rocks in Florida and presented two subsurface structure maps contoured, respectively, at the top and base of the Upper Cretaceous rocks.

The regional stratigraphy and structure of Florida and a review of the sequence of significant events in the geologic history of the peninsula were presented by Gunter, Vernon, and Calver (1953).

Patton (1954) discussed the oil possibilities of the southeastern States, pointed out the main structural features of the area comprising these States, and mentioned the differences in lithology that characterize the sedimentary rocks in different parts of the area.

Jordan (1954) described the lithology and facies changes of the major stratigraphic units in Florida and presented isopach maps of the Lower Cretaceous and Upper Cretaceous rocks in the State.

Woodring (1954) contributed information on the geological history of the Caribbean region, and on paleogeographic maps accompanying the report, he showed the relation of the Cretaceous and Tertiary rocks of the Caribbean complex to rocks of equivalent age in southern Florida.

Forgotson (1956, 1957) described the stratigraphy, tectonic framework, and paleogeography of the outcropping and subsurface rocks of the Trinity Group in the Gulf Coastal Plain from southwest Texas to the Florida Keys. In his reports, references to Florida are made, chiefly, in a correlation chart, a stratigraphic cross section through wells, a regional isopach and lithofacies map, and a regional map showing the tectonic framework of the Trinity Group.

From 1942 to the present date, annual reports on exploratory drilling and developments in the southeastern States, inclusive of Florida, have been published in the Bulletin of the American Association of Petroleum Geologists.

Information circulars relating to exploration for oil and gas in Florida have been issued annually, beginning in 1948, by the Florida Geological Survey (Gunter, 1948–58). The circulars present tables of conveniently arranged data pertaining to the oil and gas test wells that have been drilled in the State since 1900; they present maps showing the location of test wells and tabulated statistics relating to oil production in the Sunniland field.

SIGNIFICANT EVENTS

The discovery of the Sunniland oil field in 1943 started a period of active exploration in the peninsula that continued through 1950. The collections of well samples maintained by many of the oil companies engaged in exploration in the area, and the large and accessible collection of the Florida Geological Survey provided a wealth of material for investigations of the subsurface carried on by commercial geologists and by geologists of the State Geological Survey and the U.S. Geological Survey. From these investigations, the interpretation of the regional subsurface stratigraphic and structural pattern of the peninsula has gradually evolved.

Most of the available information about the different types of crystalline rocks, volcanic rocks, and lower Paleozoic strata that compose the Coastal Plain floor in central Florida is derived from the cores taken in wells that were drilled during this period of 1943 to 1950. The discovery of Comanche rocks in the Arnold well in Lake County, Fla., has already been mentioned (p. 12); a granite penetrated in the lower part of the well was the first occurrence of igneous rocks reported in Florida (Campbell, 1940, p. 95–96). Amygdaloidal basalt, rhyolite porphyry, and related kinds of volcanic rocks were first penetrated in central Florida early in 1946 in the Humble Oil & Refining Co. G. C. Carlton well, Highlands County. Lower Paleozoic strata, which were discovered in Florida in 1926 or 1927, have been penetrated in wells that are located, for the most part, in the north one-third of the peninsula and the adjacent part of southeastern Georgia (Applin, 1951a, fig. 1; Bridge and Berdan, 1951). In the area covered by this report, two wells, The Ohio Oil Co. Hernasco Corp. 1 (44, table 1), Hernando County, and the Sun Oil Co. H. N. Camp 1 (53, table 1), Marion County, penetrated a sequence of unfossiliferous white sandstone and quartzitic sandstone, to which Bridge and Berdan (1951, p. 5–7) tentatively assigned an Early Ordovician age. For a more complete description of the stratigraphy and correlation of the pre-Coastal Plain rocks, the reader is referred to published articles by Applin (1951a), Bridge and Berdan (1951), and Berdan and Bridge (1951).

In 1946, a sequence of Upper Jurassic(?) or Lower Cretaceous(?) carbonate rocks and evaporites was penetrated in the Republic Oil Co. O. D. Robinson-State of Florida 1, Monroe County. The stratigraphic significance of these rocks was more clearly shown the following year, however, when samples became available from the Gulf Oil Corp. State of Florida, lease 373, 1, on Big Pine Key, Monroe County. Both wells terminated in the Upper Jurassic(?) or Lower Cretaceous(?) unit. Although the precise age continues to be a subject of investigation, the lithology of these rocks and their distinctive microfauna serve to differentiate them from the overlying carbonate rocks of the Comanche Series.

Also during the period from 1943 to 1950, studies of the microfaunas and the lithology of the carbonate-evaporite facies of the Comanche rocks enabled geologists to differentiate the units of Trinity, Fredericksburg, and Washita age, and progress was made in the correlation of local units in the beds of Trinity age. A very thin but widespread and distinctive bed of green shale that is assignable to either the upper part of the Comanche Series or the lower part of the Gulf Series was used by geologists as a reliable marker for the correlation of well logs. A characteristic dense gray irregularly silty limestone that overlies the green shale bed probably was also well known to geologists during the early period of exploration, although faunal evidence for correlating it with the basal beds of the Atkinson Formation of the Gulf Series did not become available until later.

A decrease in the number of wells drilled during 1951 and 1952 was followed by an increase in exploratory activity from 1953 to 1955. In 1954, two oil wells were completed in the Sunniland Limestone in the Forty Mile Bend field, Dade County, but were abandoned in 1955, about 20 months after the field was discovered. Beginning in 1955 the downward trend of exploration resumed.

The wells drilled in south Florida after 1950 provided additional data that established more precise correlations but did not materially change the earlier stratigraphic interpretations. Data on two of the wells, which are here mentioned, seem to have more than ordinary significance. In 1951, a set of 80 consecutive diamond-bit cores penetrated more than 7,700 feet of Paleocene and Cretaceous carbonate rocks and evaporites in the Humble Oil & Refining Co. Collier Corp. 1, Collier County. The cores, the first of which was taken at a depth of 4,891 feet in the Cedar Keys (Paleocene) Limestone, penetrated the Gulf Series and part of the Comanche Series and terminated in beds of Trinity age at 12,600 feet, the total depth of the well. This instructive set of cores shows in striking fashion the nature of a substantial part of the thick section of carbonate rocks and evaporites that underlie the south part of the Florida peninsula. In 1957, a well in St. Lucie County was the first to be drilled through the Upper Jurassic(?) or Lower Cretaceous(?) unit into older rocks. In this well, the

Amerada Petroleum Corp. Cowles Magazines well 2, cores show that the unit is 2,220 feet thick and that it rests unconformably on metamorphosed igneous intrusive rocks. The total depth of the well is 12,748 feet.

Interpretation of these data from the drilling of wells and, consequently, the subsurface structural mapping are still in a stage of development and change

STRUCTURAL FEATURES

The regional structural features of the Florida peninsula (fig. 1) markedly affect the distribution, thickness, lithology, and biostratigraphy of the sedimentary units and are closely related to the tectonics of the Gulf of Mexico basin. Inasmuch as the structural features are frequently mentioned in this report in connection with the descriptions of stratigraphic units, a brief description of each of them is appropriate.

PENINSULAR ARCH

Peninsular arch (Applin, 1951a, p. 3–5, figs. 2, 3, 4) is the name applied to the large anticlinal fold or arch that is the dominant subsurface structural feature of the north two-thirds of the Florida peninsula. The arch, which is about 275 miles long, trends about S. 35° E. from south-central Georgia to the vicinity of Lake Okeechobee (fig. 1). The highest part of the arch in the Cretaceous and pre-Coastal Plain rocks is in Union County and the southern part of Columbia County.

OCALA UPLIFT

The term "Ocala uplift" (fig. 1) seems to have been first published in a U.S. Geological Survey press release (Hopkins, 1920) dated April 19, 1920, that was later "republished" by Gunter (1921, p. 16–19) and quoted, in part, by Vernon (1951, p. 54). In this release, Hopkins clearly defined the surface structure to which he gave the name Ocala uplift. He stated

'* * * the anticlinal fold * * * trends south-southeast, and forms the axis of the Floridian Peninsula. The axis of this uplift passes near Live Oak, 10 to 20 miles west of Gainesville, and an equal distance west of Ocala, and represents the southern continuation of the broadly anticlinal area of south-central Georgia. There are two high areas along this anticline. One, called the Ocala uplift, appears to have its highest part or crest in eastern Levy County, and the other near Live Oak. Of these, the Ocala uplift is the larger and structurally higher (Vernon, 1951, p. 54.)

The name Ocala uplift was later applied to the entire anticlinal structure mentioned by Hopkins. Investigations by a number of geologists have shown that the crest of the anticline centers around outcrops of Avon Park Limestone (middle Eocene) and Ocala Limestone (upper Eocene) in Citrus, Levy, and Dixie Counties on the west coast of the peninsula, and structure contour maps published by Mossom (1926, p. 256) and later by Vernon (1951, pls. 1, 2) clearly define the trend of the axis from Madison County at the north to Polk County at the south. Vernon (1951, p. 53) pointed out that the structural deformation of the Ocala uplift probably began during early Miocene.

The search for oil in Florida directed the attention of geologists engaged in subsurface studies to the Peninsular arch in the central part of the peninsula, and in the past 10 or 15 years several published articles and maps extended the term "Ocala uplift" to include the area of the arch. In the present report, however, usage of the name Ocala uplift is restricted to the anticlinal fold in post-Cretaceous rocks as first described by Hopkins. On the basis of the available data, we regard the uplift as a faulted and folded structure in the Eocene and younger rocks on the southwest flank of the older and dominant Peninsular arch.

SOUTH FLORIDA EMBAYMENT

The name south Florida embayment was introduced by Pressler (1947, p. 1856, fig. 1) for a large regional feature of which he evidently considered south Florida to be a segment. He stated

The area of southern Florida south of the Ocala uplift, the island of Cuba, the Bahama Islands, and the intervening submerged areas are designated the South Florida embayment of the Gulf of Mexico sedimentary basin. The sedimentary fill of this embayment is believed to attain a maximum thickness in excess of 15,000 feet approaching 20,000 feet in thickness in the Gulf basin off the southwest coast of Florida. This section, which is composed principally of limestones and anhydrite, thins updip from the center of the embayment toward the northeast on the flanks of the Ocala uplift of Florida, and the Bahama uplift or flexure, and southwest on the Cuban uplift.

"The synclinal axis of this embayment is believed to plunge toward the Gulf and trend northwestward between Cuba and the Bahamas, and Cuba and Florida along a general line through Great Inagua Island to a point near the south end of Andros Island, thence across the Bahama Banks to the Florida Keys near the north end of Key Largo and across Dade and Monroe counties to the southwest coast of Florida. West of the southwest coast of Florida, this synclinal axis is considered to make juncture with the geosynclinal axis of the Gulf basin which trends north and west generally paralleling the west coast of Florida to the vicinity of the Apalachicola River delta, where it trends westward paralleling the coast of west Florida.

Patton (1954, p. 160) enumerated the structural features of southern Alabama, southern Georgia, and Florida and stated that "The south Florida embayment * * * extends from the south side of the Ocala uplift to the Straits of Florida just south of the Florida Keys."

As interpreted by us (fig. 1), the synclinal axis of the embayment trends about N. 65° W. from the eastern end of Florida Bay across the southern tip of the peninsula and plunges toward the Gulf of Mexico.

SOUTH FLORIDA SHELF

Insofar as the south Florida embayment of Pressler (1947, p. 1856, fig. 1) is related to the southern part of the peninsula, the interpretation of the structure was based mainly on the information available in in 1947. Subsurface data that subsequently became available from additional deep wells in the area, however, suggest some revision of the earlier structural interpretation.

The name south Florida shelf (fig. 1) is here proposed for a broad relatively flat area in the Comanche rocks southwest of the Peninsular arch and bordering the south Florida embayment on the northeast. The shelf, which trends about S. 45° E., extends nearly 200 miles across the peninsula from Charlotte County on the Gulf coast to Key Largo, Monroe County, on the Atlantic coast. The width of the shelf is about 75 miles at the top of the Comanche rocks. The available subsurface data indicate that the shelf may swing around the eastern end of Florida Bay and trend southwestward along the Florida Keys. Between the south Florida shelf on the southwest and the Peninsular arch on the northeast, a syncline plunges southeastward across Palm Beach and Broward Counties. Local structural "highs," each covering an area of several townships, are situated along the shelf.

BROWARD SYNCLINE

The name Broward syncline is here proposed for a syncline in the Comanche rocks that plunges southeastward from east-central Hendry County across Palm Beach and Broward Counties to the vicinity of Fort Lauderdale on the southeast coast of the peninsula. The Broward syncline is between the south Florida shelf on the southwest and the Peninsular arch on the northeast.

STRATIGRAPHY

COASTAL PLAIN FLOOR

The Coastal Plain floor in the Florida peninsula is the truncated surface of a wide variety of igneous and sedimentary rocks that are chiefly Precambrian(?) and early Paleozoic in age. A few wells in the northern part of the peninsula penetrated rocks of Late Triassic(?) age that evidently form a part of the truncated floor on which the coastal plain rocks were deposited. On the southeast coast of the peninsula, a single well penetrated highly altered rocks of undetermined age which underlie the coastal plain rocks. The graphic patterns in figure 3, which are based on the available data from oil test wells (Applin, 1951a, tables 1, 2, 3), show our provisional interpretation of the areal geology of the truncated surface of the ancient rocks.

The pre-Mesozoic rocks (Applin, 1951a, p. 5–15; Bridge and Berdan, 1951) that make up the greater part of the Coastal Plain floor in central and northern Florida have been provisionally classified as (a) Precambrian(?) granite and diorite; (b) Precambrian(?) or lower Paleozoic(?) rhyolite and pyroclastic rocks; and (c) unmetamorphosed quartzitic sandstone, gray to black noncalcareous micaceous shale, and gray to black noncalcareous nonmicaceous shale that range in age from Early Ordovician to Early or possibly Middle Devonian. A well completed in 1957 in St. Lucie County on the southeast coast of the peninsula terminated in highly altered igneous intrusive rocks of undetermined age.

Several wells in the northwestern part of the peninsula penetrated a sequence of rocks that has been tentatively classified (Applin, 1957) as the Late Triassic Newark Group. The rocks are, chiefly, terrestrial or marginal clastic deposits cut by intrusions and flows of diabase and basalt. The structural relations of these Triassic(?) rocks are not clearly defined by the available data, but they seem to form a westward-thickening wedge that intervenes between the older Paleozoic rocks and the younger Lower Cretaceous clastic strata. Elsewhere in the northern part of the peninsula, Triassic(?) diabase cuts early Paleozoic strata in several wells, and in a few others a thin layer of weathered diabase rests on early Paleozoic strata and underlies Lower Cretaceous clastic rocks.

The depth below the present sea level to the Coastal Plain floor (fig. 3) ranges from about 2,600 feet in a well in Columbia County, in northern Florida, to more than 12,500 feet in several wells in the vicinity of Lake Okeechobee. The oil test wells in south Florida have not been drilled sufficiently deep to penetrate the Coastal Plain floor, although a well on Big Pine Key, Monroe County, the deepest test in the State, reached the total depth of 15,455 feet.

The subsurface data relating to the composition and geologic history of the Coastal Plain floor in the Florida peninsula, though fragmentary and, in part, subject to more than one interpretation nevertheless aid in interpreting the stratigraphy and structure of the overlying strata. From a regional standpoint, too, the pre-Jurassic rocks contribute significant information on the geology of the southeastern part of the United States. King (1950, p. 658) pointed out that the discovery of unmetamorphosed Paleozoic strata in Florida shows "* * * that southeast of the Appalachian system there is a foreland or shelf of little deformed rocks just as there is northwest of it."

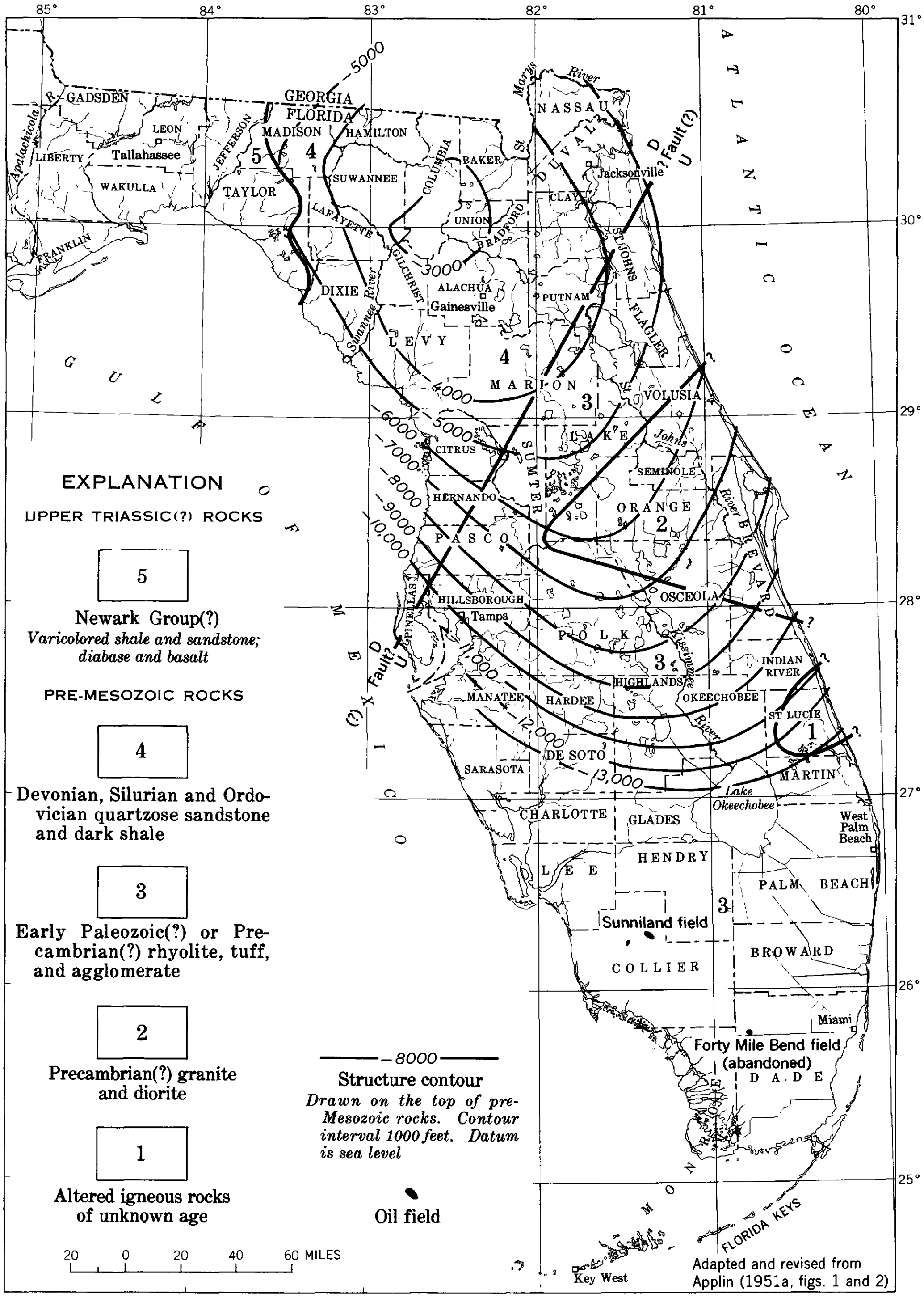

FIGURE 3.—Map of the Florida peninsula showing the areal distribution of pre-Mesozoic and Upper Triassic(?) rocks that compose the Coastal Plain floor, and structure contours on the truncated surface of the pre-Coastal Plain rocks.

Subsequent to the publication of the data on pre-Jurassic rocks in Applin (1951a), Bridge and Berdan (1951), and Reeside and others (1957), the Amerada Petroleum Corp. Cowles Magazines 2, St. Lucie County, penetrated 23 feet of highly altered igneous intrusive rocks from 12,725 to 12,748 feet, the total depth (table 1). Dr. C. S. Ross, U.S. Geological Survey, examined samples of cores provided by the Amerada Petroleum Corp., and he reported:

12,734 ft. has the habit of a diabase with well bounded, elongated plagioclase crystals. Alteration has produced a large proportion of chlorite; most of this occurs rather evenly disseminated, but some of it occurs in rounded areas up to 2 mm in diameter; with this there is finely disseminated calcite. The outer rims of the plagioclase crystals are nearly fresh, but the cores (probably originally more calcic) are altered. The development of chlorite is so complete that the ferromagnesian minerals from which it was derived are not evident.

12,744 ft. represents a much more altered rock and its original character is not entirely clear. Secondary quartz is abundant, and a very light colored phlogopite type of mica is present and may be secondary. Part of the plagioclase is fresh.

12,748 ft. The rock is dominantly plagioclase (An 50 to 60) and high-iron green hornblende (about one-third of rock). Fewer amounts of quartz, biotite, and traces of much altered diopside. Magnetite fairly abundant.

The specimens 12,744 and 12,748 ft. show more metamorphism than 12,734 ft. and possibly much more. On the other hand 12,734 ft. shows alteration but no essential destruction of the original diabasic structure. Therefore, it is possible that 12,734 ft. represents a dike that was intrusive into the other rocks. It would help if one could be sure just how much 12,744 and 12,748 ft. have been changed from the original rock, but there seems little doubt that they represent rather femic intrusive rocks.

The earlier reports relating to the igneous rocks in other wells in central Florida do not suggest the intensive alteration that Mr. Ross describes.

JURASSIC(?) TO CRETACEOUS ROCKS

The Mesozoic rocks discussed in this report form a wedgelike mass that pinches out around an irregular-shaped area of lower Paleozoic strata in northern Florida and thicken gradually southeastward, southward, and southwestward toward the coast of the peninsula. These rocks, which range in age from late Jurassic(?) or Early Cretaceous(?) to early Late Cretaceous, attain a known thickness of about 8,000 feet in a well on the Florida Keys, and deeper drilling in certain parts of south Florida will undoubtedly reveal even greater thicknesses.

The subsurface sedimentary section described in this report begins with the Upper Jurassic(?) or Lower Cretaceous(?) unit, which is followed by the units of the Comanche Series and lastly the basal unit of the lower member of the Atkinson Formation of the Gulf Series. Gradual lateral changes in the lithologic character of the rocks, ranging from a predominantly carbonate-evaporite facies in the south to a marginal clastic facies and possibly to continental deposits in the north, are a significant factor in the sedimentary or depositional history of the area. During Late Jurassic(?) or Early Cretaceous(?) and Comanche time, south Florida was covered by clear warm very shallow waters of a subtropical sea. The microfaunal assemblages in the various stratigraphic units are composed largely of organisms favoring a warm shallow-water habitat. Carbonate rocks containing many lenses of oolitic limestone, bioclastic limestone, and calcareous shale are associated with abundant beds and lenses of anhydrite; terrigenous material is mostly lacking; intraformational conglomerates are present, chiefly in the lower part of the section. The general lithologic similarity of this thick sequence of rocks is taken as an indication that the rate of deposition in the area kept pace, approximately, with the rate of subsidence of the sea bottom.

The basal beds of the Atkinson Formation of the Gulf Series which is the youngest unit to be discussed, overlie the beds of Washita (Comanche) age in central and south Florida. Like the carbonate rocks of the Comanche Series, the basal limestone of the Atkinson Formation in south Florida is of shallow-water origin. Northward along the peninsula, calcareous facies of the unit contain terrigenous material in progressively increasing amounts, so that in north Florida the unit is entirely a near-shore clastic facies.

UPPER JURASSIC(?) OR LOWER CRETACEOUS(?)

FORT PIERCE FORMATION

A sequence of carbonate rocks and evaporites containing a distinctive microfaunal group whose described species are classified partly as Late Jurassic and partly as earliest Cretaceous has been penetrated in three deep oil test wells in the southeastern part of the Florida peninsula and in three on the Keys (fig. 4). A marginal clastic facies of red-bed character underlies the carbonate rocks of this unit and rests on highly altered igneous intrusive rocks of the Coastal Plain floor (p. 17) in the Amerada Petroleum Corp. Cowles Magazines 2 (68a, fig. 4), St. Lucie County, but the other five wells stopped in carbonate rocks. This clastic facies of Late Jurassic(?) or Early Cretaceous(?) age is here named the Fort Pierce Formation; it underlies beds of early Trinity (Comanche) age and is the oldest sedimentary stratigraphic unit found so far by drilling in south Florida.

The Cowles Magazines 2 (sec. 19, T. 36 S., R. 40 E), St. Lucie County, was selected by us as the type well of the formation and was named for the city of Fort Pierce about 9 miles north of the well. The well, which was unproductive, was completed July 17, 1957, at the total depth of 12,748 feet. Samples from the well are indexed as No. W–4323 in the files of the Florida Geological Survey at Tallahassee (Gunter, 1958, p. 13).

A set of consecutive samples of the Fort Pierce Formation taken from the Cowles well as a depth of 10,460 to 12,680 feet and provided by the Amerada Petroleum Corp., was studied microscopically by E. R. Applin, and publication of the description of these samples is authorized by this corporation (written communication, 1958). A log from samples of the Fort Pierce Formation is shown on plate 5 (68a) and

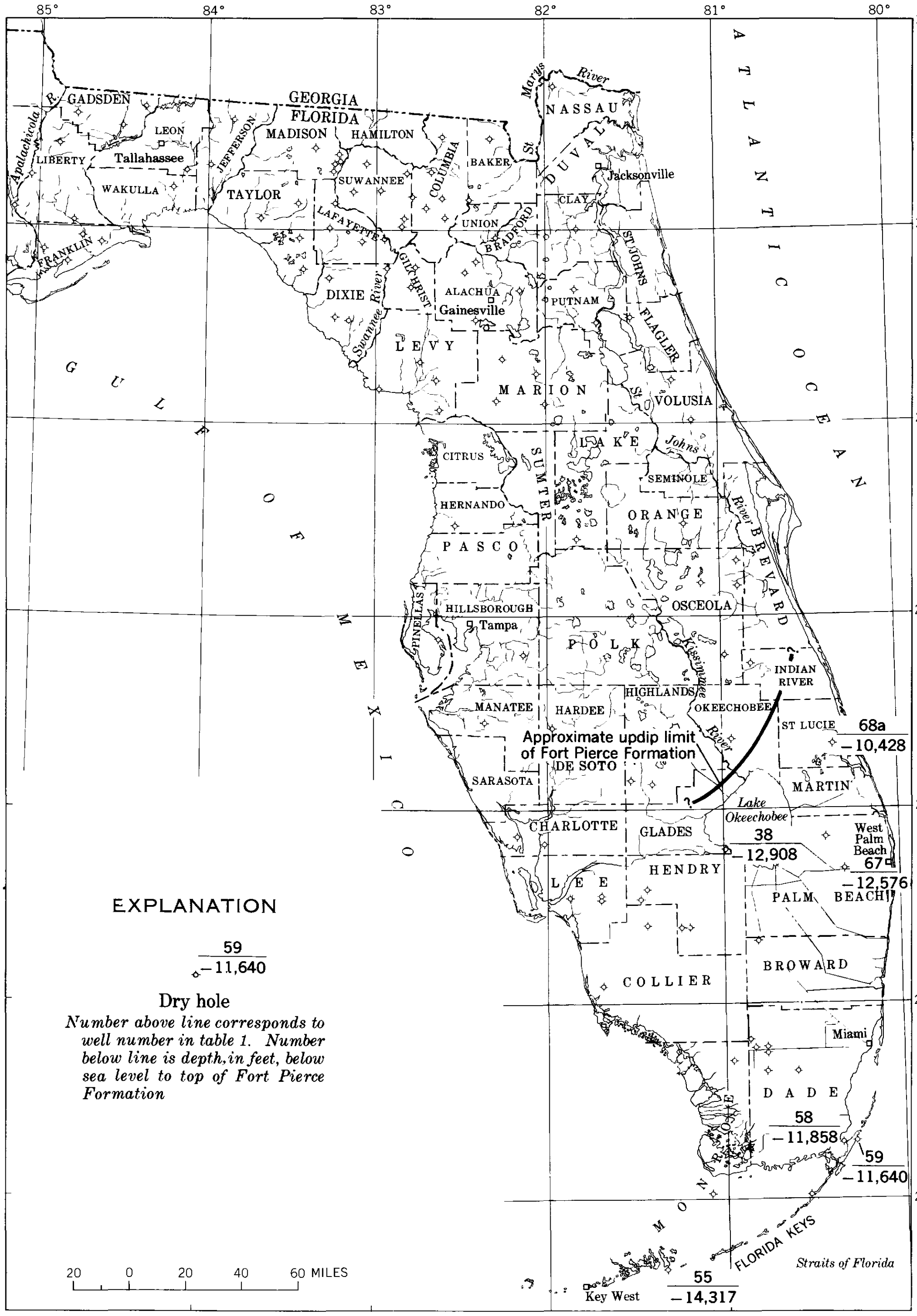

FIGURE 4.—Map of the Florida peninsula showing the location of wells that penetrated the Fort Pierce Formation in south Florida and on the Keys.

the sample descriptions are given in the following paragraphs. The samples are drill cuttings with the exception of core 16 at 11,583–11,665 feet and core 17 at 11,757–11,785 feet. The cutting samples were taken at 10-foot intervals, but in the description consecutive samples showing generally similar lithology have been combined. Descriptions of the two cores are based on sawed slices of representative parts of the cores.

Type section of the Fort Pierce Formation in the Amerada Petroleum Corp. Cowles Magazines 2, sec. 19, T. 36 S., R. 40 E., St. Lucie County, Fla. (68a, pl. 5)

	Depth (feet)
Upper Jurassic(?) or Lower Cretaceous(?):	
Fort Pierce Formation:	
Limestone, olive-brown, flaky, moderately hard; containing abundant traces of poorly preserved fragmental fossils, some fragments of dark-gray shale, and some of anhydrite	10, 460–10, 510
Limestone, olive-tan, flaky, moderately hard, oolitic; finely oolitic anhydritic dolomitic limestone. Sample at 10,520–10,530 ft is 50 percent anhydrite	10, 510–10, 530
Shale, dark-gray, fissile; anhydrite. Sample from 10,540–10,550 ft is 50 percent anhydrite	10, 530–10, 550
Dolomite, olive-tan, microsucrosic; dolomitic limestone containing traces of fragmental fossils; fragments of dark-gray shale and some of anhydrite	10, 550–10, 560
Anhydrite, 50 percent; fragments of dark-gray shale, limestone, and dolomite like preceding sample, 50 percent	10, 560–10, 590
Limestone, light-brown, dolomitic, anhydritic, oolitic; 10 percent anhydrite and some dark-gray shale	10, 590–10, 600
Shale, anhydrite, and carbonate rocks each compose about one-third of sample. Dolomite and limestone are light brown and dark spotted; shale is dark gray and fissile	10, 600–10, 610
Mainly anhydrite and dark-gray shale accompanied by fragments of limestone similar to that in preceding samples	10, 610–10, 660
Limestone, olive-brown; occasionally anhydritic and dolomitic; containing fragmental fossils and dark-gray fissile shale; 25 percent anhydrite	10, 660–10, 690
Anhydrite, 50 percent; dark-gray shale, 50 percent; a few fragments of dolomitic anhydritic irregularly oolitic fossiliferous limestone. A fragment of *Choffatella* noted	10, 690–10, 700
Anhydrite, 50 percent; light-brown limestone, dolomite, and dark-gray shale, 50 percent. Limestone contains fragmental fossils, among which is *Pseudocyclammina* sp. Some dolomite and limestone fragments are oolitic and pseudo-oolitic. Pseudo-oolites occur as gray, broadly elliptical spots, moderately small and even in size and of undetermined origin	10, 700–10, 720
Upper Jurassic(?) or Lower Cretaceous(?)—Continued	
Fort Pierce Formation—Continued	
Dolomite, light-brown, sucrosic, 75 percent; anhydrite, 25 percent. Sample contains a few fragments of limestone and a few of dark-gray shale. Dark streaks and spots in the dolomite are possibly carbonaceous. Limestone fragments contain sections of *Pseudocyclammina* sp. and specimens of fossils belonging to the *Verneuilina* fauna discussed in this report	10, 720–10, 730
Dolomite, light- and olive-brown, sucrosic; some dolomitic limestone, a few fragments of anhydrite, and a few of dark-gray shale. Dolomite and limestone are highly gray spotted and contain oolites and pseudo-oolites. Some pseudo-oolites are probably molds of ostracodes. A few scattered specimens of small miliolids occur in the limestone	10, 730–10, 770
Limestone, tan and olive-brown, dark-gray-spotted, flaky; small amounts of anhydrite and dark-gray shale. Some limestone fragments are oolitic, some are shale streaked, and a few are anhydritic. The limestone contains a few specimens of ostracodes and small miliolids and a few sections of *Pseudocyclammina* sp	10, 770–10, 800
Dolomite, olive-gray, sucrosic, pseudo-oolitic; tan and olive-gray irregularly dark spotted dolomitic limestone, in part oolitic; small amounts of anhydrite and dark-gray shale. Pseudo-oolites in dolomite are probably ostracodes	10, 800–10, 820
Limestone, olive-gray, tan, gray-spotted; olive-gray-tan sucrosic pseudo-oolitic dolomitic limestone; small amounts of dark-gray shale and anhydrite	10, 820–10, 840
Dolomite, light-grayish-tan, sucrosic, highly oolitic; small amounts of dolomitic limestone like preceding sample, dark-gray shale and anhydrite	10, 840–10, 860
Limestone, olive-tan, gray-spotted; varying amounts of anhydrite and dark-gray shale	10, 860–10, 920
Limestone, tan; some gray limestone and a little anhydrite. Limestone contains scattered specimens of miliolids, *Pseudocyclammina* sp., and fragments and molds of undetermined microfossils. Some limestone fragments are pseudo-oolitic	10, 920–10, 940

Upper Jurassic(?) or Lower Cretaceous(?)—Continued

Fort Pierce Formation—Continued

	Depth (feet)
Limestone, tan, oolitic, microfossiliferous. Oolites in sample at 10,940–10,950 ft are even in size, tightly packed, show well-developed structure. Oolites in sample at 10,950–10,960 ft are irregularly distributed and less uniform in size. Limestone contains scattered specimens of miliolids, *Pseudocyclammina* sp., and other fossils not determined	10, 940–10, 960
Limestone, light-brown, dense, dolomitic; dark-gray-spotted microsucrosic dolomite; greenish and dark-gray shale; anhydrite in varying amounts	10, 960–11, 000
Limestone, tan, irregularly gray-spotted; dolomitic limestone; varying amounts of anhydrite and dark-gray shale. Some fragments of limestone contain evenly distributed oolites about 0.25 mm in diameter	11, 000–11, 030
Limestone, tan and olive gray; olive-gray sucrosic dolomite; varying amounts of anhydrite and dark-gray shale. Limestone and dolomite fragments are irregularly spotted dark gray, and some of them contain oolites, miliolids, ostracodes, and fragments of undetermined microfossils	11, 030–11, 070
Dolomite, olive-gray and tan; limestone; about 25 percent anhydrite; some dark-gray shale. Some limestone fragments contain oolites and fragmental fossils. Some dolomite fragments and some shale fragments contain blebs of anhydrite	11, 070–11, 100
Anhydrite 50 percent; limestone, dolomite, and dark-gray shale 50 percent	11, 100–11, 110
Limestone, tan and olive-gray, somewhat oolitic, gray-spotted	11, 110–11, 120
Limestone, like the preceding sample and dolomitic limestone; anhydrite, 10–20 percent; some dark-gray shale	11, 120–11, 140
Dolomite, light-brown, sucrosic; tan to olive-gray gray-spotted dolomitic limestone containing traces of molds of microfossils; small amounts of shale and anhydrite	11, 140–11, 170
Limestone, gray-streaked and spotted, somewhat oolitic; containing traces of fossil debris; dolomite; 25 percent anhydrite; some dark-gray shale	11, 170–11, 190
Limestone, light-brown and dark-spotted, somewhat oolitic; containing miliolids; anhydrite about 25 percent of sample	11, 190–11, 200
Anhydrite, 25–75 percent; limestone like preceding sample; some dark-gray shale	11, 200–11, 230

Upper Jurassic(?) or lower Cretaceous(?)—Continued

Fort Pierce Formation—Continued

	Depth (feet)
Limestone, light-tan and light-grayish-tan; microsucrosic dolomite; some anhydrite and dark-gray shale	11, 230–11, 260
Dolomite, light-olive-tan, microsucrosic; dark-streaked and spotted somewhat oolitic dolomitic limestone; 10–20 percent anhydrite; some dark-gray shale	11, 260–11, 300
Mainly shale and anhydrite; some limestone like the preceding sample	11, 300–11, 320
Shale, dark-gray, splintery, 50 percent; 50 percent tan dark-spotted limestone and anhydrite	11, 320–11, 330
Limestone, light-tan, olive-tan, and gray hard flaky somewhat oolitic and gray-spotted; some dark-gray shale; about 10 percent anhydrite	11, 330–11, 350
Limestone, light-tan, flaky; olive-gray sucrosic dark-streaked carbonaceous dolomite; 10–50 percent anhydrite; some dark-gray shale. Cutting fragments contain a few oolites, molds of ostracodes, and some fossil debris	11, 350–11, 400
Dolomite, tan and olive-gray, microsucrosic, somewhat anhydritic; about 15 percent anhydrite; some dark-gray shale	11, 400–11, 430
Dolomite, tan and olive-gray, microsucrosic, highly gray streaked and spotted, somewhat anhydritic; some fragments oolitic and contain molds of ostracodes and specimens of miliolids. Samples contain some limestone and dark-gray shale	11, 430–11, 460
Limestone, light-tan, gray-spotted, dolomitic; olive-gray gray-spotted somewhat oolitic sucrosic dolomite; some anhydrite and dark-gray shale. Gray spots in limestone and dolomite may be carbonaceous	11, 460–11, 470
Dolomite, olive-tan, finely crystalline, highly gray streaked and spotted; about 10 percent anhydrite; some limestone and dark-gray shale	11, 470–11, 480
Limestone,. tan, gray-spotted; contains irregularly distributed moderately fine grains of sand, a little anhydrite, and a few fragments of shale	11, 480–11, 500
Dolomite, light-tan and olive-gray, finely granular; dark-spotted oolitic dolomitic limestone. Dolomite and limestone contain sediment-binding algal growths. Sample contains fragments of anhydrite and blue-green shale	11, 500–11, 510

Upper Jurassic(?) or Lower Cretaceous(?)—Continued

Fort Pierce Formation—Continued

Depth (feet)

Dolomite, tan and gray, gray-spotted, finely granular, pseudo-oolitic. Samples contain varying amounts of anhydrite up to 25 percent and some dark-gray shale. Sample at 11,520–11,530 ft contains a few grains of sand ---- 11, 510–11, 580

11,583–11,583½ ft. Shale, dark-gray, laminated; contains several thin lenses of grayish-tan sucrosic dolomite.

11,583½–11,587 ft. Limestone, light-brown, subcrystalline; irregularly banded with anhydrite.

11,587–11,593 ft. Limestone, olive-gray, dolomitic; contains rounded dark spots, apparently molds of ostracodes.

11,593–11,593½ ft. Shale, dark-gray, laminated; contains abundant small even-sized pellets of pyrite.

11,593½–11,598½ ft. Dolomite, olive-gray, dense, microsucrosic.

11,598½–11,599½ ft. Shale, dark-gray, hard, flaky, laminated.

11,599½–11,619½ ft. Dolomite, dark-olive-gray, dense, microsucrosic.

11,619½–11,620 ft. Anhydrite, light- and dark-gray.

11,620–11,630½ ft. Dolomite, olive-gray, dense, microsucrosic, dark-spotted.

11,630½–11,634 ft. Anhydrite, light- and dark-gray.

11,634–11,641½ ft. Limestone, olive-gray, dense; contains irregularly distributed dark crystalline spots.

11,641½–11,642½ ft. Anhydrite, white, with gray mottling.

11,643½–11,645½ ft. Dolomite, olive-gray, dense, microsucrosic, finely pyritic.

11,645½–11,646½ ft. Anhydrite, mottled dark- and light-gray.

11,646½–11,647½ ft. Dolomite, olive-gray, dense, microsucrosic.

11,647½–11,649½ ft. Anhydrite, white with dark-gray mottling.

11,649½–11,654½ ft. Dolomite, gray-spotted, dense, subcrystalline, anhydritic. Gray spots are probably oolites and molds of ostracodes.

11,654½–11,655 ft. Shale, dark-gray; fracture conchoidal.

11,655–11,662½ ft. Dolomite, olive-gray, dense, microsucrosic; contains blebs and streaks of anhydrite and irregularly distributed dark-gray elliptical spots in thickly packed groups.

11,662½–11,665 ft. Dolomite, tan, sucrosic, contains abundant fine parallel lines of dark broken veinlets ---- 11, 583–11, 665 Core 16

Dolomite, tan and olive-gray, dark-streaked and spotted; many fragments of dark-gray shale and a few of anhydrite. Dolomite in sample at 11,670–11,680 ft contains scattered sand grains. Sample at 11,710–11,720 ft contains pink anhydrite ---- 11, 665–11, 720

Dolomite, shale, and anhydrite like preceding samples. Dolomite contains irregularly distributed very fine to moderately coarse sand grains ---- 11, 720–11, 757

11,757–11,757 ft 10 in. Limestone, olive-tan; contains abundant fine to very fine sand grains and scattered coarse grains.

11,757 ft 10 in.–11,759 ft. Dolomite, light-gray, dense, microsucrosic, and light-greenish-gray argillaceous conglomeratic sandstone. Quartz sand grains are poorly sorted and very fine to coarse (0.125–1.0 mm).

11,759–11,761½ ft. Dolomite, olive-gray; abundantly oolitic.

11,761½–11,767½ ft. Dolomite, tan, finely crystalline, pitted, carbonaceous(?). Pits in dolomite are probably molds of small fossils or fossil fragments.

11,767½–11,769 ft. Dolomite, dark-olive-gray, sucrosic; contains vague traces of fragmental fossils.

11,769–11,771½ ft. Dolomite, olive-tan, subcrystalline; carbonaceous(?); contains a few ostracodes.

11,771½–11,772 ft. Anhydrite, light-gray.

11,772–11,778 ft. Dolomite, olive-gray, dense, microsucrosic, anhydritic, carbonaceous(?).

11,778–11,779 ft. Anhydrite.

11,779–11,784½ ft. Dolomite, olive-tan, dark-streaked, microsucrosic ---- 11, 757–11, 785 Core 17

Dolomite, tan, sucrosic, dark-streaked and spotted; some fragments coarsely porous. Samples contain some dark-gray shale and sample at 11,820–11,830 ft contains cuttings of anhydrite ---- 11, 785–11, 830

Dolomite, dark-streaked and spotted, sandy; dark-gray shale, a little blue-green shale, and some anhydrite. Sand grains in dolomite are fine to coarse; composed of quartz and some chalcedony ---- 11, 830–11, 860

Upper Jurassic(?) or Lower Cretaceous(?)—Continued

Fort Pierce Formation—Continued

	Depth (feet)
Dolomite, brown, sucrosic, slightly anhydritic, 50 percent; 50 percent anhydrite and some dark-gray shale. Dolomite is dark streaked and spotted	11, 860–11, 870
Dolomite, light-brown, dark-streaked and spotted, sandy; some anhydrite and dark-gray shale	11, 870–11, 880
Dolomite, like preceding sample but more sandy; anhydrite about 10 percent of sample; a trace of glauconite	11, 880–11, 890
Dolomite, light-brown, dark-gray spotted and streaked, irregularly sandy; some light-brown hard dark-spotted limestone, anhydrite, and dark-gray shale	11, 890–11, 910
Dolomite, light-brown, dark-streaked and spotted, slightly sandy, carbonaceous(?); some dark-gray shale and anhydrite. About 20 percent anhydrite in sample at 11,920–11,930 ft	11, 910–11, 940
Dolomite, light-brown, gray-spotted, and some limestone, 50 percent; about 50 percent dark-gray shale and a small amount of blue-green shale and anhydrite	11, 940–11, 950
Limestone, tan, and gray-streaked sucrosic dolomite. A few limestone and dolomite fragments are finely sandy and a few are pseudo-oolitic. Samples about 20 percent dark-gray shale and a small amount of blue-green shale	11, 950–11, 970
Limestone, light-brown and gray, and microsucrosic dolomite; about 25 percent dark-gray flaky shale and a small amount of blue-green shale. A few sections of ostracodes and poorly defined fragments of a coiled rotalid form observed in the limestone	11, 970–11, 980
Dolomite and limestone, tan and gray, dark-streaked; about 20 percent dark-gray flaky shale and a small amount of dark-brownish-gray shale; a trace of anhydrite	11, 980–11, 990
Dolomite, light-brown, sucrosic, gray-spotted, pseudo-oolitic, slightly anhydritic; about 25 percent dark-gray shale	11, 990–12, 020
Dolomite, like the preceding sample but probably carbonaceous; about 20 percent dark-gray flaky shale; a small amount of anhydrite	12, 020–12, 060
Dolomite, light-gray and grayish-tan, dark-gray spotted; some fragments pseudo-oolitic. A little dark-gray shale and anhydrite in the sample	12, 060–12, 070

Upper Jurassic(?) or Lower Cretaceous(?)—Continued

Fort Pierce Formation—Continued

	Depth (feet)
Limestone and dolomite, various types, partly cavings; some shale and a small amount of anhydrite	12, 070–12, 080
Dolomite, light-brown and light-gray, sucrosic, and some limestone. Dolomite and limestone are dark spotted and streaked and a few fragments pseudo-oolitic. Some gray shale and a trace of anhydrite	12, 080–12, 090
Dolomite, like the preceding sample; some dark-gray shale; 10–20 percent anhydrite	12, 090–12, 110
Dolomite, like the preceding sample; numerous fragments of cream to light-brown chalky limestone, containing much dark-gray fragmental fossil material and a few oolites	12, 110–12, 130
No samples	12, 130–12, 132
Dolomite and shale like the preceding sample; many fragments of rich brown porous dolomite, in which the texture ranges from cryptocrystalline to very finely crystalline	12, 132–12, 138
Dolomite, olive-tan, sucrosic; some dark-gray shale	12, 138–12, 150
Dolomite, light-brown, very porous. Rock apparently formed by dolomitization of highly oolitic limestone and removal of oolites	12, 150–12, 160
Dolomite, various types; some dark-gray shale and anhydrite	12, 160–12, 170
Dolomite, brown, dark-gray streaked and spotted, sucrosic; some dark-gray shale and anhydrite. Sample at 12,180–12,182 ft is 50 percent anhydrite	12, 170–12, 182
Limestone, gray-streaked and spotted, hard, flaky; fragments of shale and anhydrite	12, 182–12, 186
Dolomite, rich tan, sandy, coarsely crystalline, porous; similar to sample 12,150–12,160 ft	12, 186–12, 190
Dolomite, light-gray and light-brown, sandy, very finely crystalline, irregularly porous; some gray shale and anhydrite. Porosity due to removal of oolites	12, 190–12, 220
Dolomite, dark-streaked and spotted, sucrosic, carbonaceous(?), sparsely fossiliferous; some dark-gray shale and about 50 percent anhydrite	12, 220–12, 230
Dolomite, light- and dark-gray mottled, sucrosic; dark-gray and some greenish-gray shale; trace of anhydrite	12, 230–12, 270
Dolomite, like preceding sample, and hard brown limestone containing vaguely defined fragmental fossils and a few grains of sand. *Pseudocyclammina* sp. noted	12, 270–12, 280

Upper Jurassic(?) or Lower Cretaceous(?)—Continued

Fort Pierce Formation—Continued

	Depth (feet)
Dolomite, sucrosic; some shale and a little anhydrite	12, 280–12, 290
Limestone, tan, gray- and brown-spotted, sparsely oolitic, sandy, carbonaceous. Spotted appearance of limestone apparently due to unidentified microfossils and fragments of microfossils	12, 290–12, 310
Dolomite, dark-gray-spotted and streaked, sparsely oolitic; gray and brown hard flaky limestone and some dark-gray shale	12, 310–12, 314
Dolomite dark-gray streaked and spotted, porous, very finely crystalline, sparsely sandy. Shapes of some dark spots suggest microfossils	12, 314–12, 316
No samples	12, 316–12, 320
Dolomite, tan and grayish-tan, spotted and streaked, sucrosic, sparsely sandy; gray sparsely sandy limestone, some anhydrite and dark-gray shale	12, 320–12, 340
Dolomite, gray and light-brown, gray-spotted and streaked, sucrosic; some fragments irregularly pitted and porous, and a few are pseudo-oolitic. A little anhydrite and gray shale noted in the sample	12, 340–12, 350
Dolomite, light-brown, gray-spotted and streaked, microsucrosic, somewhat sandy and anhydritic. Sample contains about 5 percent anhydrite and some dark-gray flaky shale	12, 350–12, 370
Dolomite, like preceding sample, 50 percent; dark-gray shale and anhydrite, 50 percent	12, 370–12, 380
Limestone and tan and grayish-tan microsucrosic dolomite; some dark-gray shale and a small amount of anhydrite	12, 380–12, 390
Limestone and dolomite like preceding sample; some dark-gray shale and 50 to 75 percent anhydrite	12, 390–12, 410
Anhydrite 50 percent; dark-streaked and spotted dolomite and gray shale 50 percent	12, 410–12, 430
Dolomite, dark-streaked and spotted; gray shale; many fragments of dark-brownish-red sparsely sandy shale. Anhydrite is about 25 percent of sample	12, 430–12, 450
Dolomite, light-brown and gray, gray-streaked and spotted, microsucrosic; some gray shale and many fragments of brownish-red sparsely sandy shale; a little anhydrite	12, 450–12, 460
Dolomite, like preceding sample, and some slightly sandy limestone; some red shale and anhydrite	12, 460–12, 470

Upper Jurassic(?) or Lower Cretaceous(?)—Continued

Fort Pierce Formation—Continued

	Depth (feet)
Dolomite, dark-gray shale, and anhydrite in about equal parts. Samples at 12,490–12,510 ft contain fragments of dark-brownish-red flaky sparsely sandy shale	12, 470–12, 510
Shale, red, and some dark-gray shale, 50 percent; 50 percent light-brown gray-streaked and spotted dolomite and some anhydrite	12, 510–12, 520
Shale, dark-red, and dark-gray, 50 percent; 50 percent tan, gray-spotted and streaked dolomite, some limestone and a small amount of dolomitic sandstone	12, 520–12, 530
Shale and dolomite, like preceding sample, and many fragments of light-red highly and very finely sandy limestone. Mostly fine-grained to very-fine-grained sand, but some is medium grained; a few grains of pink feldspar	12, 530–12, 570
Shale, dolomite, and sandy limestone, like preceding sample, with the addition of fragments of pink hard calcareous medium- to coarse-grained sandstone	12, 570–12, 620
Mainly cavings(?) of dolomite, limestone, dark-gray shale and anhydrite. Sample also contains fragments of dark-brownish-red sandy micaceous shale(?), irregularly streaked with light-blue-green calcareous undetermined material. In addition, sample contains fragments of sandstone, composed of fine to coarse poorly sorted quartz grains, fragments of feldspar, and undetermined materials	12, 620–12, 630
Mainly anhydrite, dull dark-red, highly sandy clay shale, light-gray-green highly sandy clay shale, and cavings of materials from higher depths. Sample also contains red and white mottled cryptocrystalline limestone containing inclusions of red clay; light-greenish-gray and reddish calcareous sandstone composed of poorly sorted quartz grains and fragments of feldspar	12, 630–12, 640
Similar, in general, to the preceding sample, with the addition of fragments of blue-green streaked sandy clay shale and gray-green shale	12, 640–12, 650
Similar to the preceding sample. Dull dark-red shale and red calcareous sandstone are common. Anhydrite less abundant than in preceding samples	12, 650–12, 660
Similar to the preceding sample with an increase in the amount of gray-green shale	12, 660–12, 670

Upper Jurassic(?) or Lower Cretaceous(?)—Continued

Fort Pierce Formation—Continued	Depth (feet)
Similar to the preceding sample. Red shale, red sandy shale, and gray-green clay shale are abundant; red medium-grained calcareous sandstone is common	12, 670–12, 680
Pre-Mesozoic rocks:	
Weathered residuum:	
Similar to the preceding sample, with the addition of many fragments of weathered(?) igneous rock	12, 680–12, 690
Similar to the preceding sample. Fragments of weathered(?) igneous rock abundant; red shale and sandstone common	12, 690–12, 700
Igneous rock, weathered(?), 50 percent of sample. Sample contains red shale, red sandy clay shale, red and white limestone, red sandstone, and cavings of materials from higher depths	12, 700–12, 710
Igneous rock, weathered, 75 percent of sample; materials described in preceding samples, 25 percent	12, 710–12, 725

DISTRIBUTION AND THICKNESS

The available data from the six wells that penetrated the Fort Pierce Formation (fig. 4) by no means define its subsurface areal extent, and, as already mentioned, the full thickness of the unit is known only in the Cowles Magazines well. Wells that stopped in the Fort Pierce Formation penetrated it to depths ranging from 175 to 1,115 feet. The depth below sea level at the top of the unit (fig. 4) ranges from 10,428 feet in the Cowles well to 14,317 feet in the Gulf Oil Corp. State of Florida Lease 373, 1 (55, fig. 4), on Big Pine Key, Monroe County.

LITHOLOGY

The lithology of the Fort Pierce Formation is known, chiefly, from wells that terminated in a sequence of carbonate rocks and evaporites. In the Amerada well in St. Lucie County (68a, fig. 4) which penetrated the entire sedimentary section, however, a 250-foot sequence of red fine- to coarse-grained arkosic sandstone, light-red calcareous sandstone, and interbedded red and varicolored shale underlies the carbonate rocks and rests unconformably on weathered residuum that in turn overlies the altered igneous rocks of the Coastal Plain floor. The graphic logs from samples (pl. 5) aid in the discussion of the stratigraphy of the Fort Pierce Formation insofar as it has been penetrated by wells in southern Florida.

The carbonate rocks of the Fort Pierce Formation, although superficially similar lithologically to the overlying Comanche carbonates, are, nevertheless, distinguishable on the basis of certain frequently recurring microscopic characteristics. Buff, gray, and olive-gray, medium-grained to subcrystalline limestone is the most abundant rock type in the older unit; dolomite and dolomitic limestone are next in abundance, and hard dark-gray shale is a lesser constituent. The logs from samples (pl. 5) show that variable amounts of anhydrite are interbedded with the carbonate rocks in the different wells. Of common occurrence are dark argillaceous calcilutites in which the average grain size is less than 2 microns. This dense fine-textured limestone (figs. 5, 6) frequently contains vaguely defined pellets of calcareous mud and some anhydrite in scattered blebs and irregular stringers. Minute evenly distributed dolomite rhombs and comminuted fossil shells often give the limestone a silty appearance (fig. 5), and crystals and crystalline aggregates of barite occur in a few random areas. Owing to the aphanitic texture and dark color of the limestone, its sparse fossil content is often vaguely defined, but some fossils and fossil debris can generally be identified (fig. 5). The bioclastic limestone, or micrococquina, frequently contains abundant oolites, in some of which various faunal elements serve as nuclei (fig. 9, a). Lenses of algal limestone, which are largely fabricated by the organisms themselves, occur at irregularly spaced levels. Varying degrees of secondary crystallization commonly characterize the limestone of the Fort Pierce Formation. Figure 9 is a photomicrograph of an oolitic limestone in which the matrix has been completely recrystallized. In other limestone only parts of the faunal elements have been recrystallized. Some shell fragments have been replaced by mixed intergrowths of barite and anhydrite combined with a little pyrite and a few dolomite rhombs; other fragments have been replaced by coarse transparent calcite. Some rhombic dolomite occurs in lenslike accumulations of variable thickness, but more commonly it occurs (fig. 7) as a partial replacement of the limestone in areas of irregular size and shape. Comparison of figures 6 and 7, which are photomicrographs of different parts of the same thin section, demonstrates the irregular distribution of the dolomite. The average size of the dolomite rhombs is useful in distinguishing the Fort Pierce Formation, because the average size of the rhombs generally exceeds that of the dolomite rhombs of the Comanche Series. The long diagonal of the dolomite rhombs in the Fort Pierce Formation ranges from 8 to 66 microns, the most frequently recurring values falling between 20 and 50 microns. In contrast, figure 8 shows a typical example of dolomite in the Comanche Series in which the long diagonal of the rhombs ranges from 2 to 25 microns and the mode between 6 and 10 microns.

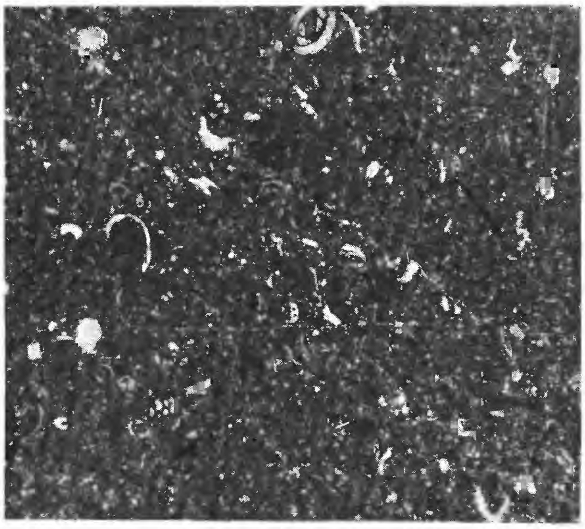

FIGURE 5.—Photomicrograph of a thin section of a dense sparsely fossiliferous limestone, Fort Pierce Formation. Gulf Oil Corp. State of Florida Lease 373, 1, Big Pine Key, Monroe County, Fla. Core, 15,439-15,449 feet. ×30.

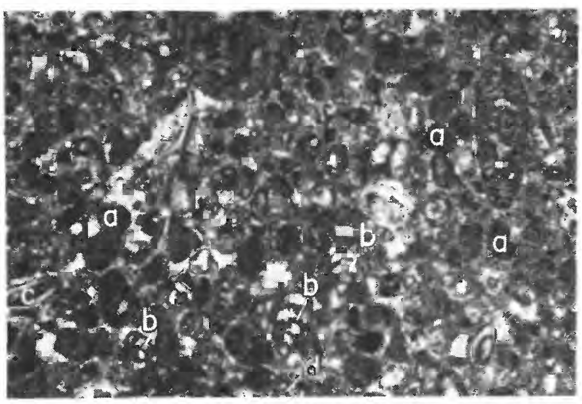

FIGURE 6.—Photomicrograph of a thin section of a finely fossiliferous pelleted limestone (a) from the Fort Pierce Formation. Sections of small verneuilinids (b), *Ophthalmidium* (c), and a small rotalid form (d).

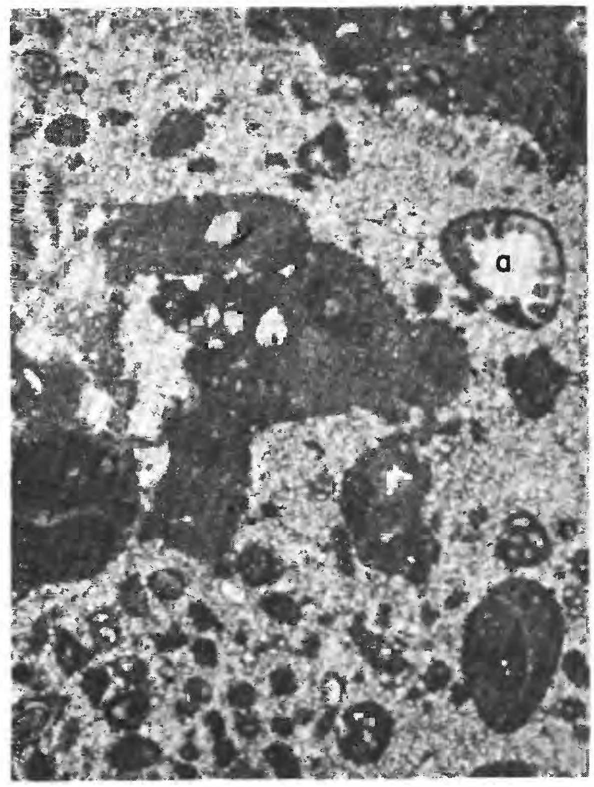

FIGURE 7.—Photomicrograph of thin section of a coarse-textured dolomite from the Fort Pierce Formation. Section of *Coscinoconus* cf. *C. alpinus*(?) is shown at a. Humble Oil & Refining Co. Tuscon Corp. 1, Palm Beach County, Fla. Core, 12,736-12,742 feet. ×30.

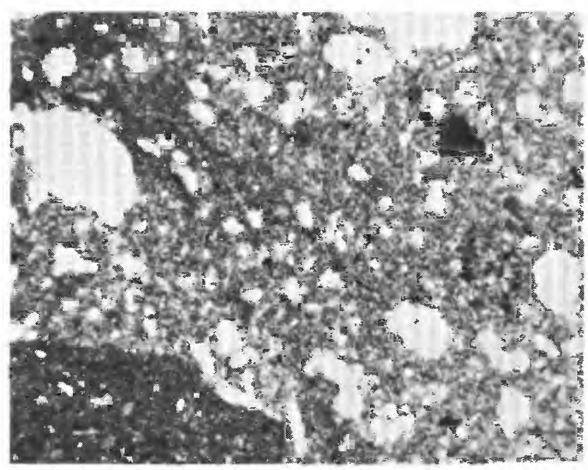

FIGURE 8.—Photomicrograph of thin section of typical dolomite of the Comanche Series. Dark area in lower left is remnant of the unaltered chalky limestone. Humble Oil & Refining Co. State of Florida 1, Dade County, Fla. Beds of Washita age. Core 7,922-7,932 feet. ×30.

A typical example of oolitic limestone, which is a conspicuous lithologic feature in the Fort Pierce Formation, is shown in figure 9. At our request, H. A. Tourtelot, U.S. Geological Survey, studied thin sections of a core of an oolitic limestone (fig. 10) taken from a depth of 13,043 feet in the Coastal Petroleum Co. Tiedtke and Schroeder 1 (38, pl. 5), Glades County. His report is here summarized.

The oolitic limestone consists of 60 percent oolites, 20 percent rock fragments, 19 percent cement, and 1 percent free Foraminifera and insoluble residue. The materials are chiefly calcite in several forms and contain minor amounts of dolomite and anhydrite. The oolites are composed of concentric layers of opaque and clear carbonate and probably did not form where they now are found. The shapes in thin section are principally oval but some are round. The dimensions of the oolites range from 1.0 by 0.8 mm for the largest to 0.5 by 0.3 mm for the smallest. The rock fragments are of two petrographic types. The most common type consists of pieces having the same size range as the oolites but lacking visible concentric layering; the second consists of oolites in a matrix of opaque fine-grained carbonate.

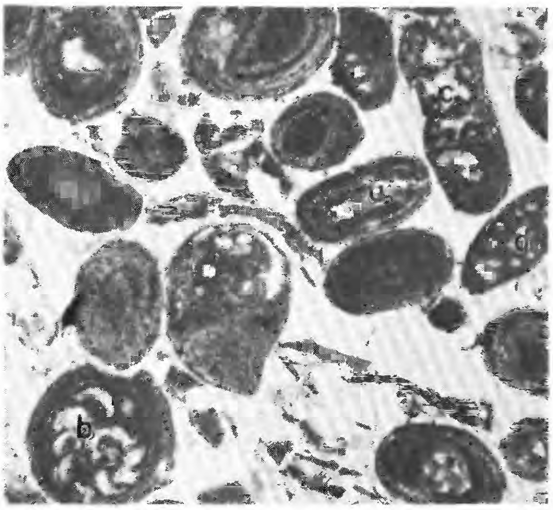

FIGURE 9.—Photomicrograph of thin section of oolitic limestone, Fort Pierce Formation, showing some faunal details and relation of fauna to oolites. Small letters refer to features discussed in text. Coastal Petroleum Co. John Tiedtke and William Schroeder 1, Glades County, Fla. Core, at 12,966 feet. ×30.

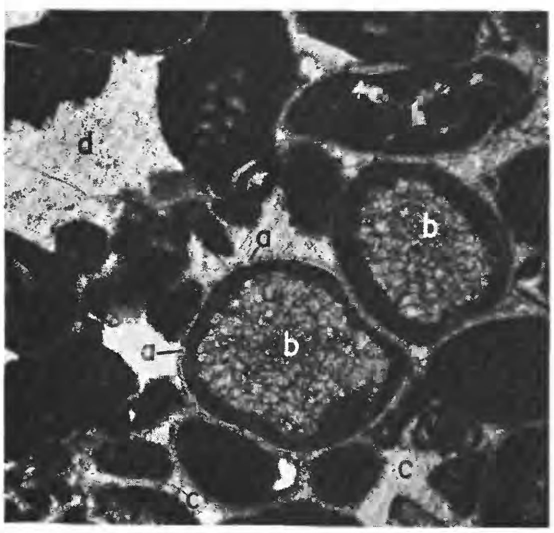

FIGURE 10.—Photomicrograph of thin section of oolitic limestone, Fort Pierce Formation, illustrating hypothetical stages in the lithification of the rock. Details given in text. Coastal Petroleum Co. John Tiedtke and William Schroeder 1, Glades County, Fla. Core, at 13,043 feet. × 40.

Several episodes of solution occurred and can be related to stages in the cementation of the rock. Interpenetration of rock fragments and free oolites is the earliest recognized solution activity, indicating that both had about the same hardness at the earliest stage of diagenesis that can be recognized. The borders of some fragments cut across the enclosed oolites as though parts of the oolites had been broken or worn off before the fragments were deposited in their present location. The rock fragments and oolites are intermixed in random fashion, suggesting that the two kinds of particles differed little in density or in other characteristics that would have led to sorting by the depositing medium. In addition, no evidence of plastic deformation of the rock fragments was seen. These considerations suggest that the rock fragments were derived from a preexisting rock and suggest that the breakup of this rock supplied the free oolites.

During most of its diagenesis, the oolitic limestone was a very porous material containing voids amounting to about 20 percent of the volume of the rock. Subsequent cementation of the limestone, which filled the voids, was accompanied by the deposition of two generations of calcite and one or possibly two closely associated kinds of anhydrite. The apparent porosity of the rock at present is less than 1 percent.

In a general way, the paragenesis is suggestive of mineralization caused by trapped connate sea water by which calcite was successively dissolved and deposited leaving a residue rich in sulfate. The earliest detectable evidence of solution indicates that the oolites and rock fragments were solid at the time of deposition. Successive solution episodes were probably a more or less continuous process. Some of the anhydrite, however, is clearly the latest mineral of the rock. The earliest solution, after deposition of the rock, would increase the carbonate content of the connate water until calcite was deposited as a void lining. The short prismatic crystals of calcite fringe the cavities, their long axes perpendicular to the wall of the void (fig. 10, a). During or after this deposition of the fringing calcite, conditions changed so that dolomite was deposited in favorable places, where dolomite has replaced the centers of some oolites (fig. 10, b). Continuation of solution, perhaps accompanied by change in pressure, resulted in the precipitation of sparry calcite (fig. 10, c) that filled the central part of the voids. This process would have left a solution enriched in sulfate, some of which may have been deposited contemporaneously with the calcite in the voids, or which may have replaced selectively the sparry calcite. The final residual sulfate was deposited as a replacement of all components of the rock (fig. 10, d). This hypothetical sequence of events, which would most likely occur shortly after burial of the sediments, is presented as a suggestion of the processes leading to the lithification of the oolitic limestone. Some or all of the anhydrite, of course, could have been deposited much later from migrant sulfate solutions derived from underlying or overlying anhydrite units.

FAUNA

The faunal assemblage that characterizes the Fort Pierce Formation is mainly new and undescribed. Of the few fossils that have been identified and of the few for which tentative determinations have been made, some are recorded only from the Cretaceous, and others are known only from the Jurassic. Because of the inconclusive data, we do not feel justified in restricting the unit to either the Jurassic or the Cretaceous, or in attempting to establish a boundary between the two systems. Consequently, in this paper, the formation is given the indefinite age assignment of Late Jurassic(?) or Early Cretaceous(?). In the wells that have penetrated the formation, the overlying rocks are Trinity (Comanche) age.

The carbonate and evaporite sequence of the Fort Pierce Formation is differentiated chiefly on the basis of its characteristic faunal assemblage. Foraminifera are dominant in the fauna, and algal specimens are probably second in abundance. Ostracodes, though present, are comparatively scarce and poorly preserved. Small fragments of pelecypods and some small specimens of gastropods are closely packed in some lenses in the limestone.

Forminiferal assemblages in the formation are more diversified than in the overlying rocks of the Comanche Series. The miliolid family, which is strongly dominant in the Comanche, is common although not dominant in the older unit (pl. 3, m), and several genera and species of the Valvulinidae are at least equally or more abundant. The Lituolidae are represented by many specimens of *Choffatella decipiens* Schlumberger (pl. 1, figs. 12–14), several species of *Pseudocyclammina* (fig. 9, b; pls. 3, b and 4, b) and several species of *Lituola* (fig. 9, c; pls. 3, c and 4, c). Sections of a lens-shaped foraminifer (fig. 9, d; pls. 3, d and 4, d), probably related to *Ovalveolina,* are a striking feature of the fauna. Small but highly varied specimens of uniserial possibly attached forms having chambers of somewhat irregular size and shape (pls. 3, e and 4, e) are common in limestone of this unit. One specimen is questionably identified as *Coscinoconus* cf. *C. alpinus* Leopold (fig. 7, a) and has not previously been recorded from this hemisphere.

The most distinctive and characteristic foraminifer is believed to be a primitive form of *Cuneolina.* Plate 3, a1–a7, which shows random sections of typical specimens cut at different depths and directions, demonstrates the succession of internal structural details, as well as the average size and configuration of the fossil.

Dr. Z. Reiss (1961, p. 231, nos. 1–2; p. 235, photomicrographs 1 and 2), Geological Survey of Israel, published photomicrographs of thin sections of samples of outcropping Lower Cretaceous limestone in Galilee containing a fossil that he called "*Praecuneolina.*" Upon seeing the photomicrographs of "*Praecuneolina,*" E. R. Applin considered this form to be the same as, or closely similar to, the *Cuneolina*-like form that is a characteristic feature of the microfaunal assemblage of the Fort Pierce Formation. At E. R. Applin's request, Dr. Reiss examined photomicrographs of the form from the Fort Pierce Formation, and in the interchange of correspondence the Florida fossil was informally referred to as "*Cuneokosk.*" Dr. Reiss had kindly authorized the publication of the following quotation from his letter dated May 10, 1962.

> As far as I can see from your photos, the "*Cuneokosk*" specimens are apparently congeneric with what I called "*Praecuneolina.*" The latter occurs in our Lower Cretaceous in rather well-dated strata from late Barremian to Vraconian. They are associated in the early Aptian with a (new) species of *Nautiloculina* and I believe I can recognize sections of this form on some of your photos.

Other interesting genera and species of Valvulinidae that occur in the microfaunal assemblage are a very minute form related to *Coskinolina*? (pl. 3, f), several species of partly triserial and partly biserial Foraminifera the chambers of which seem to rotate spirally about the elongate axis in early stages of their development (pl. 3, g), and a comparatively scarce *Cuneolina*? (pl. 3, h), which is possibly related to the *Cuneolina*-like key fossil. This form is distinguished from the key fossil by the much more delicate and more numerous chamberlets into which the subepidermal chamber wells are divided. Specimens of *Conuspira*? (pl. 3, i), several species of *Ophthalmidium* (pl. 3, j), and a few unidentified specimens of Foraminifera (pl. 3, x) all help to characterize this fauna. Near the top of the formation in some wells, there are lenses of limestone as shown in figure 6, in which small verneuilinid species (b), several species of *Ophthalmidium* (c), and a small rotalid form (d) are dominant faunal features.

The Sligo Formation of Early Cretaceous age in the subsurface in the western part of the Gulf Coastal Plain occupies the approximate stratigraphic position of the Fort Pierce Formation in Florida. Published data on the microfauna of the Sligo are lacking, but preliminary investigations by E. R. Applin in connection with the preparation of this report indicate some persistent similarities in the foraminiferal assemblages.

An abundant flora of dasyclad algae is a characteristic, though undescribed, feature of the limestones of the Fort Pierce Formation. Cuvillier (1956, pl. 16, fig. 2) showed a photomicrograph of a characteristic limestone from the Neocomian of western Aquitaine containing many fragments and sections of *Acicularia* similar to those that are common in Florida in limestone of the Fort Pierce Formation. E. R. Applin has observed abundant specimens of several genera of Dasycladacae in samples of Lower Cretaceous limestone from Mexico.

Other types of algal deposits are also common. At our request, Dr. J. H. Johnson (written communication, 1954) described three cores of algal limestone from the Coastal Petroleum Co. John Tiedtke and William Schroeder 1 (38, pl. 5), Glades County, Fla. These cores are typical examples of algal deposits in the Fort Pierce Formation.

Core 13,016 ft.—Oolites associated with dark algal patches and pellets. The algal material occurs as worn rounded fragments that are so badly recrystallized that there is considerable loss of structure. The rather vague remaining structure suggests a form of Jurassic age found at Shikoku, Japan, and described by Yabe as the *Pycnoporidium*.

Core 13,039 ft.—The rock is an algal limestone. It is suggested that it was formed by layers of sediment-binding algae that entrapped many shell fragments, small algal pellets, and miscellaneous fine debris. The materials are highly recrystallized.

Core 13,058 ft.—Limestone containing fragments of shells and coral. Some of the dark-gray pellets are algal, representing colonies of a low-lime-precipitating algae (probably green). They represent molds of a felt of fine algal threads that have been somewhat recrystallized. Similar material coats and fills some shell fragments. Pieces in specimen suggest *Nipponophycus* and *Pycnoporidium*.

As mentioned above, most of the macrofossil material is highly fragmental or immature, but a few moderately well preserved specimens obtained from cores have been generically identified.

Two fragmental specimens of macrofossils in a core of limestone at 11,891–11,910 feet in the Sinclair Oil Gas Co. H. R. Williams 1 (59, pl. 5), Monroe County, were identified by R. W. Imlay, U.S. Geological Survey (written communication, 1956), as "the rudist *Toucasia*, and an oyster-like pelecypod that probably belongs to the genus *Chondrodonta* Stanton." Imlay reported,

A similar appearing *Chondrodonta* occurs in the Glen Rose Limestone in southwest Texas (see Stanton, 1947, pl. 39, figs. 6, 8, 9, Prof. Paper 211). The rudist *Toucasia* ranges from the Barremian to Turonian in Europe. In Mexico it is common in massive limestones of Barremian to Lower Aptian age, but ranges as high as Cenomanian (Buda limestone). The specimens of *Toucasia* * * * do not belong to the species that occur in the Fredericksburg Group in Texas, but similar specimens are known from the Glen Rose Limestone in Texas and from the Cupido and Padilla Limestones in northern Mexico.

Several other fossil groups aid in distinguishing the the fauna of the Fort Pierce Formation.

Specimens of "stratigraphically diagnostic microfossils, originally described from the Upper Jurassic and Lower Cretaceous of central and southern Europe" were described by Bronnimann (1955) from Late Jurassic and Early Cretaceous deposits of Cuba. The Fort Pierce Formation also contains specimens representing several genera and possibly some species of these fossils that are sometimes referred to as "Problematica" (1955, p. 28) because their taxonomic affiliations are unknown or are highly questionable. Specimens of *Nannoconus* that "occur in prodigious numbers in the dense Lower Cretaceous limestones" (1955, p. 28) of Cuba have been recognized in thin sections of limestone from the Fort Pierce Formation. The genus *Lombardia*, which Bronnimann (1955, p. 43) described as "the most striking and abundant of the problematic microfossils in the middle and upper Portlandian of Cuba," is also present in the Fort Pierce Formation, and lenses of oolitic limestone often contain many specimens of a form that Bronnimann (1955, p. 39–40) described as the genus *Favreina*. Cuvillier (1956, pl. 4, fig. 2; pl. 15, fig. 1) questionably identified the same or closely similar forms from the Infra-Lias or Neocomian of western Aquitaine as "coprolites of Crustacea," and similar fossils from Upper Jurassic limestones in the Middle East were figured by Elliott (1956, pl. 1, fig. 6) as *Coprolithus salevensis* Parêjas. Plate 1, figure 6, illustrates the occurrence of *Favrenia* in an oolitic limestone in Florida.

In Florida, as in Cuba (Bronnimann, 1955, p. 28) and Mexico (Bonet, 1956, p. 418), *Nannoconus* is generally accompanied by specimens of another group of diminutive organisms, the calpionellids or fossil tintinnids. In a discussion of these fossils, Glaessner (1945, p. 12) stated, "* * * their wide geographic range and stratigraphic restriction to Upper Jurassic and Lower Cretaceous rocks give to these small organic remains a considerable value for stratigraphic work."

Sections of a stromatoporoid in a core at 14,630–14,639 feet in the Gulf Oil Corp. State of Florida Lease 373, 1, Monroe County, Fla. were identified by Curt Teichert, U.S. Geological Survey (written communication, 1957) as a species probably belonging "to *Shuqraia* Hudson, or a very closely related genus." Teichert pointed out that the species indicated a Late Jurassic age for the containing beds because the genus *Shuqraia* is known from rocks of that age in Japan, Arabia, Somaliland, and Portugal.

CRETACEOUS

COMANCHE SERIES

DISTRIBUTION AND THICKNESS

Comanche rocks, which underlie the area in central and south Florida that is discussed in this report, were penetrated in the wells that are listed in table 1 and shown in figure 11. Most of the wells in south Florida terminated at various levels in the Comanche rocks, but six (fig. 4) penetrated the underlying Fort Pierce Formation. Nearly all the wells in central Florida (fig. 11) penetrated the entire thickness of the Comanche

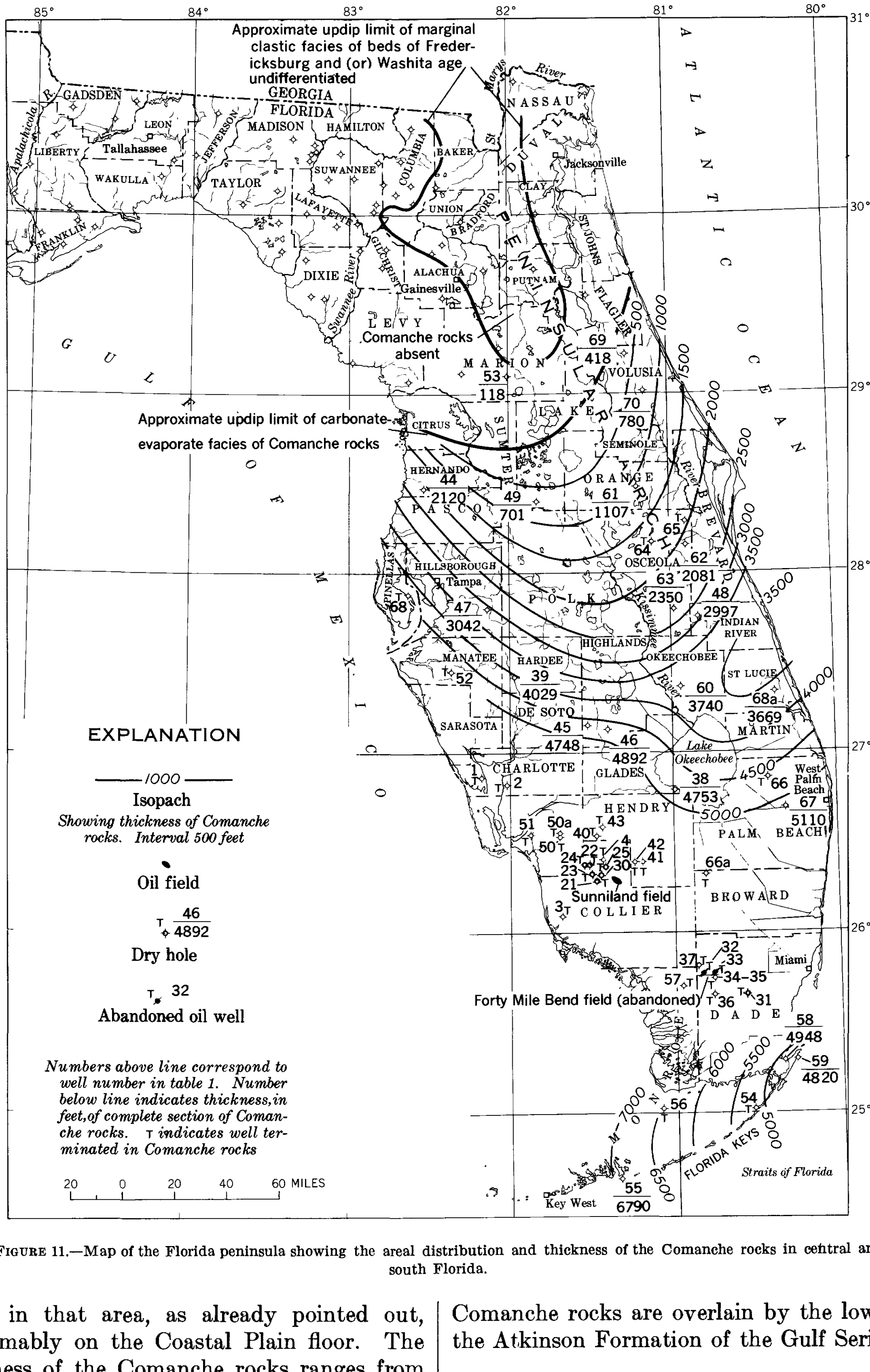

FIGURE 11.—Map of the Florida peninsula showing the areal distribution and thickness of the Comanche rocks in central and south Florida.

rocks, which in that area, as already pointed out, rest unconformably on the Coastal Plain floor. The known thickness of the Comanche rocks ranges from 0 (fig. 11, line *F–F′*) in the north part of the peninsula to nearly 7,000 feet in a well (55, fig. 11) near Key West. Throughout central and south Florida, the Comanche rocks are overlain by the lower member of the Atkinson Formation of the Gulf Series.

LITHOLOGY

General similarity in gross lithology is a striking feature of the interbedded carbonate rocks, evaporites, and few dark shales that make up the Comanche Series in south Florida. A few thick beds of anhydrite are traceable over much of the area, but for the most part, distinctive lithologic criteria are lacking as a reliable basis for the differentiation of stratigraphic units. The carbonate rocks of the Comanche Series and the Fort Pierce Formation, which are closely similar lithologically, are nearly 8,000 feet thick in the Gulf Oil Corp. State of Florida Lease 373, 1 (55, fig. 11), Monroe County. The well terminated in the Fort Pierce Formation.

The Comanche limestone is dark olive brown to cream and ranges from a hard subcrystalline to a relatively soft and chalky texture. It contains almost no terrestrial material and is composed of very fine grained calcium carbonate that is frequently irregularly mixed with fossil debris. Algae are generally the frame-building organisms of biostromal lenses that were cored in some wells. A pelleted appearance due to the irregular concentration of the calcium carbonate characterizes much of the limestone, and highly oolitic lenses are common at various levels. The beds of chalky limestone are generally dolomitized to varying degrees, and the hard limestone is often invaded by nests of large dolomite crystals. All the limestone seems to have been highly susceptible to recrystallization.

The dolomite is light to dark brown, very fine grained, generally calcitic, frequently highly porous, and in texture is sucrosic to microsucrosic. Vugs are often lined with light-tan coarse-grained rhombic dolomite.

Anhydrite occurs as blebs in some of the shale, limestone, and dolomite; as a replacement for all or part of the matrix in some coquinod limestone; and as pure to highly impure beds of varying thickness.

The shale is dark gray to black, moderately hard, thinly laminated, silky textured, and generally unfossiliferous.

STRATIGRAPHIC NOMENCLATURE

The carbonate rocks of the Comanche Series are separable into three major stratigraphic units, chiefly on the basis of distinctive microfaunal assemblages that occur in a uniform sequence in the different wells in the area. Certain microlithologic characteristics provide additional criteria for differentiating the units, and electrical logs are valuable aids in correlation. Species of Foraminifera that are diagnostic of the several faunal assemblages seem to be restricted in their upward range, but in the cutting samples from the widely scattered wells, determination of the highest occurrence of the fossils may be fortuitous, and their presence is in some places obscured by dolomitization of the limestone. Consequently, in this paper, provisional boundaries of the stratigraphic units are arbitrarily determined on the basis of lithologic and electric-log characteristics that are traceable from well to well, and which occur at, or slightly above, the highest level of the diagnostic fossils. Paleontological investigations show that the sequence of microfossil assemblages in the Comanche units in Florida closely resembles the sequence in the standard outcropping and subsurface stratigraphic sections of the rocks of the Comanche Series of Texas. Consequently, the diagnostic Foraminifera that aid in distinguishing the Trinity, Fredericksburg, and Washita Groups in Texas provide a basis for the correlation of the approximately synchronous units in Florida. However, neither the identity of the unit boundaries nor the continuity of the units from Texas on the west to Florida on the east have been definitely established, and the nomenclature of the major subdivisions has been applied in a correlative sense to the Comanche units in Florida. This usage has become established through published articles (Southeastern Geol. Society, 1949; Applin, 1951a; 1951b; 1952; Jordan, 1952; 1954; Gunter and others, 1953), and we have avoided creating many names for local usage.

The designation of the Comanche units in Florida as, respectively, beds of Trinity, Fredericksburg, and Washita age denotes only their approximate synchroneity with the Texas units. We have made no attempt to differentiate local stratigraphic units in the beds of Fredericksburg and Washita age, but several local units are recognized in the beds of Trinity age.

A new local name, Punta Gorda Anhydrite, is given to an important lithologic unit that occurs in the beds of Trinity age and that is well known to geologists engaged in subsurface investigations in south Florida. Directly overlying the Punta Gorda Anhydrite in most wells, a unit commonly called the Sunniland Limestone contains the oil-productive zone in the Sunniland field, Collier County, and in the Forty Mile Bend field, Dade County. The name Sunniland Limestone was formally defined by Applin (1960, p. B209). More complete explanations of the names Punta Gorda Anhydrite and Sunniland Limestone are presented in connection with the description of these units.

In order to clarify the discussion of the stratigraphy of the Trinity, we informally designate as beds of early Trinity age the Punta Gorda Anhydrite and older Trinity beds; the Trinity beds younger than the Punta Gorda Anhydrite are herein called the beds of late Trinity age.

FACIES

Regional submergence of the Florida peninsula apparently began early in the Mesozoic Era, and the discussion of the Fort Pierce Formation shows that submergence was definitely in progress in Late

Jurassic(?) or earliest Cretaceous(?) time. From then to the close of Comanche time, encroachment of the sea upon the peninsula was interrupted by only relatively minor fluctuations of the strand line.

The sediments of the Comanche Series were deposited, in general, in a transgressing sea (fig. 12) whose margin encroached northward during Trinity, Fredericksburg, and Washita time; this action was accompained by progressive subsidence of the Coastal Plain floor. The farthest known advance of the Comanche sea is shown roughly by line *F–F′* in figure 12.

As already pointed out, the Comanche Series and the Fort Pierce Formation in south Florida are predominantly a carbonate evaporite facies. Significant facies changes, however, mark the advance of the sea over the Coastal Plain floor in the central part of the peninsula. By a series of onlaps, the Fort Pierce Formation and the units of Trinity, Fredericksburg, and Washita age transgress northward from south Florida and wedge out along the Peninsular arch. In central Florida, the carbonate-evaporite facies of each unit thins progressively northward and grades into lithologically diverse deposits, here termed a "mixed facies," that are, mainly, argillaceous and arenaceous limestone and dolomite, neritic clastic rocks, and some evaporites. The mixed facies, in turn, grades shoreward into an unfossiliferous marginal clastic or red-bed facies composed of irregularly interlensing mudstone, siltstone, poorly sorted fine- to coarse-grained sandstone, and red, green, and varicolored shale.

In each well in central Florida, the marginal clastic facies is at the base of the Comanche rocks and rests unconformably on the Coastal Plain floor. Inasmuch as this facies was deposited along the margin of an advancing sea, it follows that it is of different ages at different places. Although the marginal facies is a unit of more or less uniform lithology, we do not consider it a time unit, but rather than its geologic age ranges from Late Jurassic(?) or Early Cretaceous(?) to Washita.

Because the sediments composing the marginal clastic facies of the Comanche rocks were deposited on the erosional surface of the Coastal Plain floor, variations in the thickness of the clastic rocks are here interpreted as indications of buried topographic features, some of which may be erosional, and some of which may be related to pre-Comanche structures. Variations in thickness of the clastic rocks in the peninsula are shown in figure 13. The isopachs show three roughly parallel areas of thinning that extend across the peninsula from northeast to southwest, separated by areas in which the clastic rocks attain relatively greater thicknesses. Although a definitive explanation of the features shown by the isopachs does not seem feasible on the basis of the available subsurface data, the coincidence of some features on the isopach map (fig. 13) and on the map of the Coastal Plain floor (fig. 3) may be pointed out. On the map of the Coastal Plain floor, the boundary separating the early Paleozoic strata on the northwest and the rhyolite, tuff, and agglomerate on the southeast has been interpreted by some geologists (Applin, 1951a, p. 17, fig. 5; Bridge and Berdan, 1951, p. 3; Vernon, 1951, p. 48, fig. 11) as a fault having its downthrown side on the northwest. The trace of the "fault" in the pre-Coastal Plain rocks (fig. 3) coincides roughly with the area of thick clastic sedimentary deposits (fig. 13) that are between the northern and middle areas of thinning. Subsurface mapping of the Comanche rocks suggests that the southernmost area of thinning is, likewise, an effect of concealed structure in the pre-Coastal Plain rocks.

CROSS SECTIONS

Figure 14 shows the location of the stratigraphic and structure subsurface cross sections to which references are made in this report. A set of three cross sections (pl. 6) through some of the wells in figure 14 typify the stratigraphy of the Comanche rocks, showing graphically the lithology, paleontology, and correlation of the different units. The lithologic logs and paleontological data are based on E. R. Applin's microscopic studies of the cores and cuttings from the different wells; the curves of the electrical characteristics of the rocks are based on commercial electric logs.

BEDS OF TRINITY AGE

Beds of Trinity age underlie all of south Florida and much of the central part of the peninsula. Plate 7 shows the location of the oil test wells that penetrated the unit and the approximate updip limit of the carbonate-evaporite facies (line *A–A′*), the mixed facies (line *B–B′*), and the marginal clastic facies (line *C–C′*). Line *C–C′* is, consequently, the approximate inner margin of the beds of Trinity age on the Peninsular arch. Most of the wells in south Florida terminated at various levels in the carbonate-evaporite facies of Trinity age, but as already described, six wells (fig. 4) were drilled through the beds of Trinity age and penetrated the underlying Fort Pierce Formation. In the central part of the peninsula, all except two of the wells that entered the bed of Trinity age were drilled through the unit and terminated in the rocks of the Coastal Plain floor. These two wells (52, 68, pl. 7) terminated in the marginal clastic facies of beds of early Trinity age.

In general, the beds of Trinity age thicken southward (pl. 7) from 0 at their updip limit to about 2,600 feet in several wells in the vicinity of Lake Okeechobee.

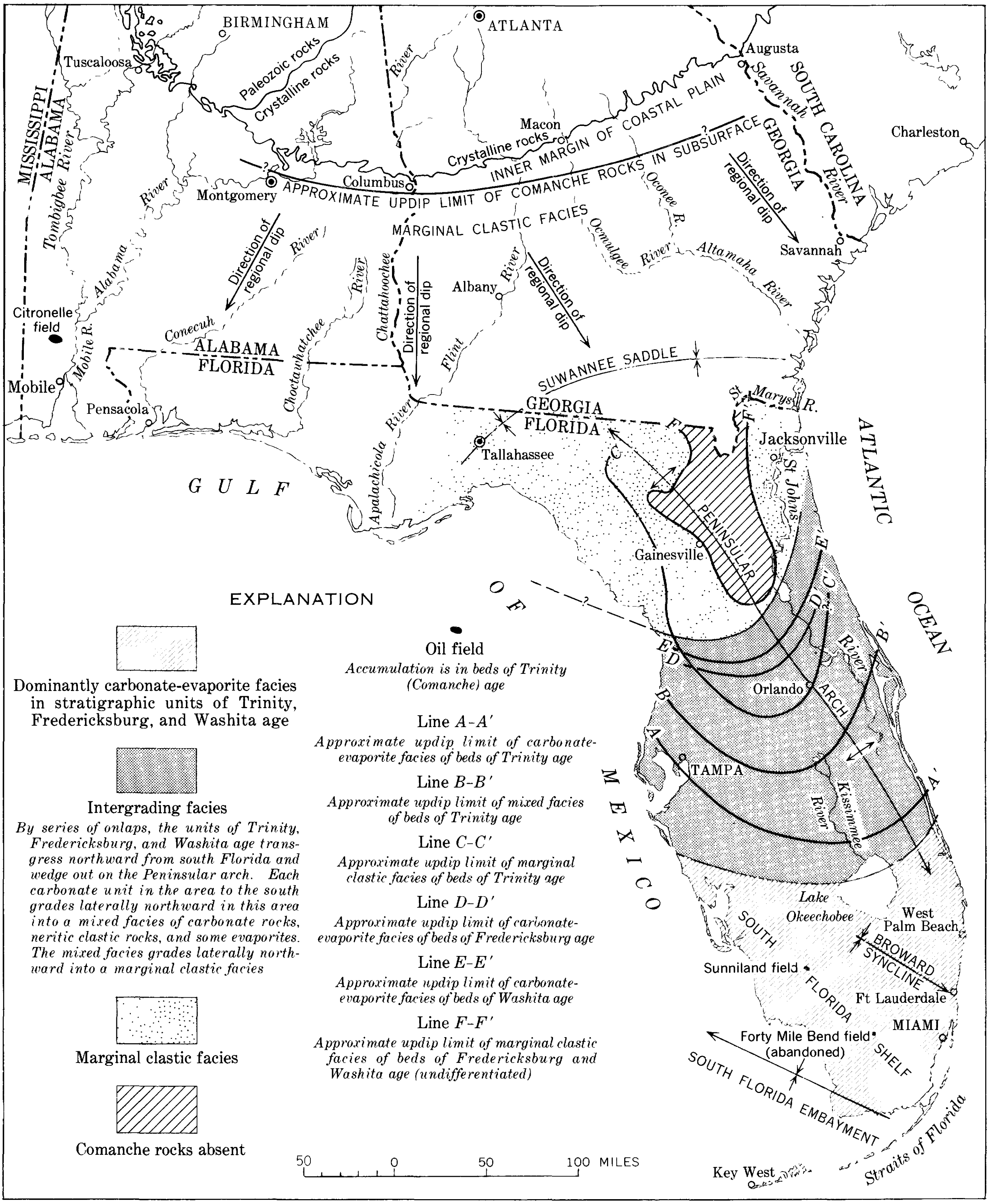

FIGURE 12.—Map of southeastern United States showing the geologic setting of the Comanche rocks.

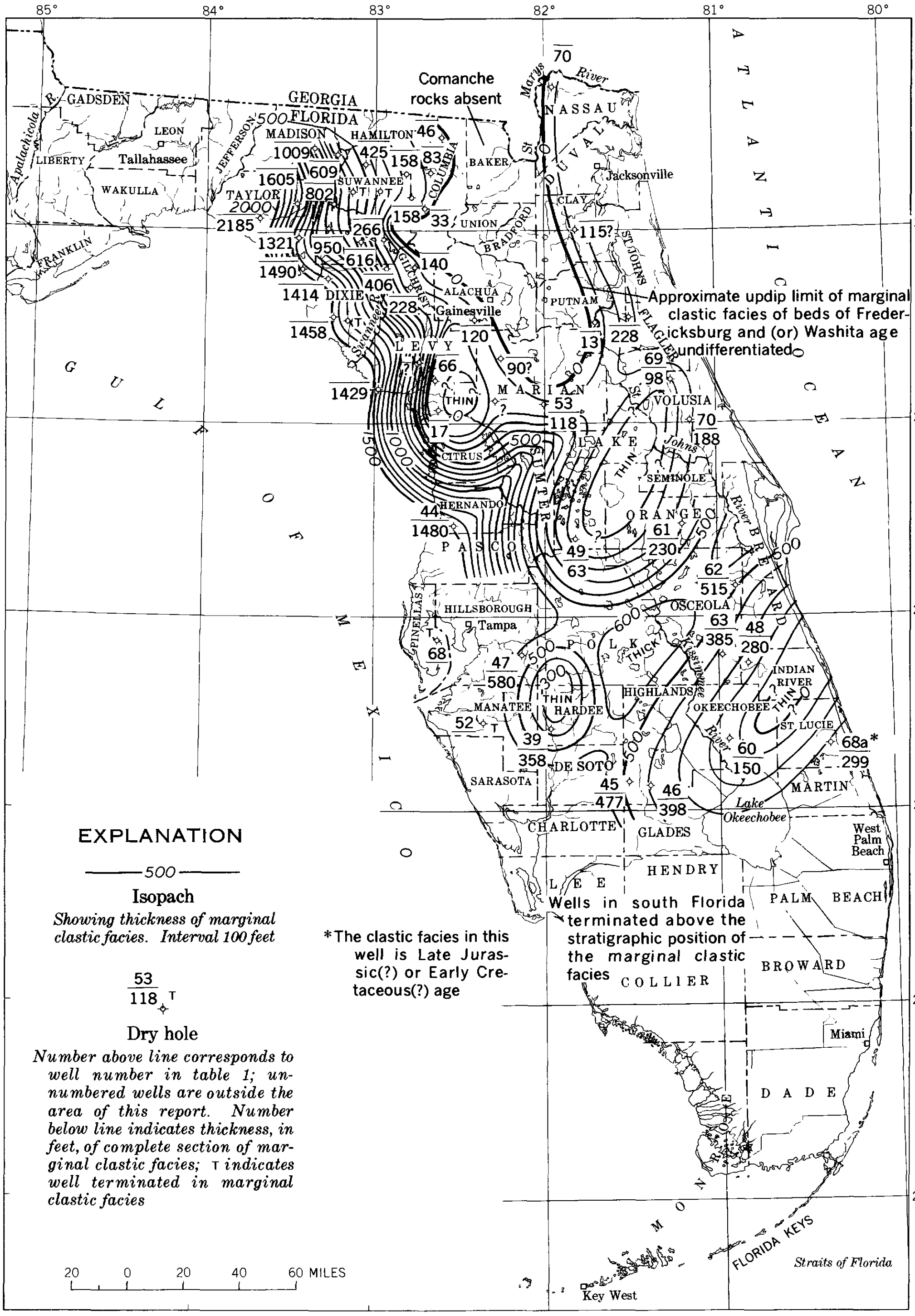

FIGURE 13.—Map of the Florida peninsula showing the thickness of the marginal clastic facies of the Comanche rocks.

Near the southeastern end of the axis of the Peninsular arch, however, the southward thickening of the beds of Trinity age is interrupted locally in the Amerada Petroleum Corp. Cowles Magazines 2 (68a, pl. 7), St. Lucie County. Along the Florida Keys, the thickness ranges from 2,200 feet in wells south of Miami (58, 59, pl. 7), to nearly 3,000 feet in a well near Key West (55, pl. 7).

The microfauna of the marine beds of Trinity age in Florida is characterized by several genera of larger Foraminifera—*Orbitolina*, *Dictyoconus*, *Choffatella*, and *Pseudocyclammina*. Published reports relating to the

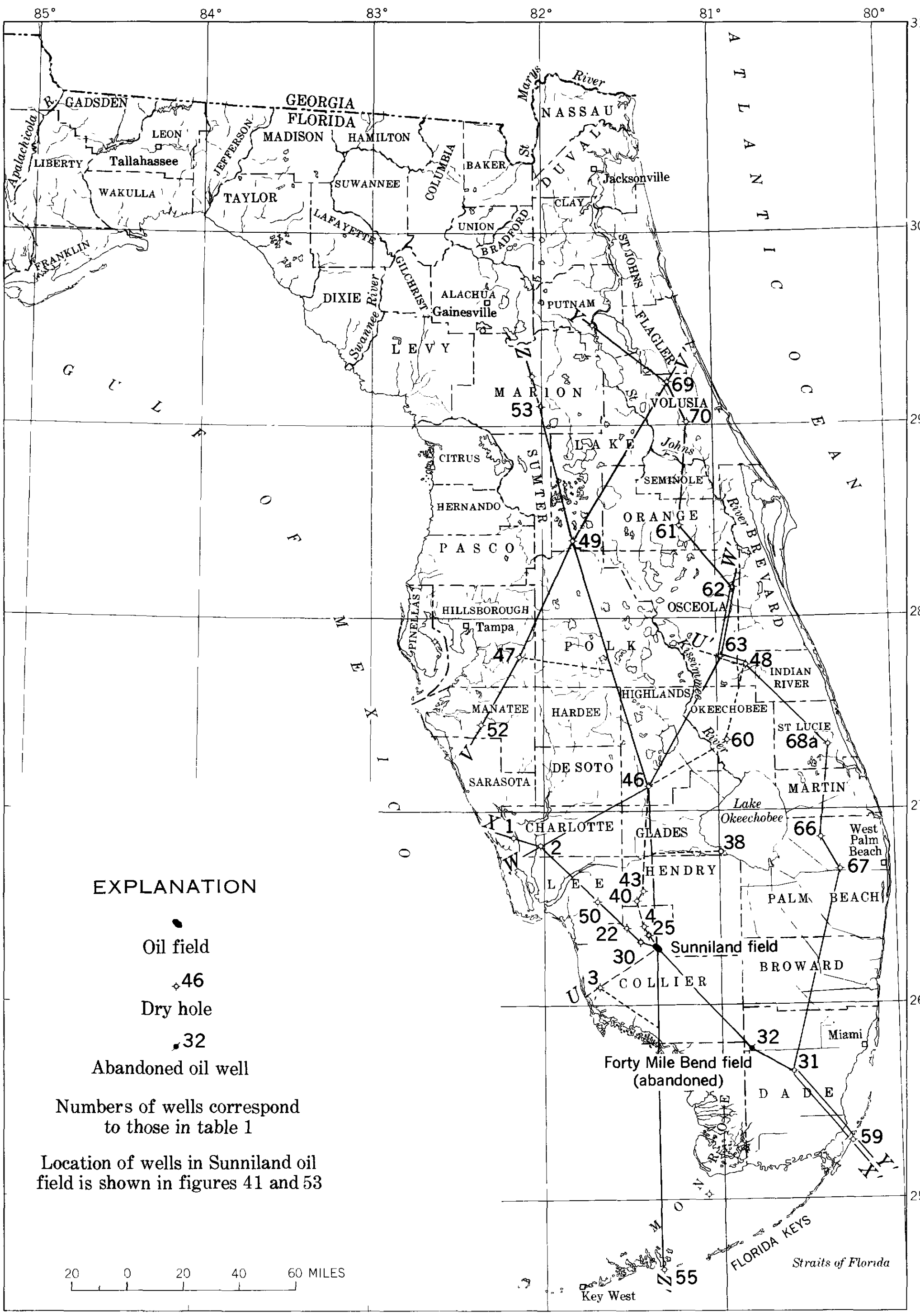

Figure 14.—Map of the Florida peninsula showing the location of cross sections.

occurrence of the genus *Orbitolina* in North America restrict its highest authenticated vertical range to beds of Trinity age. Douglass (1960a, p. 6) stated "*Orbitolina* can be found in most exposures of the Glen Rose Limestone [Trinity Group] from North-central Texas to southeastern Arizona." Douglass described 10 species of *Orbitolina* but found only 2 of them, *Orbitolina texana* (Roemer) and *Orbitolina minuta* Douglass, in the Comanche rocks in Florida. On the basis of these species, he subdivided the Glen Rose Limestone of Texas and stated (p. 6) "*Orbitolina texana* is never found in the upper part of Glen Rose," and (p. 7)

Orbitolina minuta, "in general, occurs in the upper part of the Glen Rose, from the '*Saleina* Zone' up." He also wrote (p. 7), "To the east the recognition of the upper and lower parts of the Glen Rose seems to be possible at least as far as Florida, where *Orbitolina texana* occurs below the Big Anhydrite (of local usage) [Punta Gorda Anhydrite of this paper], and *Orbitolina minuta* is found in the younger beds." In the present paper no attempt has been made to correlate the Glen Rose Limestone of Texas with a definite part of the beds of Trinity age in Florida, but a general relation is indicated by the occurrence of these two species of *Orbitolina*. The position of *O. texana* and *O. minuta* in beds of Trinity age in Florida will be discussed later in this paper in connection with the descriptions of the faunal characteristics of the different units.

Distribution and thickness of beds of early Trinity age

Plate 7 shows the locations of the wells in central and south Florida that penetrated beds that are classified in this report as of early Trinity age, although the available subsurface data do not substantiate beyond question the early Trinity age of the marginal clastic rocks in several far updip wells. Consequently, the inner margin of the unit is not clearly defined. As interpreted by us, however, the marginal clastic rocks whose updip limit is indicated on plate 7 by the line *C–C′*, are, in part at least, early Trinity in age. Two updip wells on the east flank of the Peninsular arch, the Warren Petroleum Co. George Terry 1 (61, pl. 7), Orange County, and the Sun Oil Co. Powell Land Co. 1 (70, pl. 7), Volusia County, penetrated marginal clastic rocks that, on the basis of correlation with wells farther downdip, are provisionally classified as beds of early Trinity age. The clastic rocks in the Terry and Powell Land Co. wells rest unconformably on the rocks of the Coastal Plain floor, and possibly underlie unconformably(?) the mixed facies of the beds of Fredericksburg age. On the southwest flank of the Peninsular arch, The Ohio Oil Co., Hernasco Corp. 1 (44, pl. 7), Hernando County, penetrated the marginal clastic facies of the Comanche rocks from 6,240 to 7,720 feet. These clastic rocks in the Hernasco well rest on early Paleozoic sedimentary rocks at 7,720 feet (Applin, 1951a, p. 23; Bridge and Berdan, 1951, p. 5, 6) and underlie carbonate rocks of Fredericksburg age at 6,240 feet. The clastic rocks from 6,565 to 7,720 feet (table 1) are provisionally classified as Trinity in age. The rocks in the Hernasco well that are classified as Trinity in age are not subdivided in this report, but we suggest that both early and late Trinity beds may be present.

At the updip limit, the beds of early Trinity age wedge out against the rocks of the Coastal Plain floor, and southward, the unit thickens to at least 2,200 feet. Most wells in south Florida were not drilled sufficiently deep to penetrate the full thickness of the beds of Trinity age, but on the Florida Keys, beds of early Trinity age range in thickness from about 1,400 feet in two wells (58, 59, pl. 7) south of Miami, to more than 2,000 feet in a well (55, pl. 7) near Key West.

Lithology of lower part of beds of early Trinity age

The lower part of the beds of early Trinity age in south Florida is mainly a carbonate-evaporite facies which, in the manner previously described (p. 32), grades laterally northward in central Florida into a mixed facies, that, in turn, changes into a marginal clastic facies. The marginal clastic rocks rest unconformably on the Coastal Plain floor. In south Florida, the early Trinity carbonate-evaporite sequence overlies the Fort Pierce Formation without a marked break in sedimentation, although an anhydrite at the base of the beds of Trinity age in several wells (38, 55, 67, pl. 5) indicates an interlude in carbonate deposition. In two other wells (58, 59, pl. 5) the sequence at the contact is continuous limestone.

Beds of limestone are more common than beds of dolomite in the lower part of the early Trinity, and like the limestone in the Fort Pierce Formation it is often recrystallized to a marked degree. Nests of large dolomite crystals are frequently developed in some of the dense limestone lenses. Bioclastic and algal limestone, which was mentioned as common features of the lithology of the Fort Pierce Formation, occur also at many different levels in the carbonate rocks of the early Trinity. Although both the lower part of the early Trinity and the Fort Pierce Formation are composed of carbonate rocks and evaporites of generally similar lithology, they are nevertheless separable on the basis of minor differences in the appearance of the rocks. The beds of limestone in the early Trinity are generally lighter colored, coarser grained, less indurated, and less argillaceous than those in the Fort Pierce Formation; the beds of dolomite, as a rule, are more finely crystalline and more uniform in texture. Dolomite in the beds of early Trinity age generally occurs in lenses of variable thickness, but in the Fort Pierce Formation it frequently replaces limestone in areas of irregular size and distribution. Beds of oolitic limestone are a common characteristic of both units. The oolites in the early Trinity limestone, although well sorted in individual lenses, show, on the whole, a wider range of variation in size than the oolites in the underlying rocks.

Typical examples of the variations in the oolitic limestone in beds of early Trinity age are shown in figures 15, 16. In these figures, radial structure of the oolites is generally emphasized, although in some lenses the oolites show only vestiges of concentric structure and little or no radial structure. The arrangement of the oolites varies from closely packed and well sorted (fig. 15) to irregularly distributed and poorly sorted (fig. 16). Some of oolites are distorted and are apparently mashed together or strongly compressed. Pseudo-oolitic limestone is also common (fig. 17). This limestone is composed mainly of rounded pellets that do not have, or have lost, the characteristic peripheral structure.

A set of consecutive cores from the Sinclair Oil & Gas Co. H. R. Williams 1 (59, pls. 6, 7) on Key Largo, Monroe County, discloses many lenses of dark-gray shale in the carbonate-evaporite sequence of the early Trinity unit. Lithologically similar dark shale is common at the equivalent stratigraphic level in several other wells on the south Florida shelf.

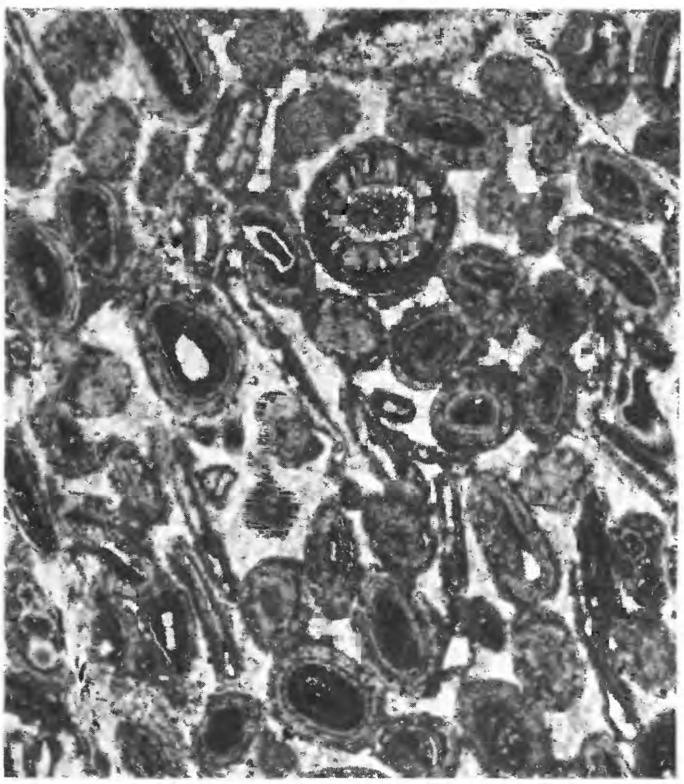

FIGURE 15.—Photomicrograph of a thin section of oolitic limestone of early Trinity age cut normal to the bedding plane. The secondarily crystallized matrix encroaches on the outer rims of some of the oolites. Humble Oil & Refining Co. G. C. Carlton Estate 1, Highlands County, Fla. Core, 11,288–11,292 feet. ×30.

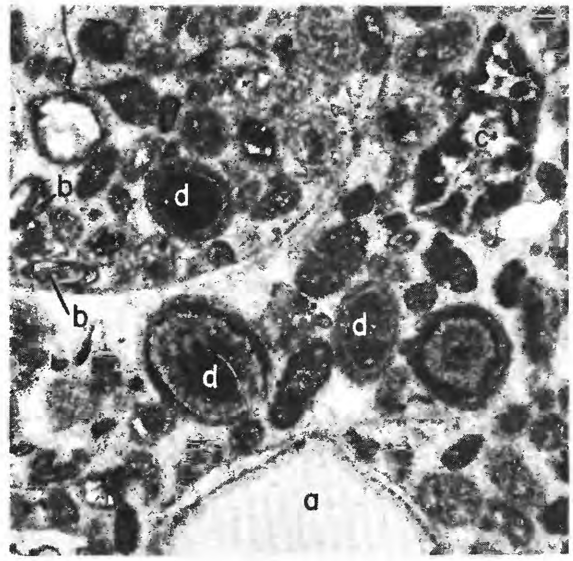

FIGURE 16.—Photomicrograph of a thin section of bioclastic and oolitic limestone of early Trinity age, containing shell fragments (a), Foraminifera (b), algae (c), and oolites (d) in a wide range of sizes. Considerable recrystallization indicated by blurred outlines of many oolites but oolites not recrystallized. Humble Oil & Refining Co. Lowndes Treadwell 1A, Charlotte County, Fla. Core, 13,097–13,102 feet. ×30.

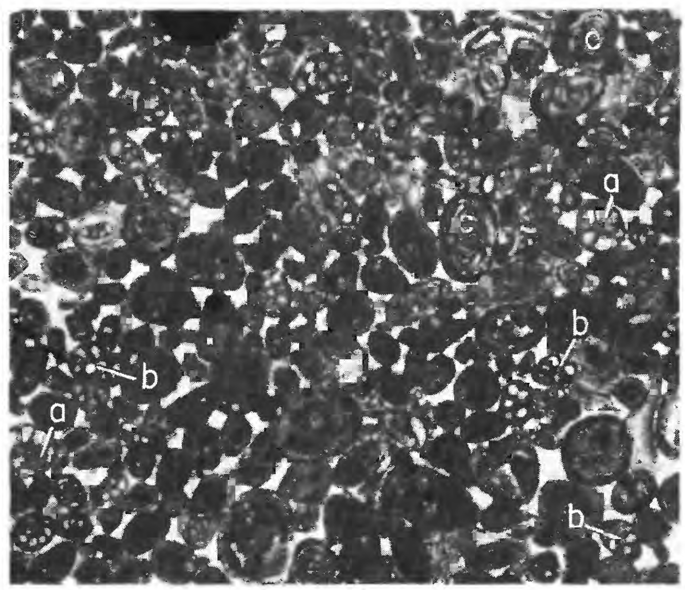

FIGURE 17.—Photomicrograph of a thin section of pseudo-oolitic limestone of early Trinity age composed of about 50 percent Foraminifera and 50 percent mud pellets. Letters refer to faunal details given on page 43. Humble Oil and Refining Co. Gulf Coast Realties Corp. 2, Sunniland field, Collier County, Fla. Core, 13,504–13,508 feet. ×30.

Petrographic studies of thin sections indicate that some beds of limestone contain a small amount of terrigenous material. The photomicrograph in figure 18, was made from a part of a thin section cut from a core of limestone in the Humble Oil & Refining Co. G. C. Carlton Estate 1 (46, pl. 7), Highlands County. A petrographic analysis shows that this limestone contains a minor amount of quartz in fine sand and silt sizes, a minor amount of pyrite, carbonaceous material, and a trace of glauconite. Turbulent, possibly very shallow water depositional conditions are suggested by such features as the phenoclast of a dark oolitic limestone at a in figure 18, the comminuted fossil debris, and the fluidal arrangement of this debris. Figure 19, is a photomicrograph of a thin section cut from a core from the Humble Oil & Refining Co. Tucson Corp. 1 (67, pl. 7), Palm Beach County. The rock is an extremely

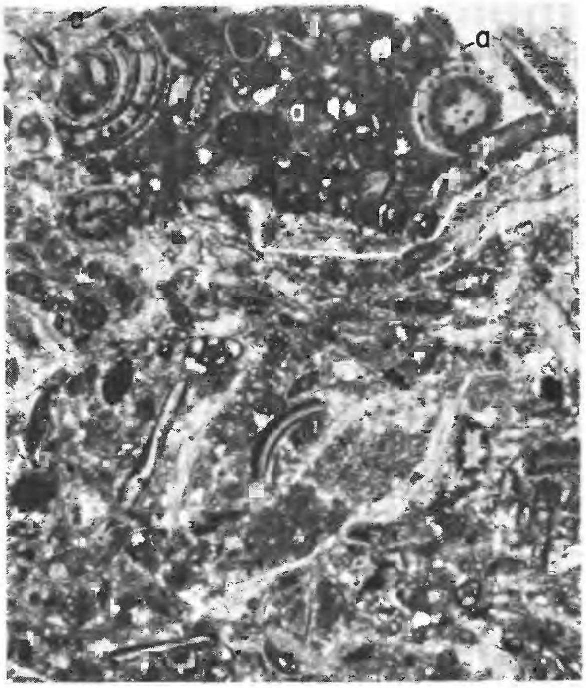

FIGURE 18.—Photomicrograph of a thin section of a limestone of early Trinity age demonstrating turbulent depositional conditions. Note phenoclast (a) near top of figure. Humble Oil & Refining Co. G. C. Carlton Estate 1, Highlands County, Fla. Core, 11,210-11,215 feet. × 30.

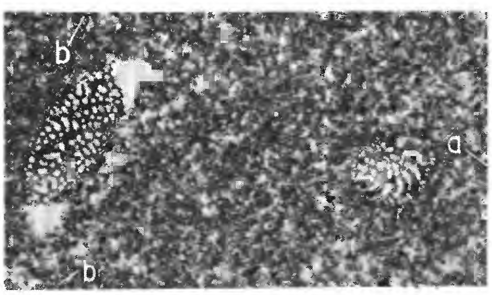

FIGURE 19.—Photomicrograph of a thin section of chalky-textured limestone of early Trinity age showing fragments of sections of *Choffatella* (a) and ***Anchispirocyclina henbesti*** Applin and Jordan (b). Humble Oil & Refining Co. Tucson Corp. 1, Palm Beach County, Fla. Core, 11,317-11,321 feet. × 30.

fine grained laminated limestone containing closely spaced carbonaceous partings, scattered minute pyrite, and a small amount of quartz and feldspar about 20 microns in size.

A typical example of the mixed facies of the lower part of the beds of early Trinity age is shown by the set of cores and cuttings from the Humble Oil & Refining Co. T. S. Jameson 1 (47, pl. 7), Hillsborough County. The sequence of alternate carbonate rocks, shallow-water marine clastic rocks, and some red sandy shale composing the mixed facies in the Jameson well is shown on the log from samples on plate 6 and by E. R. Applin's description of the samples that follows.

Mixed facies of the lower part of the beds of early Trinity age in the Humble Oil & Refining Co. T. S. Jameson 1, sec. 7, T. 31 S., R. 22 E., Hillsborough County, Fla. (47, pls. 6 and 7).

	Depth (feet)
Comanche Series:	
Lower part of beds of early Trinity age:	
Cuttings. Shale, gray, dark-blue-green, and light-reddish-brown; a few siderite nodules	9, 048–9, 078
Cuttings. Shale, like above but somewhat dolomitic	9, 078–9, 138
No samples	9, 138–9, 168
Core. Dolomite, gray, impure, sucrosic; containing many small carbonaceous fragments and a few blebs of anhydrite	9, 168–9, 178
Cuttings. Dolomite, light-gray, finely granular, carbonaceous; contains gray shale streaks and blebs of anhydrite	9, 178–9, 230
Core. Shale, moderately hard, dark-greenish-gray; containing carbonaceous fragments	9, 230–9, 234
Core. Dolomite, sucrosic; containing blebs of anhydrite	9, 234–9, 242
Cuttings. Dolomite, light-brown, gray-spotted, finely granular, and gray to greenish-gray shale	9, 242–9, 292
Core. Shale, grayish-green; containing fragments of fossil bivalves and blebs of pink anhydrite	9, 292–9, 294
No samples	9, 294–9, 318
Cuttings. Shale, bluish-green and reddish-brown, silty	9, 318–9, 345
Core. Shale, dark-brownish-gray, thinly laminated, pyritic	9, 345–9, 355
Core. Shale, dark-greenish-gray; containing fragments of fossil bivalves	9, 355–9, 375
Core. Limestone, dark-gray, agrillaceous; contains fragments of fossil bivalves, fragments and specimens of *Choffatella decipiens*, and fragments of other microfossils	9, 375–9, 385
No samples	9, 385–9, 395
Core. Shale, dark-gray, finely sandy to silty, dolomitic, slightly glauconitic. Core. Sandstone, light-gray, fine-grained, dolomitic, slightly glauconitic	9, 395–9, 405
Core. Shale, gray, calcareous, sandy, and somewhat glauconitic; contains many fragments of fossil bivalves. Core. Limestone, dark-greenish-gray, hard marly, sandy; containing fragments of fossil bivalves	9, 405–9, 415
No samples	9, 415–9, 430
Cuttings. Top of marginal clastic facies	9, 430

The beds of Trinity age in the Ohio Oil Co. Hernasco Corp. 1 (44, pl. 7), Hernando County, are a marginal clastic facies that is considered as undifferentiated in this report. They unconformably overlie early Paleozoic sedimentary rocks (Applin, 1951a, p. 23; Bridge and Berdan, 1951, p. 5, 6) at 7,720 feet, and their top is provisionally placed at 6,565 feet.

In two other updip wells, the Warren Petroleum Co. George Terry 1 (61, pls. 7, 9), Orange County, and the Sun Oil Co. Powell Land Co. 1 (70, pls. 7, 9), Volusia County, the age of the marginal clastic rocks is not clearly indicated. On the basis of the relative thicknesses of the Comanche units in these wells and in other wells farther downdip, however, the marginal clastic rocks in the Terry well and the Powell Land Co. well are provisionally classified as the shoreward facies of the lower part of the beds of early Trinity age.

Punta Gorda Anhydrite

Punta Gorda Anhydrite is the name here introduced for an important lithologic unit that has been penetrated in the beds of Trinity age in many wells in central and south Florida. The unit is composed chiefly of anhydrite and contains lesser amounts of irregularly interbedded limestone, dolomite, and dark shale. Bedded salt, which occurs in several scattered wells, is a relatively minor constituent. Geologists engaged in subsurface investigations in connection with the exploration for oil and gas have informally referred to the unit as the "thick anhydrite," "thick anhydrite section" (Southeastern Geological Society, 1949, cross section *A–A'*), and the "lower massive anhydrite." In our classification (fig. 2), the Punta Gorda Anhydrite is the upper part of the beds of early Trinity age.

The name Punta Gorda Anhydrite was selected for the unit in 1954 by Dr. Louise Jordan, Mr. A. C. Raasch, Jr., and Miss E. T. Caldwell. At their request the name was reserved by the Geologic Names Committee, U.S. Geological Survey. Because the name was not proposed in a published article, Dr. Jordan suggested (written communication, 1957) that we adopt the name and introduce it in this report. The Humble Oil & Refining Co. Lowndes Treadwell 1A (sec. 17, T. 42 S., R. 23 E.), Charlotte County, Fla., was designated by Jordan, Raasch, and Caldwell (written communication, Jordan, 1957) as the type locality. The unit was named for the city of Punta Gorda, about 6 miles north of the Treadwell well. The well, which was unproductive, was completed December 29, 1945, at a depth of 13,304 feet. Samples from the well are indexed as No. W–979 (Gunter, 1949, p. 22) in the files of the Florida Geological Survey at Tallahassee.

The Treadwell well was the first one in which the anhydrite section was penetrated by continuous cores. Descriptions of the cores of the type section of the Punta Gorda Anhydrite from 11,690 to 12,157 feet were made available for this report by the Humble Oil & Refining Co. The core descriptions, in connection with the electric log and the log from samples (2, pl. 6), show clearly the lithology of the unit and its upper and lower boundaries.

Type section of the Punta Gorda Anhydrite in the Humble Oil & Refining Co. Lowndes Treadwell 1 A, sec. 17, T. 42 S., R. 23 E., Charlotte County, Fla. (2, pl. 6)

Comanche Series:
Punta Gorda Anhydrite:

Core		*Depth (feet)*
24	Recovered 6 in.:	
	Anhydrite	11, 690–11, 700
25	No recovery	11, 700–11, 710
26	No recovery	11, 710–11, 714
27	Recovered 2 ft:	
	Anhydrite	11, 714–11, 719
28	Recovered 5 ft:	
	3½ ft, anhydrite.	
	1½ ft, anhydrite with thin lenses of dark-gray dense shale	11, 719–11, 724
29	Recovered 4 ft:	
	Anhydrite with thin lenses of dark-gray dense shale	11, 724–11, 734
30	Recovered 10 ft:	
	Anhydrite	11, 734–11, 744
31	Recovered 3½ ft:	
	½ ft, anhydrite with lenses of gray, dense, dolomitic limestone.	
	½ ft, dolomite, brownish-gray, crystalline, granular.	
	1½ ft, dolomite, gray, dense, granular, and dolomitic limestone with anhydrite and pebbles.	
	1 ft, anhydrite	11, 744–11, 754
	Authors' note. A thin bed of salt at about 11,750 ft is suggested by comparison of the electrical log of the Treadwell well with the logs of other wells in south Florida in which salt was recovered in cores. According to information from the Humble Oil & Refining Co., the Baroid log of the Treadwell well shows an increase in salinity from 18,500 to 26,000 ppm at 11,776–11,790 ft. Lag in return of drilling fluid may not be accounted for on the Baroid log.	
32	Recovered 4½ ft:	
	Anhydrite	11, 754–11, 759
33	Recovered 5 ft:	
	Anhydrite	11, 759–11, 764
34	Recovered 10 ft:	
	Anhydrite with lenses of gray dolomite in middle 2 ft	11, 764–11, 774
35	Recovered 8 ft:	
	Anhydrite	11, 774–11, 784
36	Recovered 10 ft:	
	Anhydrite	11, 784–11, 794
37	Recovered 4½ ft:	
	Anhydrite with thin streaks of dark-gray dolomitic limestone	11, 794–11, 799
38	Recovered 9 ft:	
	Anhydrite with thin streaks of gray dense dolomite	11, 799–11, 808

Comanche Series—Continued
Punta Gorda Anhydrite—Continued

Core		Depth (feet)
39	Recovered 10 ft:	
	Anhydrite	11,808–11,818
40	Recovered 10 ft:	
	3 in, anhydrite.	
	2 ft, dolomite, gray, dense.	
	7 ft 9 in, anhydrite	11,818–11,828
41	Recovered 10 ft:	
	4 in., dolomite, gray, dense.	
	9 ft 8 in., anhydrite, with a few scattered laminations of gray dolomitic limestone	11,828–11,838
42	Recovered 10 ft:	
	4 ft, anhydrite.	
	3 ft, anhydrite, impure, with lenses of dolomitic limestone.	
	3 ft, shale, gray, dense, calcareous	11,838–11,848
43	Recovered 4½ ft:	
	1½ ft, limestone, gray, dense, shaly, with 2-in. streak of anhydrite and limestone at bottom; trace of carbonaceous material.	
	1½ ft, shale, gray, soft, calcareous.	
	1½ ft, limestone, gray, dense, shaly, with 1-in. streak of anhydrite pebbles; trace of carbonaceous material	11,848–11,858
44	Recovered 7 ft:	
	1½ ft, dolomite, gray, crystalline, with flakes of anhydrite.	
	½ ft, limestone, gray, dense.	
	5 ft, limestone, gray, dense, with some dolomitic limestone and 9 in. gray dense limestone with anhydrite pebbles at top	11,858–11,868
45	Recovered 8 ft:	
	7 ft 9 in, limestone and dolomitic limestone, dark-gray, dense.	
	3 in, anhydrite with lenses of dolomitic limestone	11,868–11,878
46	Recovered 4 ft:	
	Anhydrite with scattered lenses of dolomitic limestone	11,878–11,882
47	Recovered 5 ft:	
	3 ft, anhydrite with scattered lenses of gray dolomitic limestone.	
	2 ft, limestone, gray, dense, dolomitic; trace of carbonaceous material	11,882–11,887
48	Recovered 1½ ft:	
	Limestone, gray, dense, dolomitic, and crystalline dolomite	11,887–11,889
49	Recovered 3½ ft:	
	½ ft, dolomite, brownish-gray, dense, crystalline.	
	2 ft, limestone, dolomitic, hard, gray, dense; trace of carbonaceous material in fractures, and anhydrite pebbles in bottom.	
	1 ft, anhydrite with streaks of brown, granular crystalline dolomite	11,889–11,897

Comanche Series—Continued
Punta Gorda Anhydrite—Continued

Core		Depth (feet)
50	Recovered 3 ft:	
	½ ft, limestone, dolomitic, brown, granular, dense, crystalline, with crystals of brown dolomite.	
	2½ ft, limestone, dolomitic, gray, dense, granular; a fracture shows slight stain and cut of dark-brown heavy oil	11,897–11,904
51	Recovered 10 ft:	
	4 in, limestone, dolomitic, hard, gray dense.	
	9 ft 8 in, anhydrite	11,904–11,914
52	Recovered 8 ft:	
	3 ft, anhydrite with scattered lenses of dense, brownish-gray dolomite.	
	1 ft, limestone, dolomitic, dark-gray, dense; with pebbles of anhydrite.	
	½ ft, limestone, dolomitic, dark-gray, dense, oolitic, crystalline.	
	1 ft 3 in, limestone, dolomitic, dark-gray, dense.	
	3 in, shale, dark-gray, dense.	
	2 ft, anhydrite	11,914–11,924
53	Recovered 9 ft:	
	7½ ft, anhydrite with a few lenses of dense, brownish-gray dolomite.	
	2½ ft, anhydrite with a few lenses of gray and brownish-gray dolomitic limestone	11,924–11,933
54	Recovered 9 ft:	
	8 ft, anhydrite with lenses of dense, gray, dolomitic limestone.	
	1 ft, limestone, dolomitic, gray, dense	11,933–11,943
55	Recovered 10 ft:	
	4 ft, limestone, slightly oolitic, gray, dense, miliolid, with some dolomitic limestone.	
	3 ft, shale, gray, dense, calcareous.	
	3 ft, limestone, gray, dense, and some dolomitic limestone	11,943–11,953
56	Recovered 10 ft:	
	5 ft, anhydrite with scattered lenses of gray limestone.	
	3 in, limestone, dolomitic, gray, dense.	
	4 ft 9 in, anhydrite with scattered laminations of dark-gray limestone	11,953–11,963
57	Recovered 10 ft:	
	Anhydrite	11,963–11,973
58	Recovered 10 ft:	
	Anhydrite with a few thin laminations of dark-gray dolomite	11,973–11,983
59	Recovered 10 ft:	
	Anhydrite with lenses of brownish-gray crystalline dolomite, black shale, and gray dense dolomite	11,983–11,993

Comanche Series—Continued
Punta Gorda Anhydrite—Continued

Core		Depth (feet)
60	Recovered 7½ ft:	
	6 ft, anhydrite with lenses of gray dense dolomite.	
	1 ft, limestone, dolomitic, brownish-gray, dense, crystalline.	
	½ ft, dolomite, gray, dense	11, 993–12, 003
61	Recovered 6 ft:	
	Anhydrite with thin laminations of black shale and gray dense dolomite	12, 003–12, 013
62	Recovered 10 ft:	
	Anhydrite with thin laminations of brown and gray dolomite	12, 013–12, 023
63	Recovered 8 ft:	
	Anhydrite	12, 023–12, 031
64	Recovered 10 ft:	
	Anhydrite	12, 031–12, 041
65	Recovered 9 ft:	
	Anhydrite with lenses of gray dolomite	12, 041–12, 051
66	Recovered 7 ft:	
	Anhydrite	12, 051–12, 058
67	Recovered 9 ft:	
	Anhydrite	12, 058–12, 068
68	Recovered 9 ft:	
	4 ft, anhydrite.	
	½ ft, dolomite, gray, dense, with pebbles of anhydrite.	
	2 ft, shale, dark-gray and black, calcareous.	
	1 ft, limestone, gray, dense, dolomitic.	
	2 ft 3 in. limestone, dolomitic, gray, dense.	
	3 in. anhydrite with lenses of gray dense dolomite	12, 068–12, 078
69	Recovered 10 ft:	
	Anhydrite with thin lenses of greenish-gray calcareous shale and light-gray dolomite	12, 078–12, 088
70	Recovered 10 ft:	
	Anhydrite with lenses of dark-gray dolomitic limestone and calcareous shale	12, 088–12, 098
71	Recovered 8½ ft:	
	Anhydrite with lenses of dark-gray dolomitic limestone and calcareous shale	12, 098–12, 108
72	Recovered 10 ft:	
	Anhydrite like above with less limestone and shale	12, 108–12, 118
73	Recovered 10 ft:	
	2½ ft, anhydrite with lenses of gray dolomite.	
	½ ft, dolomite, dense, brownish-gray.	
	7 ft, anhydrite with lenses of gray dolomite	12, 118–12, 128
74	Recovered 10 ft:	
	Anhydrite with lenses of gray dolomite	12, 128–12, 138

Comanche Series—Continued
Punta Gorda Anhydrite—Continued

Core		Depth (feet)
75	Recovered 4 ft:	
	1 ft, anhydrite with lenses of greenish-gray shale.	
	3 ft, anhydrite	12, 138–12, 142
76	Recovered 8 ft:	
	Anhydrite with a few lenses of gray dense dolomitic limestone	12, 142–12, 150
77	Recovered 10 ft:	
	7 ft, anhydrite with many lenses of brownish-gray dense dolomite.	
	1 ft, dolomite, brownish-gray, dense, with pebbles of anhydrite.	
	2 ft, dolomite, brownish-gray, dense	12, 150–12, 160

The Punta Gorda Anhydrite is a wedgelike unit in the upper part of the beds of early Trinity age that has been penetrated in most of the deep oil test wells in Florida (pl. 7) along the southwest flank of the Peninsular arch and on the south Florida shelf. Few wells in the Sunniland oil field, however, penetrated the Punta Gorda Anhydrite, because drilling generally stopped after testing the productive zone of the overlying Sunniland Limestone. Although the available subsurface data do not show clearly the nature of the inner margin of the unit, the Punta Gorda Anyhdrite seems to grade laterally into a mixed facies and to wedge out approximately along a line that extends southeastward across the peninsula from about midway on the west coast to the vicinity of Palm Beach on the east coast (pl. 7). Data from additional deep tests are needed to definitely establish the limits of the anhydrite along the southeast coast of Florida from Lake Okeechobee to Miami. From the updip limit of the Punta Gorda, the anhydrite thickens south and southwestward, the known thickness ranging from about 200 feet in the Humble Oil & Refining Co. Jameson 1 (47, pl. 7) Hillsborough County, to 630 feet in Humble's Gulf Coast Realties Corp. 2, in the Sunniland field (fig. 14; pl. 7), Collier County, and nearly 800 feet in the Sinclair Oil & Gas Co. H. R. Williams 1 (59, pl. 7), on Key Largo, Monroe County. In the Gulf Oil Corp. State of Florida Lease 373, 1 (55, pl. 7), on Big Pine Key, Monroe County, the beds of early Trinity age are 2,100 feet thick and are composed chiefly of anhydrite. Consequently, we have not differentiated the lower part of the beds of early Trinity age and the Punta Gorda Anhydrite in this well.

The thick beds of anhydrite that characterize the lithology of the Punta Gorda are irregularly interspersed with relatively thin beds of hard dense limestone, dolomite, and dark shale. Bedded salt, which is not known to exceed 30 feet in thickness, was penetrated, or was probably penetrated, in 12 wells (table 2 and pl. 7). Many of the wells in south Florida were not drilled

TABLE 2.—*Occurrence of bedded salt in wells in south Florida*

Well number on pls. and figs.	County	Name and location of well	Total depth of well (feet)	Elevation of well (feet)	Depth to top of Punta Gorda Anhydrite (feet)	Method of determination of salt	Depth to salt (feet)	Remarks
1	Charlotte	Gulf Oil Corp. W. H. and A. G. Vanderbilt 1, sec. 35, T. 41 S., R. 21 E.	12,722	22	11,505	Electric log	11,650–11,670 (approx)	
2	do	Humble Oil & Refining Co. Lowndes Treadwell 1A, sec. 17, T. 42 S., R. 23 E.	13,304	20	11,690	do	11,745–11,760 (approx)	See description of type section of Punta Gorda Anhydrite (p. 39).
3	Collier	Humble Oil & Refining Co. Collier Corp. 1, sec. 27, T. 50 S., R. 26 E.	12,600	25	12,428	Cores	12,452?	Reported in salt at total depth.
6	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. 2, sec. 30, T. 48 S., R. 30 E.	13,512	34	11,875	do	11,978–12,032	Core 11,974–11,980. Dolomite, top 8 in. Anhydrite, middle 4 ft. Rock salt, bottom 1 ft. 4 in. Core 11,980–11,990. Rock salt. Core 11,990–12,009. Anhydrite. Core 12,009–12,019. Dolomite and anhydrite. Core 12,019–12,029. Anhydrite. Core 12,029–12,032. Anhydrite, top 1 ft 8 in. Rock salt, bottom 1 ft 4 in.
21	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. "B" 1, sec. 23, T. 48 S., R. 28 E.	12,220	32	11,970	Electric log	12,100–12,120 (approx)	
22	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. "C" 1, sec. 21, T. 47 S., R. 28 E.	12,120	37	11,940	Cores	12,058?–12,085	Core 12,058? Salt, white. Core 12,063–12,070. Salt and thin stringer of anhydrite. Core 12,070–12,075. Rock salt. Core 12,075–12,080. Rock salt and lense of anhydrite. Core 12,080–12,085. Rock salt and anhydrite thickly shot with salt. Core 12,085–12,120. Chiefly anhydrite containing blebs of salt.
24	do	Humble Oil & Refining Co. Gulf Coast Realties Corp. "E" 1, sec. 19, T. 47 S., R. 28 E.	12,210	31	11,950	Electric log	12,090–12,115 (approx)	
31	Dade	Coastal Petroleum Co. State of Florida Lease 340-A 1, sec. 25, T. 55 S., R. 37 E.	11,520	33	11,010	do	11,230–11,250 (approx)	
50	Lee	Gulf Oil Corp. Consolidated Naval Stores 1, sec. 27, T. 45 S., R. 26 E.	12,865	45	11,774	do	11,890–11,920 (approx)	
51	do	Humble Oil & Refining Co. W. E. Kirchoff 1, sec. 23, T. 45 S., R. 24 E.	12,877	24	11,860	do	11,975–12,000 (approx)	
55	Monroe	Gulf Oil Corp. State of Florida Lease 373 1, sec. 2, T. 67 S., R. 29 E.	15,455	23	12,240	do	12,525–12,550 (approx)	On Big Pine Key. Deepest test in Florida.
56	do	Gulf Oil Corp. State of Florida Lease 826-G, 1, unsurveyed area in Florida Bay at lat 25° 0′ 53″ N; long 81° 5′ 54″ W.	12,631	21	11,912	Core descriptions provided by Gulf Oil Corp. as published on electrical log of well.	12,150–12,167 12,517–12,527 12,625–12,626	17 ft. White coarsely crystalline salt with scattered brown limestone stylolites. 10 ft. Clear to milky-white crystalline salt. 1 ft. Clear crystalline salt.

sufficiently deep to penetrate the stratigraphic position of the salt. Although the updip limit of the occurrence of salt is shown, provisionally, on plate 7, the available data from the widely scattered wells provide no definite information about its lateral continuity.

A set of continuous cores that penetrated the Punta Gorda Anhydrite in the Coastal Petroleum Co. Tiedtke and Schroeder 1 (38, pl. 7) Glades County, shows that between the depths of 11,201 and 11,360 feet a nearly solid mass of anhydrite is cut by a few very thin lenses of shale and dolomite. Photographs of typical core segments from the Tiedtke well (figs. 20–22) illustrate the character of the dolomite and shale lenses in the anhydrite section.

At 11,216 feet in the Tiedtke well (fig. 20), the anhydrite is cut by a horizontal band or lens of dense fine-grained dolomite about half an inch thick. The upper contact of the dolomite and the anhydrite is even and clear cut, but the lower contact is relatively irregular. Just above and below the thin dolomite lens the individual components in a mass of irregularly rounded and sutured fragments of anhydrite range in their longest dimension from less than an inch to 2 or 3 inches. The linear arrangement of the blebs parallel to the transverse axis of the core suggests rude stratification, and the elongation of the individual fragments along the lines of stratification suggests compaction of the sediments. Dolomite and a small amount of dark-gray shale fill the interfragmental spaces. The rounded outlines of the anhydrite blebs and the absence of angular fractures imply that the formation of the fragmental pattern was prior to lithification of the sediments.

The basal part of the Punta Gorda Anhydrite in the Tiedtke well, from 11,360 to 11,390 feet, is composed chiefly of anhydrite interbedded with relatively thin lenses of grayish-tan dolomite containing blebs and inclusions of anhydrite. A core at 11,378 feet (figs.

21, 22) indicates that the dolomite was formed nearly contemporaneously with the deposition of the carbonate sediments and also that the sediments were compacted and distorted prior to complete lithification. Laminae of very fine grained argillaceous dolomite bend around irregular undulations on the surface of the subjacent anhydrite layer; paper-thin partings of dark-gray shale and alternate dark and light bands in the dolomite emphasize small ptygmatic folds. At 11,390 feet, the base of the Punta Gorda Anhydrite in the Tiedtke well, the anhydrite is in sharp contact with a bed of dark-gray shale which, in turn, overlies dolomite and limestone in the lower part of beds of early Trinity age.

FIGURE 20.—Thin lens of dolomite (dark material) and infiltration of dolomite between segments of the anhydrite, Punta Gorda Anhydrite. Coastal Petroleum Co. John Tiedtke and William Schroeder 1, Glades County, Fla. Core, at 11,216 feet. (No enlargement.)

Fauna of the beds of early Trinity age

The microfauna of the beds of early Trinity age seems to be uniform in its general character, but in some respects the fauna of this unit, like the lithology, is more closely related to the Fort Pierce Formation than to younger parts of the Trinity. This is not surprising because the indicated environmental conditions are similar, and because we have not observed a sharp break in sedimentation between the Fort Pierce Formation and the beds of early Trinity age. Differences in many of the components of the faunal groups give each of these units a distinctive faunal aspect.

Miliolids are common to abundant in the bioclastic limestone in the lower part of the unit of early Trinity age (fig. 24), but several other genera of small Foraminifera occur with nearly equal frequency as shown in figure 17, where specimens of a small trochoid rotalid form (fig. 17, a), a small *Verneuilina* sp. (fig. 17, b), and several species of Ophthalmididae (fig. 17,c) are common. We have already mentioned the occurrence of

FIGURE 21.—Photograph of drill core showing distribution of dolomite (dark material), suggesting compression and distortion of the sediments prior to complete lithification. (Punta Gorda Anhydrite.) Coastal Petroleum Co. John Tiedtke and William Schroeder 1, Glades County, Fla. Core, at 11,378 feet.

FIGURE 22.—Opposite side of core shown in figure 21.

calpionellids or fossil tintinnids in the Fort Pierce Formation. Specimens of organisms that we questionably identify as calpionellids also occur in dense and often sparsely fossiliferous limestone of Trinity age. Figure 23 shows a thin section of a limestone containing an abundance of comminuted fossil material, some algal filaments (a), and scattered specimens of *Calpionella*? (b). Although *Choffatella decipiens* Schlumberger (pl. 1, figs. 12–14; and fig. 26) is very common in some fossiliferous limestones of the Fort Pierce Formation, it may also be considered one of the characteristic fossils of the lower part of the early Trinity beds where it is frequently accompanied by many specimens of *Orbitolina texana* (Roemer) (fig. 25) and some specimens of *Pseudocyclammina hedbergi* Maync. Maync (1949, p. 535) discussed the vertical range of *Choffatella decipiens* and stated "the genus *Choffatella* with its type species * * * came into existence at the very beginning of the Lower Cretaceous * * * and the genus evidently becomes extinct near the dawn of the Upper Cretaceous. *Choffatella decipiens* Schl. thus ranges from the earliest Cretaceous up to somewhere in the Albian." In Florida, *Choffatella decipiens* is not known to occur above the lower part of the beds of early Trinity age. Specimens of *Lituola* cf. *L. subgoodlandensis* are also generally present in microfaunal assemblages of the early Trinity beds.

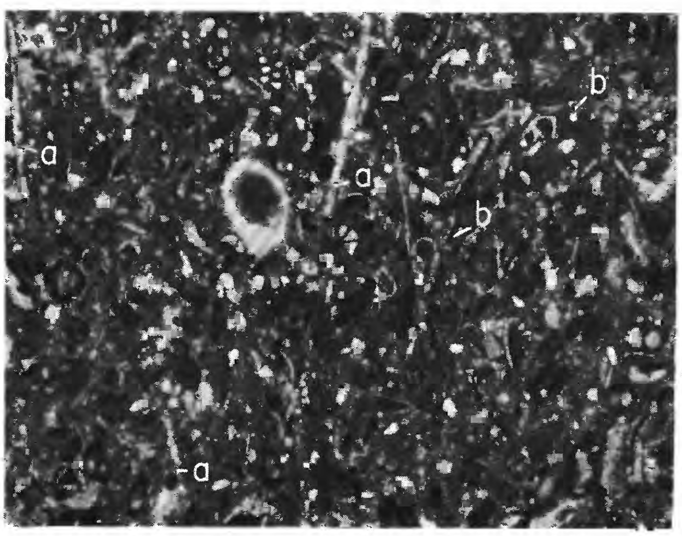

FIGURE 23.—Photomicrograph of a thin section of limestone of early Trinity age composed mainly of very finely fragmental microfossil debris. Contains algal filaments (a), and Calpionella? (b). Humble Oil & Refining Co. G. C. Carlton Estate 1, Highlands County, Fla. Core, 11,210–11,215 feet. ×30.

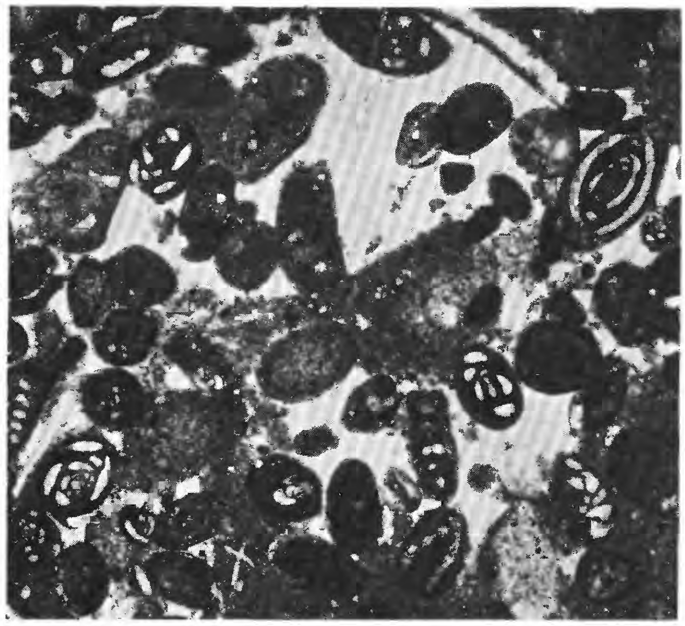

FIGURE 24.—Photomicrograph of a thin section of partly recrystallized miliolid limestone from beds of early Trinity age. Humble Oil & Refining Co. Gulf Coast Realties Corp. 2, Collier County, Fla. Core, 13,418–13,424 feet. ×30.

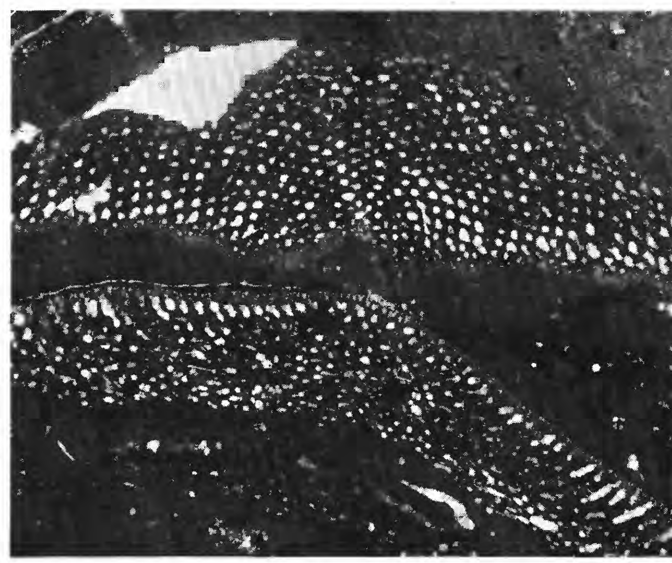

FIGURE 25.—Photomicrograph of a thin section of dark marly limestone of early Trinity age showing random sections of *Orbitolina texana* oblique to the axial plane. Triangular white area due to break in the thin section. Coastal Petroleum Co. E. C. Wright 1, Pinellas County, Fla. Core, 10,050–10,060 feet. ×30.

The species of *Orbitolina*, *Choffatella*, *Pseudocyclammina*, and *Lituola* that characterize the lower part of the beds of early Trinity age in south Florida are known to occur as far north as the vicinity of Tampa on the west coast of the peninsula. The fossils are commonly associated with the carbonate-evaporite facies, but in several wells near Tampa they occur in beds classified in this report as the mixed facies. Abundant specimens of these fossils were contained in a core of hard olive-gray shaly limestone at 10,050–10,070 feet in the Coastal Petroleum Co. E. C. Wright 1 (68, pl. 7), Pinellas County. Cores of marly and sandy limestone at 9,375–9,415 feet in the Humble Oil & Refining Co. T. S. Jameson 1 (47, pls. 6, 7), Hillsborough County,

FIGURE 26.—Photomicrograph of a thin section of limestone of early Trinity age containing a fragment of *Choffatella* and two miliolids. Humble Oil & Refining Co. Lowndes Treadwell 1A, Charlotte County, Fla. Core, 12,968–12,978 feet. ×30.

yielded many specimens of *Choffatella decipiens*. Cutting samples of hard olive-gray limestone and dark-gray shale at 10,090–11,110 feet in the Magnolia Petroleum Co. Schroeder-Manatee, Inc. 1 (52, pls. 6, 7), Manatee County, also contained abundant specimens of *Orbitolina texana*, *Choffatella decipiens*, and *Lituola* sp. The fossiliferous limestones in these three wells immediately overlie the marginal clastic facies.

The highest occurrence of *C. decipiens* in the different wells in south Florida is a significant marker that aids in the correlation of the early Trinity rocks and in the interpretation of the stratigraphy and structure of the unit. On many of the cross sections accompanying this report, the highest occurrence of the fossil in the different wells is correlated as the top of the *Choffatella* zone.

Specimens of *Dufrenoya texana* have been reported (Louise Jordan, oral communication, 1954; H. B. Stenzel, written communication, 1954) from a core of limestone at 11,527–11,550 feet in the Sinclair Oil & Gas Co. H. R. Williams 1 (59, pls. 6, 7) on Key Largo, Monroe County. The ammonities in the Williams well occur in the lower part of the beds of early Trinity age, about 120 feet above the top of the Fort Pierce Formation. *Dufrenoya texana* is a diagnostic fossil of the outcropping Cow Creek Limestone (Trinity) in central Texas (Adkins, 1928, p. 252–253), and the Pine Island Shale Member of the Pearsall Formation (Trinity) in the subsurface of the Coastal Plain of Texas, Louisiana, and Arkansas (Imlay, 1944).

Specimens of brachiopods from a core at 11,354–11,431 feet in the Williams well were reported by R. W. Imlay, U.S. Geological Survey, (written communication, 1956) to have been identified by G. A. Cooper as *Kingena* and *Cyclothyris* of Early Cretaceous age.

A diagnostic fauna has not been recognized in the Punta Gorda Anhydrite, although some irregular carbonaceous streaks in the anhydrite contain comminuted fossil fragments, and in several wells very thin lenses of miliolid limestone occur at irregular intervals. Specimens of *Orbitolina texana*, which are common also in the overlying Sunniland Limestone, are found, occasionally, in thin lenses of limestone and dolomite in the uppermost part of the Punta Gorda, and the species occurs also in beds of early Trinity age as high as the base of the Punta Gorda. Abundant specimens of *Orbitolina texana* occur in a core at 11,433 feet in the Coastal Petroleum Co. Tiedtke and Schroeder 1 (38, pl. 7), Glades County, in which the base of the anhydrite is at 11,390 feet. Douglass (1960b, p. 253) recorded the species from 11,425 feet in the same well. In Mississippi, *Orbitolina texana* was first recognized in Comanche rocks in the Gulf Oil Corp., J. M. Andrews 25 (sec. 6, T. 1 N., R. 16 W.) in the Baxterville field, Lamar County, Miss., where it occurred in a core of limestone at 12,948–12,998 feet near the base of the Ferry Lake Anhydrite (Trinity age). Specimens have been recognized, subsequently, in cutting fragments from approximately the same stratigraphic position in several other wells in southern Mississippi. This suggests the possibility of a broad, general correlation of the Ferry Lake Anhydrite in Mississippi, with the Punta Gorda Anhydrite in Florida.

The Punta Gorda Anhydrite and the overlying beds of late Trinity age are absent in the Humble Oil & Refining Co. W. P. Hayman 1 (63, pls. 6, 7), Osceola County. As classified by us, the youngest Trinity beds in this well are the mixed facies of the lower part of the beds of early Trinity age. A core of greenish-gray sandy shale at 8,012–8,017 feet in the Hayman well contained ostracodes, gyrogonites of charophytes, and fragments of other fossils. Dr. R. E. Peck (written communication, 1952) identified the charophytes as specimens of *Atopochara trivolvis*, a species (Peck, 1957, p. 21) that is "* * * widely distributed in the Lower Cretaceous Aptian nonmarine deposits of gulf coast and Rocky Mountain regions." Peck (1957, p. 4) further reported that the normal habitat of modern Charophyta is "* * * shallow, quiet or slowly moving bodies of fresh or brackish water."

That the habitat of the fossil may be in part facies-controlled is suggested by the occurrence of specimens of *Atopochara trivolvis* in cuttings of greenish-gray shale at 8,598–8,608 feet in the Humble T. S. Jameson 1 (47, pls. 6, 7), Hillsborough County. According to our classification, the beds in which *A. trivolvis* occurs in the Jameson well are the mixed facies of the beds of late Trinity age.

Distribution and thickness of beds of late Trinity age

Beds of late Trinity age have been penetrated in the wells in central and south Florida (pl. 7). The figure shows, also, the approximate position of the updip limit of the unit on the crest of the Peninsular arch near the south line of Osceola County and the northwest corner of Indian River County. On the southeast flank of the arch, however, the updip limit of the unit is not clearly shown by the available data from the scattered wells, and, as previously pointed out, we have not subdivided the marginal clastic rocks that comprise the beds of Trinity age in The Ohio Oil Co. Hernasco Corp. 1 (44, pl. 7), Hernasco County.

For the most part, the beds of late Trinity age rest on the Punta Gorda Anhydrite, but north and northeast of the updip limit of the Punta Gorda, the beds of late Trinity age rest unconformably on pre-Punta Gorda rocks of early Trinity age (pl. 7).

The beds of late Trinity age (pl. 7) range in thickness from 0 in the east-central part of the peninsula to more than 900 feet along the southwest coast; the thickness of the unit is estimated to be about 900 feet along the southeast coast between Palm Beach and Miami. In the wells in the Forty Mile Bend field, Dade County, the late Trinity beds are about 900 feet thick, but in two wells (58, 59, pl. 7) on Key Largo are about 700 feet thick. Local thinning in the unit north of Palm Beach is indicated by the subsurface data from a well (68a, pl. 7) in St. Lucie County.

Sunniland Limestone

Considerable economic significance is attached to the Sunniland Limestone inasmuch as it contains the reservoir rock of the Sunniland oil field in Collier County, Florida's only field producing at the present time. Thirteen productive wells have been drilled, two of which have been subsequently abandoned. According to a published report (Gunter, 1958, p. 4), the Sunniland field had produced 5,257,333 barrels of oil from the date of its discovery, September 26, 1943, to December 31, 1957. The gravity of the oil is about 25° (Gunter, 1951, p. 5–8). The Sunniland Limestone also contains the productive zone of the short-lived Forty Mile Bend oil field in Dade County, which produced nearly 33,000 barrels during 1954 and 1955 (Gunter, 1956, p. 5). In addition, many wildcat wells in south Florida are reported to have penetrated showings of oil in the Sunniland Limestone.

The name Sunniland Limestone was first published, without formal definition, by Pressler (1947, p. 1859, and fig. 3); it is used here as defined previously by Applin (1960, p. B209). The Sunniland Limestone is a subsurface unit of Trinity (Comanche) age in southern Florida and is composed chiefly of limestone, dolomite, and shale. It overlies the Punta Gorda Anhydrite and underlies the so-called upper anhydrite unit of late Trinity age which is described later in this report (p. 53).

The type well of the Sunniland Limestone is the Humble Oil & Refining Co. Gulf Coast Realties Corp. 2 (sec. 30, T. 48 S., R. 30 E.) in the Sunniland field, Collier County, Fla. The well, which was unproductive, was completed November 9, 1944, at the total depth of 13,512 feet. It was the first well that penetrated the full thickness of the unit. Samples from the well are indexed as No. W–961 in the files of the Florida Geological Survey (Gunter, 1949, p. 25). A description of the lithology and paleontology of a set of continuous cores of the Sunniland Limestone from 11,600 to 11,879 feet is given below. The core descriptions, in connection with the electric log and the log from samples (6, pl. 6), show clearly the stratigraphic relation of the Sunniland Limestone to the underlying Punta Gorda Anhydrite and to the overlying upper anhydrite unit in the beds of the late Trinity age.

A reference section from the Sinclair Oil & Gas Co. H. R. Williams 1 (sec. 24, T. 59 S., R. 40 E.), Monroe County, Fla., amplifies the findings in the type section by showing an additional occurrence of the characteristic microfauna of the Sunniland Limestone and variations in the thickness and lithology of the unit. A graphic log of the H. R. Williams well is given on plate 6, 59. The H. R. Williams well was completed August 31, 1953, at the total depth of 11,968 feet. Samples from the well are indexed as No. W–3011 in the files of the Florida Geological Survey (Gunter, 1954, p. 27).

The sets of samples of the Sunniland Limestone from the type section and the reference section, which were studied microscopically by E. R. Applin, are here described.

Type section of the Sunniland Limestone in the Humble Oil & Refining Co. Gulf Coast Realties Corp. 2, sec. 30, T. 48 S., R. 30 E. Collier County, Fla. (6, pl. 6)

Comanche Series:
Sunniland Limestone:

Core		*Depth (feet)*
65	Limestone, brownish-black, dense, shaly; contains sections of Foraminifera. Voids due to solution of fossils are filled with secondary anhydrite	11, 600–11, 607
66	Limestone, brown, dolomitic, containing a few oolites	11, 607–11, 612
67	Dolomite, brownish-gray, sucrosic; containing a few small inclusions of anhydrite	11, 612–11, 617
68	Anhydrite, interbedded with brown hard finely crystalline dolomitic limestone	11, 617–11, 622
69	Dolomite, light-brown, hard; containing inclusions of anhydrite	11, 622–11, 624

Comanche Series—Continued
Sunniland Limestone—Continued

Core		Depth (feet)
70	Limestone, light-greenish-brown, dolomitic. Slightly dolomitized parts of core contain abundant chalky molds of *Massilina* sp	11,624–11,629
71	Dolomite, light-brown, hard, sucrose, slightly porous	11,629–11,635
72	Dolomite, light-brown, sucrose, coarsely porous; contains embedded fragments of macrofossils	11,635–11,637
73	Dolomite, as in core 72	11,637–11,639
74	Chalk, light-tan, soft, dolomitic; contains sections of miliolids and abundant fragments of undetermined microfossils and macrofossils	11,639–11,644
75	Chalk, as in core 74	11,644–11,650
76	Limestone, microcrystalline, vuggy; and porous anhydrite containing inclusions of dolomite	11,650–11,660
77	Limestone, tan, soft, chalky; containing abundant fragments of microfossils and macrofossils. Sections of miliolids are common; macrofossil material is, in part, coarsely fragmental	11,660–11,670
78	Limestone, light-greenish-gray, chalky, and light-tan slightly dolomitic limestone, each containing fragments of macrofossils and unidentified tubular bodies	11,670–11,675
79	Dolomite, tan, gray-spotted, dense, sucrose; slightly porous owing to solution of small fossils	11,675–11,678
80	Dolomite as in core 79, containing a small inclusion of anhydrite	11,678–11,688
81	Dolomite, brown, hard, dense; containing sections of miliolids and abundant sections of *Dictyoconus floridanus* (Cole) and *Orbitolina texana* (Roemer)	11,688–11,698
82	Dolomite as in core 81 but without determinable fossils	11,698–11,708
83	Limestone, brown, hard; containing specimens of a small *gryphea*-like bivalve	11,708–11,715
84	Limestone, brown, hard; containing a few sections of *Dictyoconus floridanus*	11,715–11,720
85	Limestone as in core 84, apparently unfossiliferous	11,720–11,730
86	Dolomite, fine-grained; containing blebs of anhydrite	11,730–11,740
87	Limestone, brown, hard, dense; containing inclusions of anhydrite	11,740–11,750
88	Limestone as in core 87, containing scattered microscopic and macroscopic fossils	11,750–11,760
89	Limestone, brown, hard, dense, slightly argillaceous; containing scattered oolites	11,760–11,765
90	Shale, dark-gray, hard	11,765–11,775

Comanche Series—Continued
Sunniland Limestone—Continued

Core		Depth (feet)
91	Limestone, dark-greenish-brown, hard, dense; containing abundant specimens of miliolids, some specimens of *Dictyoconus floridanus*, and fragments of fossil bivalves	11,775–11,780
92	Limestone as in core 91, black-stained; containing specimens of *Orbitolina texana*	11,780–11,787
93	Limestone, brown, hard, dense; containing fragments of macrofossils and abundant sections of *Orbitolina texana*	11,787–11,797
94?	Limestone as in core 93 but unfossiliferous?	11,797–11,803
95	Shale, dark-gray, hard	11,803–11,805
96	Limestone, dark-brownish-gray, hard, argillaceous	11,805–11,815
97	Limestone as in core 96	11,815–11,825
98	Limestone as in core 96	11,825–11,835
99	Limestone, dark-grayish-brown, hard; containing abundant fragments of fossils	11,835–11,845
100	Limestone as in core 99	11,845–11,850
101	Limestone, dark-grayish brown, hard, apparently unfossiliferous	11,850–11,852
102	Limestone as in core 101, containing a few fossil fragments	11,852–11,859
103	Apparently composed of flattened pebbles of chert and limestone	11,859–11,865
104	Shale, gray, hard	11,865–11,867
105	No sample	
106	Recovered 5 ft?: 6 in., limestone, dark-gray and brown, hard; containing anhydrite inclusions, fragments of macrofossils, and small miliolids. 4 ft, anhydrite. 6 in., limestone, dark-grayish-brown, hard, slightly anhydritic	11,869–11,879

Reference section of the Sunniland Limestone in the Sinclair Oil & Gas Co. H. R. Williams 1, sec. 24, T. 59 S., R. 40 E. Monroe County, Fla. (59, pl. 6).

Comanche Series:
Sunniland Limestone:

Core		Depth (feet)
29	Recovered 75 ft: 9,956–9,958½ ft. Limestone, tan, hard; containing poorly preserved specimens of several species of Miliolidae and Ophthalmidiidae. 9,958½–9,969½ ft. Dolomite, light-olive-tan, microsucrosic. Description of core on commercial electric log shows 11 ft of limestone with brown oil stain. 9,969½–9,972 ft. Dolomite, olive-gray, hard, argillaceous, microsucrosic; containing algal fragments.	

Comanche Series—Continued
Sunniland Limestone—Continued

Core		Depth (feet)
	9,972–9,973½ ft. Anhydrite.	
	9,973½–9,981½ ft. Dolomite, light-olive-gray, sucrosic, porous, anhydritic; containing scattered fragments of macrofossils. Description of core on commercial electric log shows 8 ft of brown oil-stained limestone.	
	9,981½–9,984 ft. Anhydrite.	
	9,984–9,987 ft. Dolomite, sucrosic, oil-stained. Description of core on commercial electric log states "bleeding black oil."	
	9,987–9,990 ft. Dolomite, sucrosic, oil-stained.	
	9,990–9,996 ft. Anhydrite and microsucrosic porous oil-stained dolomite.	
	9,996–9,998 ft. Dolomite, sucrosic, porous, oil-stained.	
	9,998–9,999½ ft. Limestone, light-tan, dolomitic. Dolomite crystals range in size and are distributed irregularly in the limestone.	
	9,999½–10,002 ft. Dolomite, olive-gray, microsucrosic.	
	10,002–10,002½ ft. Dolomite, sucrosic, oil-stained.	
	10,002½–10,003½ ft. Dolomite, dense, medium-grained, chalky.	
	10,003½–10,004½ ft. Dolomite, light brown, microsucrosic.	
	10,004½–10,005 ft. Dolomite, dense, sucrosic; containing chalky areas	9, 930–10, 005
30	Recovered 75 ft:	
	10,005–10,005½ ft. Dolomite, olive-tan, fine-grained, slightly chalky.	
	10,005½–10,008 ft. Limestone, light-tan, hard; containing dolomitic areas.	
	10,008–10,009½ ft. Dolomite, olive-gray, microsucrosic; contains blebs of anhydrite(?).	
	10,009½–10,010 ft. Dolomite as in preceding part of core; containing fragments of fossil bivalves.	
	10,010–10,010½ ft. Dolomite, grayish-tan, sucrosic, anhydritic, slightly porous.	
	10,010½–10,013 ft. Dolomite, grayish-tan, sucrosic, slightly porous; containing small inclusions of anhydrite.	
	10,013–10,018½ ft. Dolomite, olive-gray, microsucrosic.	
	10,018½–10,020½ ft. Anhydrite, light-gray.	

Comanche Series—Continued
Sunniland Limestone—Continued

Core		Depth (feet)
	10,020½–10,023 ft. Limestone, dolomitic, oil-stained; containing irregularly distributed specimens of miliolids, fragments of macrofossils, and finely comminuted chalky fossil debris. Description of core on commercial electric log states "bleeding oil."	
	10,023–10,028 ft. Limestone, cream, moderately hard, chalky. Poorly preserved specimens of several species of miliolids are fairly common in the limestone. Description of core on commercial electric log stated "10,025½–10,026 ft bleeding oil."	
	10,028–10,032 ft. Limestone, light-tan, dense; containing specimens of several species of miliolids, a fragment of *Orbitolina* sp., and a section of *Dictyoconus floridanus* (Cole).	
	10,032–10,037 ft. Dolomite, olive-gray, dense, sucrosic.	
	10,037–10,040 ft. Limestone, tan, hard, dolomitic, miliolid. Very small crystals of dolomite are evenly distributed in the limestone matrix, which also contains irregular groups of tar-filled(?) veins.	
	10,040–10,042 ft. Limestone, cream; containing large coarsely crystalline areas.	
	10,042–10,046 ft. Dolomite, tan, sucrosic.	
	10,046–10,048½ ft. Limestone, cream; containing many algal fragments, a few miliolids, and some fragments of fossil bivalves.	
	10,048½–10,049½ ft. Limestone, grayish-tan, hard, irregularly dolomitic, containing a fragment of a pelecypod.	
	10,049½–10,051 ft. Dolomite, olive-gray and gray-spotted, microsucrosic.	
	10,051–10,051½ ft. Limestone, dense, miliolid, oil-stained.	
	10,051½–10,055 ft. Limestone, tan, hard, dolomitic, miliolid. Small crystals of dolomite and specimens of miliolids are unevenly distributed in the limestone matrix. Nests of algal fragments and coarse crystals of brown dolomite(?) are common. One part of the core has appearance of a conglomerate; it is composed of well-sorted rounded to angular fragments of calcareous algae.	

Comanche Series—Continued
Sunniland Limestone—Continued

Core		Depth (feet)
	10,055–10,056 ft. Dolomite, light-brown, sucrosic; containing many meandering veins filled with black tarry(?) material.	
	10,056–10,057½ ft. Limestone, light-tan, hard, miliolid; containing nests of coarse brown crystals of dolomite(?).	
	10,057½–10,058½ ft. Anhydrite.	
	10,058–10,062 ft. Dolomite, light-brown, finely crystalline, slightly chalky. Part of core is miliolid limestone containing irregularly distributed crystals of dolomite and nests of coarse crystals of brown dolomite(?).	
	10,062–10,063½ ft. Anhydrite irregularly streaked with brown sucrosic dolomite.	
	10,063½–10,066 ft. Dolomite, light-brown, dense.	
	10,066–10,072½ ft. Limestone, light-tan, dolomitic, miliolid; containing many nests of coarse brown crystals of dolomite(?). A part of the core cut normal to the bedding shows thin compressed lenses of miliolids. Other fossils are identified as *Dictyoconus floridanus*, *Orbitolina texana*, and a fragment of a large bivalve.	
	10,072½–10,074 ft. Limestone as in preceding part of core, containing fragments of bivalves and *D. floridanus*.	
	10,074–10,080 ft. Dolomite, light-brown, sucrosic; containing blebs of anhydrite	10, 005–10, 080
No sample		10, 080–10, 083
31	Recovered 73 ft:	
	10,083–10,088½ ft. Limestone, tan, hard, dolomitic; containing fragments of algae and large bivalves.	
	10,088½–10,107 ft. Dolomite, light-brown, sucrosic.	
	10,107–10,114 ft. Limestone, tan, dolomitic; containing sections of *Orbitolina texana*, *Dictyoconus floridanus*, and fragments of fossil bivalves.	
	10,114–10,120 ft. Limestone, tan, hard, dolomitized in irregular areas; contains a few fragments of macrofossils.	
	10,120–10,122 ft. Dolomite, olive-gray, hard, platy, argillaceous.	
	10,122–10, 128 ft. Limestone, tan, hard; containing many specimens of *Dictyoconus floridanus* and *Orbitolina texana*.	

Comanche Series—Continued
Sunniland Limestone—Continued

Core		Depth (feet)
	10,128–10,133 ft. Limestone, grayish-tan, hard; containing evenly distributed specimens of poorly preserved miliolids.	
	10,133–10,155½ ft. Limestone, tan, hard; containing many sections of *Orbitolina texana*	10, 083–10, 158
32	Recovered 77 ft:	
	10,156–10,157½ ft. Limestone, tan, hard, oil-stained(?); containing miliolids and traces of ostracodes and other fossils.	
	10,157½–10,162½ ft. Limestone, tan; and dense oolitic limestone characterized by a surface dotted with small pits. Oolites and small lime pellets that make up most of the limestone are embedded in a clear crystalline matrix.	
	10,162½–10,169½ ft. Dolomite, olive-gray, hard, microsucrosic, having a platy fracture.	
	10,169½–10,170 ft. Limestone, olive-tan, irregularly dolomitic; containing many scattered miliolids and nests of coarse brown crystals.	
	10,170–10,173 ft. Limestone, olive-tan, dolomitic; containing abundant very thin irregular lenses of black, tarry(?) material, poorly preserved miliolids, algae, and traces of other fossils.	
	10,173–10,196 ft. Anhydrite, light-gray; containing small inclusions of dolomite.	
	10,196–10,198 ft. Dolomite, olive-gray, sucrosic; containing veins filled with brownish-black material.	
	10,198–10,199½ ft. Dolomite, olive-gray, sucrosic, platy; containing abundant evenly distributed miliolids.	
	10,199½–10,201½ ft. Limestone, light-tan, hard, dolomitic, platy; containing nests of coarse brown crystalline material.	
	10,201½–10,223 ft. Anhydrite.	
	10,223–10,225½ ft. Dolomite, olive-gray, sucrosic.	
	10,225½–10,233 ft. Anhydrite	10, 156–10, 233

The Sunniland Limestone has been penetrated in the wells in central and south Florida shown in figure 27. The updip limit of the unit is indicated, approximately, by the line that extends across the peninsula from just south of St. Petersburg, on the west coast, to near Stuart on the east coast. In most of the wells, the

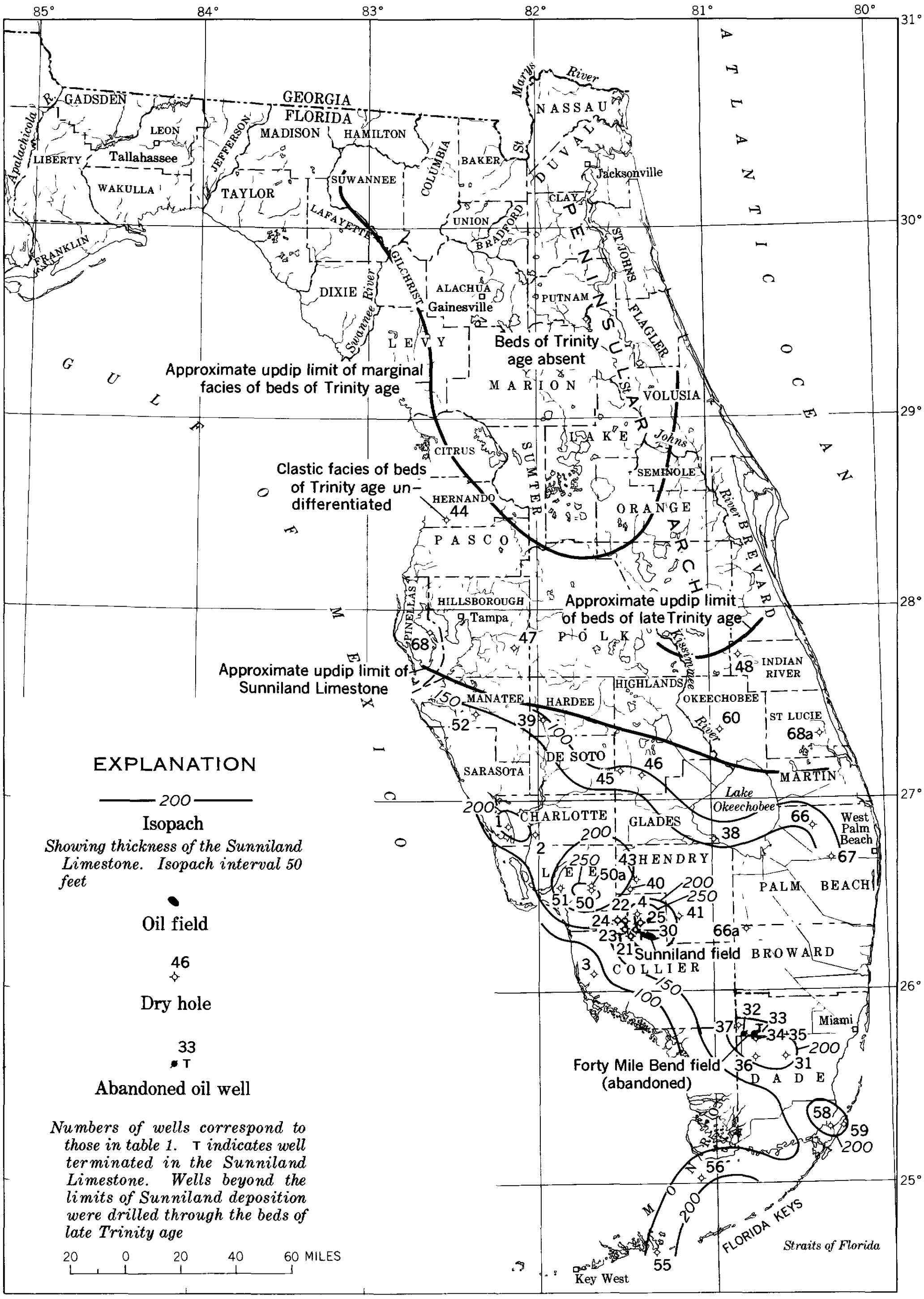

FIGURE 27.—Map of the Florida peninsula showing the areal distribution and thickness of the Sunniland Limestone in central and south Florida.

Sunniland directly overlies the Punta Gorda Anhydrite, but in two wells in Palm Beach County (66 and 67, fig. 27) in which the Punta Gorda is absent, the Sunniland rests on beds that we have classified as the lower part of the beds of early Trinity age.

Marked variations in thickness throughout its known extent are a characteristic of the Sunniland Limestone (fig. 27) in the Florida peninsula. In several wells on the southwest flank of the Peninsular arch, the thickness of the Sunniland ranges from about

100 to 150 feet, but in the scattered wells farther updip, the Sunniland has not been identified. The available subsurface data do not show clearly the shoreward nature of the unit, but as here interpreted it grades laterally into the mixed facies of the beds of late Trinity age. From the known thickness of 100–150 feet on the arch, however, a gradual southwestward thickening is indicated by the data from wells on the south Florida shelf. Sixteen wells (fig. 27; table 1) on the shelf from Charlotte County at the northwest to Key Largo, Monroe County, at the southeast penetrated more than 200 feet of Sunniland Limestone. The limestone ls 250–275 feet thick in wells in and near the Sunniland field and is nearly 250 feet thick in wells in the abandoned Forty Mile Bend field, Dade County. In contrast to the relatively thick section of the Sunniland Limestone in wells in and near the Sunniland field, the unit is only 69 feet thick in the Humble Oil & Refining Co., Collier Corp. 1 (3, fig. 27), Collier County, about 25 miles southwest of the field.

The series of moundlike features (fig. 27) alined along the basinward margin of the shelf are here provisionally interpreted as limestone banks. The Sunniland oil field, Collier County, and the abandoned Forty Mile Bend field, Dade County, are on separate mounds and showings of oil in the Sunniland Limestone were found in wells on or adjacent to other mounds in Charlotte County and Lee County and on Key Largo, Monroe County. Subsurface data from additional test wells are expected to modify ideas concerning the configuration of the mounds. The Sunniland Limestone is composed mainly of beds of dark dense argillaceous limestone and light-tan chalky limestone interbedded with lenses of sucrosic to microsucrosic brown dolomite and dark-gray shale. The contact of the Sunniland with the underlying Punta Gorda Anhydrite is generally sharply defined, but in some wells in which the contact seems to be gradational, thin beds of anhydrite interlense with limestone, shale, and dolomite containing faunal elements characteristic of the Sunniland. Near the top of the unit, too, a few thin lenses of anhydrite have been penetrated in some wells.

Stylolites are common in the Sunniland Limestone. Although stylolitic limestone occurs frequently in other units of the Comanche Series in Florida, the stylolitic tracery in the Sunniland is generally filled with a bituminous residue (fig. 30), some of which is highly pyritic. Bituminous material also fills small fractures and coats the walls of small voids in the limestone (fig. 28). In porous limestone lenses, some chamberlets in specimens of *Orbitolina* and *Dictyoconus* are filled with a tarry residue.

Lenses of bioclastic limestone occur at irregularly spaced levels in the Sunniland unit. Coarsely broken shell fragments (fig. 29) are the principal constituent of some lenses, as is algal debris of others. The algal limestone, when not completely recrystallized, is highly and irregularly porous and frequently contains showings of oil. Figure 29 shows a lens of bioclastic limestone which contains coarsely broken shell fragments and some Foraminifera in a coarsely crystalline partly dolomitized matrix. Shell fragments are bordered by very fine grained clayey-looking calcite.

A part of a core of the upper part of the Sunniland Limestone at 11,542–11,543 feet in the Gulf Oil Corp. Consolidated Naval Stores 1 (50, fig. 27), Lee County,

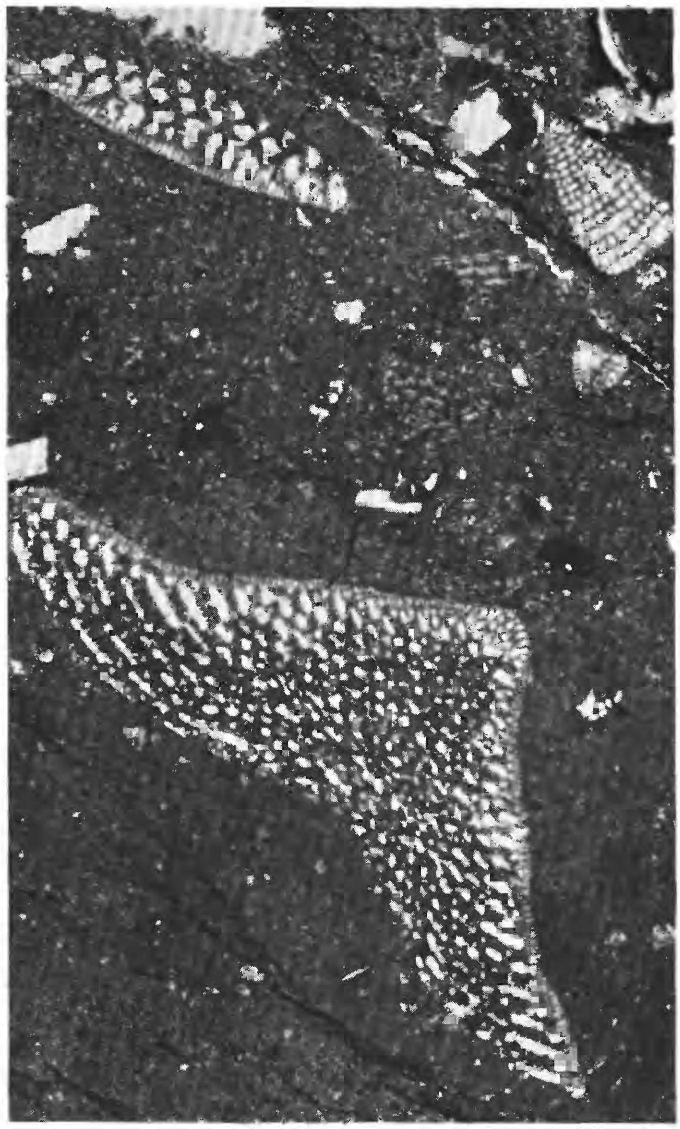

FIGURE 28—Photomicrograph of a thin section of tar-veined limestone from the Sunniland Limestone, showing close association of *Orbitolina texana* and *Dictyoconus floridanus*. Humble Oil & Refining Co. Gulf Coast Realties Corp. "C" 1, Collier County, Fla. Core, 11,850–11,859 feet. × 30.

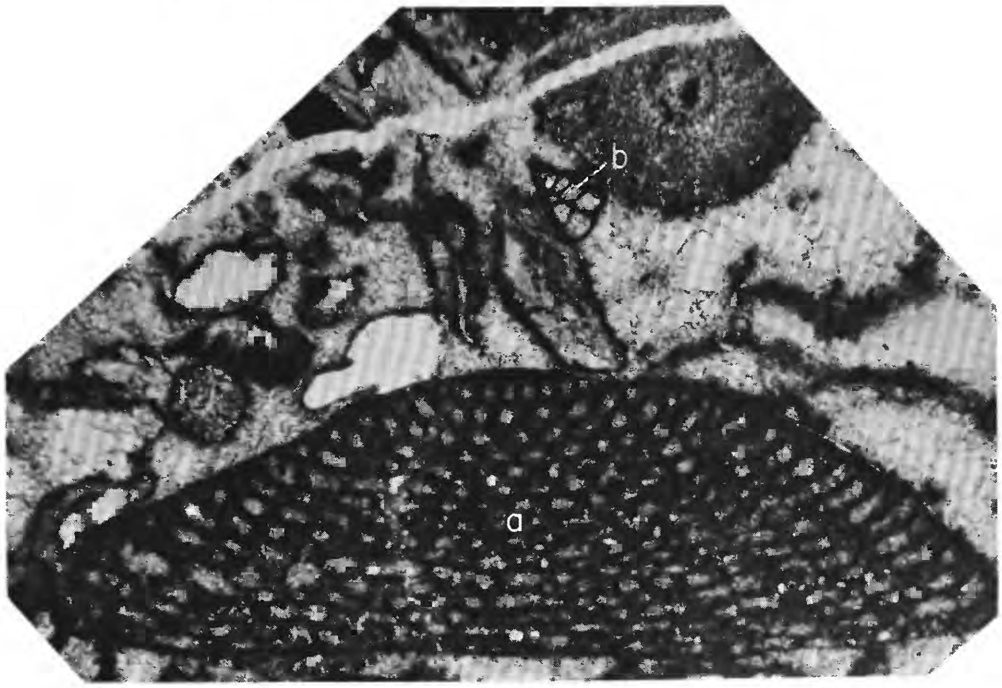

FIGURE 29—Photomicrograph of a thin section of a coarsely fragmental bioclastic limestone from the Sunniland Limestone, showing a deeply cut subaxial section of *Orbitolina texana* (a), and section of a small verneuilinid (b). Humble Oil & Refining Co. Gulf Coast Realties Corp. 12, Collier County, Fla. Core, 11,691–11,696 feet. × 30.

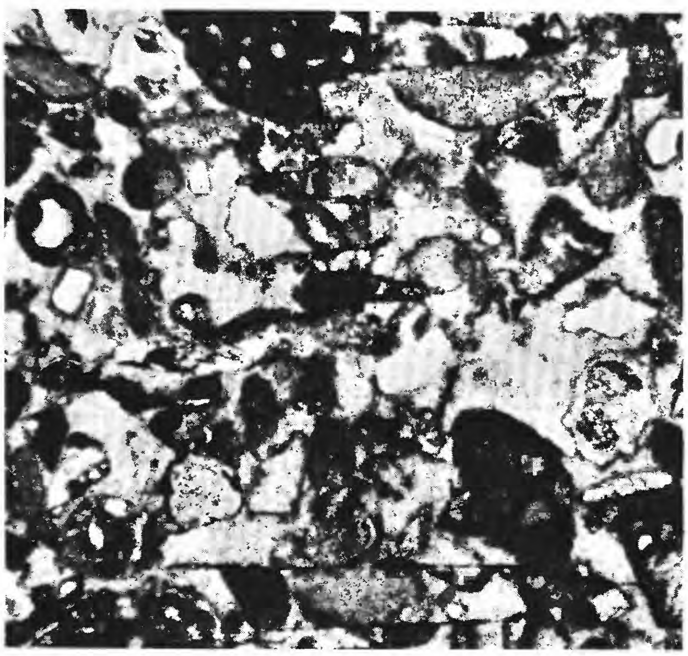

FIGURE 30—Photomicrograph of a thin section from the Sunniland Limestone showing stylolitic tracery. Columns clearly show juxtaposition of dissimilar parts of dolomite. Humble Oil & Refining Co. Gulf Coast Realties Corp. 12, Collier County, Fla. Core, 11,684—11,687 feet. × 30.

was examined, at our request, by Dr. J. H. Johnson. Johnson reported (written communication, 1954) that the rock is composed mainly "* * * of fragments of large dasycladacean algae of types that have been described * * * from Europe. * * * Such material has not been previously reported from North America. In appearance, the rock suggests an organic breccia with white crystalline calcite filling cavities and spaces between the organic fragments." Argillaceous chalky limestone (fig. 31) and dense often highly fractured limestone (fig. 28) commonly contain specimens of *Dictyoconus floridanus* (Cole) and *Orbitolina texana* (Roemer).

The reservoir rock is 36–40 feet thick in the wells at Sunniland (Pressler, 1947, p. 1859) and is composed

FIGURE 31.—Photomicrograph of a thin section of a chalky limestone from the Sunniland Limestone having an extremely fine grained groundmass that contains many specimens of *Dictyoconus floridanus*, a minor amount of silt-size quartz, and a little anhydrite. Humble Oil & Refining Co. Gulf Coast Realties Corp. "C" 1, Collier County, Fla. Core, 11,795–11,800 feet. × 30.

mainly of hard dense to porous limestone interbedded with hard dense dolomite. A thin stringer of anhydrite occurs near the top of the Sunniland in some wells.

Although the productive zone in both the Sunniland and Forty Mile Bend fields occurs in the uppermost part of the Sunniland Limestone, showings of oil in wells outside these fields are not confined to this stratigraphic level. Lithologic descriptions of cores from several wildcat wells in south Florida have been released to the public by oil companies and are published in connection with the commercial electric logs. This published data indicates that wildcat wells drilled on the south Florida shelf penetrated showings of oil in the Sunniland at various levels from the top to the base of the unit.

A set of consecutive cores from the Humble Oil & Refining Co. Collier Corp. 1 (3, fig. 27), Collier County, was examined by E. R. Applin. The uncommonly thin section of the Sunniland Limestone in this well has already been pointed out (p. 57), and the cores show, also, a pronounced difference in lithofacies from that penetrated in other wells in south Florida. In the Collier Corp. well, the Sunniland is chiefly a dark argillaceous fossiliferous somewhat oil-stained limestone, interbedded with thin streaks of dark-gray to black laminated calcareous shale having a strong sulfur odor and containing free sulfur on the shale partings.

The occurrence of *Orbitolina texana* in beds of early Trinity age in southern Florida and also in the Sunniland Limestone (late Trinity age) have already been mentioned (p. 45). Douglass (1960b, text fig. 2, no. (ms. p. 165) 20) reported the occurrence of *O. texana* in "the top of the Sunniland Zone," and in "the lower part of the Trinity group, below the thick anhydrite" (text fig. 2, no. 17). In the beds of early Trinity age in south Florida, however, *O. texana* generally occurs alone or accompanied by *Choffatella decipiens*, but in the Sunniland Limestone, many specimens of *Dictyoconus floridanus* (Cole) (pl. 1, figs. 1, 2, 5, 7, and 8) and *Orbitolina texana* (Roemer) occur in the same or in closely related lenses. This association is the unique and characteristic faunal feature of the Sunniland Limestone. Maync (1955, p. 106 and 107) described *Coskinolina sunnilandensis* from the Sunniland Limestone of southern Florida and recorded its occurrence in the Middle Albian of Venezuela and in the Urgonian of Switzerland. Douglass (1960b, p. 258), however, placed this species in the synonomy of *Dictyoconus floridanus* (Cole) and gave its distribution in Lower Cretaceous rocks in the United States as Florida, Louisiana, Texas, New Mexico, and Arizona. Specimens of *Dictyoconus floridanus*, *Dictyoconus walnutensis* (Carsey), and *Orbitolina texana* have been identified by E. R. Applin in samples from wells that penetrated Lower Cretaceous limestone immediately overlying the Ferry Lake Anhydrite in southern Mississippi. Other fossils that occur abundantly in the Sunniland Limestone in Florida are specimens of an undescribed species of *Massilina* and several undescribed species of *Quinqueloculina*.

Upper part of beds of late Trinity age

The areal distribution of the upper part of the beds of late Trinity age coincides with the areal distribution of the late Trinity beds (pl. 7). The wells mentioned in the text can be located by number on plate 7 and figure 27.

In south Florida, the beds of late Trinity age that overlie the Sunniland Limestone range in thickness from about 500 feet to more than 800 feet. The thickness of these beds in the Sunniland field is about 500 feet and is nearly 650 feet in wells in the vicinity of the Forty Mile Bend field. The Sunniland Limestone is overlain by 700 feet of late Trinity beds in the Gulf Oil Corp. State of Florida lease 373, 1 (55, pl. 7 and fig. 27), on Big Pine Key, Monroe County, and by about 500 feet in the Sinclair Oil & Gas Co. H. R. Williams 1 (59, pl. 7 and fig. 27) and the Republic Oil Co. O. D. Robinson 1 (58, pl. 7 and fig. 27), both on Key Largo. The maximum known thickness of the post-Sunniland beds of Trinity age is 854 feet in the Humble Oil & Refining Co. Collier Corp. 1 (3, pl. 7 and fig. 27), in Collier County, southwest of the Sunniland field. The upper part of the beds of late Trinity age thins progressively northward on the Peninsular arch in central Florida, and the units of the late Trinity beds in wells drilled north of the Amerada Petroleum Corp. Marie Swenson 1 (60, pl. 7 and fig. 27), Okeechobee County, are undifferentiated. As previously mentioned, the beds of late Trinity age wedge out (pl. 7 and fig. 27) in southern Osceola County and northwestern Indian River County, but the inner margin of the unit on the southwest flank of the Peninsular arch has not been definitely determined.

The beds of late Trinity age directly overlying the Sunniland Limestone are for the most part a sequence of irregularly interbedded anhydrite and argillaceous limestone that some geologists informally term the upper anhydrite or upper massive anhydrite. The observed thickness of the upper anhydrite ranges from about 30 feet in the Sinclair Oil & Gas Co. H. R. Williams 1, on Key Largo, Monroe County, to about 150–200 feet in wells in the Forty Mile Bend and the Sunniland fields and in other wells along the northwestern part of the south Florida shelf. Southwest of the Sunniland field it is at least 300 feet thick in the Humble Oil & Refining Co. Collier Corp. 1 (3, pl. 7 and fig. 27), Collier County. About 100 feet of the upper anhydrite was penetrated in the Humble Tucson 1 (67, pl. 7 and fig. 27), and in the Amerada Petroleum Corp. Southern States Land and Timber Co. 1 (66, pl. 7 and fig. 27), both of which are in Palm Beach County. The upper anhydrite was not identified in the Coastal Petroleum Co. Tiedtke and Schroeder 1 (38, pl. 7 and fig. 27), Glades County, and it apparently occurs as stringers in the Humble G. C. Carlton Estate 1 (46, pl. 7 and fig. 27), Highlands County, and in the Amerada Marie Swenson 1 (60, pl. 7 and figs. 27), Okeechobee County.

Above the upper anhydrite, the beds of late Trinity age are composed, in general, of dark dense argillaceous limestone, light-tan chalky limestone, and interbedded lenses of sucrosic to microsucrosic brown dolomite and dark-gray shale. Oolitic limestone, which is relatively scarce in the upper part of the beds of late Trinity age on the south Florida shelf, is more common in the updip wells on the southwest flank of the Peninsular arch; shale lenses, too, increase shoreward in number and thickness. Conversely, lenses of anhydrite, which are abundant in the upper part of the late Trinity beds in wells near the south end of the peninsula, are scarce to absent in updip wells.

On the basis of paleontology, it has been determined that the top of the beds of Trinity age in the carbonate-evaporite facies is at the highest occurrence of *Orbitolina minuta* Douglass. Owing to the vagaries of well samples and possibly to differences in environmental conditions, the highest occurrence of the fossil may vary stratigraphically from well to well. Consequently, in connection with the preparation of this report, the top of the unit is arbitrarily selected at a characteristic curve that appears persistently on the electrical logs of many wells about a hundred feet above the highest occurrence of *Orbitolina minuta* (pl. 6).

As already mentioned, the highest occurrence of specimens of *Orbitolina minuta* (fig. 32) is an important factor in the recognition of the top of the carbonate rocks of Trinity age. Specimens of the fossil are generally very common in another lens of *Orbitolina*-bearing limestone that occurs in many wells about 250 feet below the top of the beds of late Trinity age. Douglass (1960a, p. 6 and 7) stated that "*Orbitolina minuta* has the most widespread distribution of any of the North American species of *Orbitolinas*," but in wells drilled on the south Florida shelf, the species has been recognized only in the upper part of the upper Trinity and has not been found in wells north of the Humble Oil & Refining Co. G. C. Carlton Estate 1 (46, pl. 7 and fig. 27) Highlands County, Fla. The occurrence of *O. minuta* is sparse as compared to the common to abundant specimens of *O. texana* that are found in older parts of the beds of Trinity age.

Specimens of miliolid Foraminifera—a species of *Quinqueloculina* and one of *Massilina*—are common in the fossiliferous limestone of the late Trinity. It has been pointed out that the same forms appear in the early Trinity (fig. 24), where they often occur in oolitic limestone. In the early Trinity, however, they are generally associated with several other genera and species of Foraminifera that seem to be more narrowly restricted in their vertical range.

The occurrence of *Atopochara trivolvis* in the mixed facies of the late Trinity has already been mentioned (p. 45).

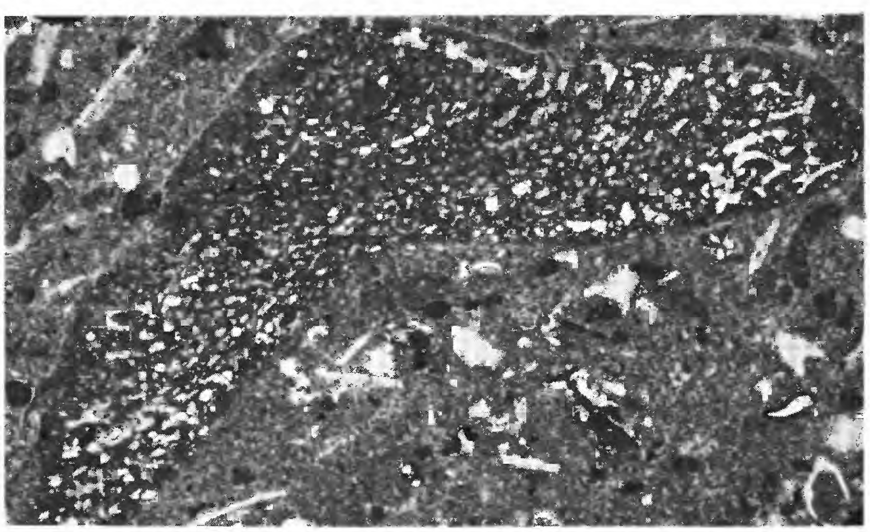

FIGURE 32.—Photomicrograph of a thin section showing a subaxial section of *Orbitolina minuta* embedded in an extremely fine grained groundmass containing brown pellets, finely broken shell fragments, and a minor amount of pyrite. From post-Sunniland beds of late Trinity age. Humble Oil & Refining Co. State of Florida 1, Dade County, Fla. Core, 11,125–11,131 feet. × 30.

Fragments of a caprinidlike bivalve characterize limestone lenses in the upper part of the late Trinity beds in several scattered wells, and similar lenses are found in the Sunniland Limestone in wells in the Sunniland field. Photomicrographs of thin sections of typical examples of this limestone showing the caprinid shell structure are given in figures 33, 34. The explanatory details of the lithology of the limestone are taken from a report by H. A. Tourtelot, who studied the samples at our request.

In this bioclastic limestone, the shell fragments are scattered in a matrix made up of aggregates of an extremely fine grained nearly opaque calcite (figs. 33a, 34a) set in a matrix of finely crystalline nearly clear calcite (figs. 33b, 34b). Most of the aggregates are irregularly rounded. These aggregates may be lime mud fragments deposited as clastic grains, or they may be merely parts of the original lime mud that was not recrystallized; some may be fecal pellets. The finely crystalline calcite between the aggregates appears to be a recrystallized matrix.

Figure 33, shows three individual fragments of rudistids brought together in random positions. At c in figures 33 and 34, the cells in the shell structure are shown to consist of irregular prismatic bodies bounded by nearly opaque calcite. The cell spaces are now filled with finely crystalline calcite. At d in figure 33, some of the segments of the shell structure are shown to have been replaced by anhydrite.

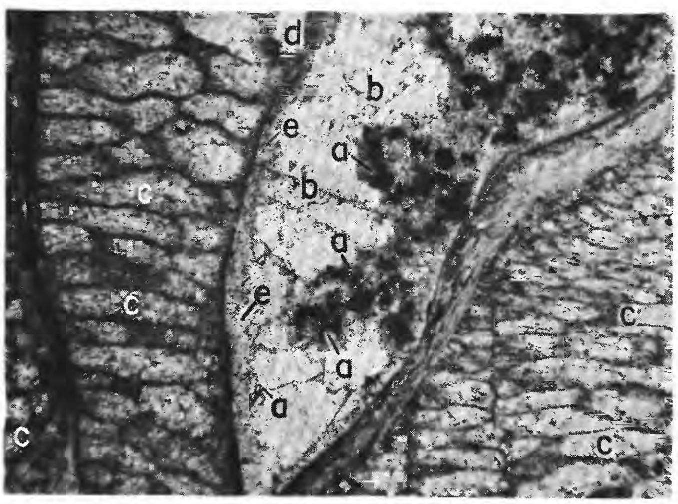

FIGURE 33.—Photomicrograph of a thin section of limestone showing rudistid shell structure and illustrating a hypothetical history of the secondary recrystallization of the rock. Letters refer to details of secondary crystallization that are given in text. From post-Sunniland beds of late Trinity age. McCord Oil Co. Damoco 1, Dade County, Fla. Core, 11,042–11,047 feet (measured depth not corrected for deviation of hole). × 28.

Short prismatic crystals of calcite line the major voids in the original rock (fig. 33, e). The crystals are oriented with long axes perpendicular to the walls of the voids. Calcite also occurs as a void filling (fig.

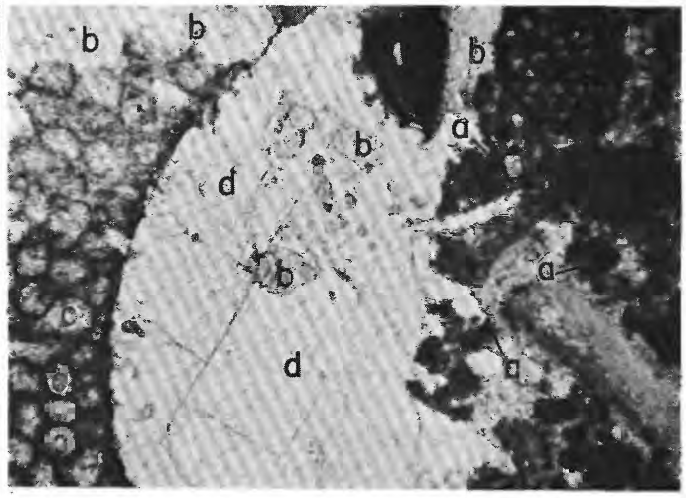

FIGURE 34.—Photomicrograph of another thin section of the rudistid limestone. From post-Sunniland beds of late Trinity age. Details of the hypothetical history of the secondary crystallization are given in the text. McCord Oil Co. Damoco 1, Dade County, Fla. Core, 11,042–11,047 feet (measured depth not corrected for deviation of hole). × 28.

33, b). The calcite, partly filling the voids, is coarsely crystalline and mirror clear. As shown at d in figure 34, the calcite has been largely replaced by anydrite. Anhydrite occurs also as isolated prismatic crystals that cut across all components of the rock and as irregular masses (fig. 34) that replace part of the rock.

The association of calcite, dolomite, and anhydrite suggests a diagenetic history similar to that proposed for the oolite described from the Fort Pierce Formation (p. 26). The interrelations of the minerals cannot be determined as clearly in this limestone as in the oolite, but no relations are apparent that suggest a significant difference in the sequence of events.

Correlation and geologic events of Trinity time

Several geologic events in the Florida peninsula during Trinity time are suggested by the areal distribution, correlation, and facies changes of the stratigraphic units of the beds of Trinity age. The areal distribution of the different units (pl. 7 and fig. 27) and their lithologic facies were discussed in preceding paragraphs. A southwest-northeast stratigraphic cross section (pl. 8) through wells situated approximately along the dip of the beds from Collier County to Osceola County shows the correlation of each stratigraphic unit across the south Florida shelf and the southwest flank of the Peninsular arch.

The stratigraphic units of the carbonate-evaporite facies were penetrated in a uniform sequence, as shown by the cross section, in the wells from the Humble Oil & Refining Co. Collier Corp. 1 (3, pl. 8), Collier County, to the Humble G. C. Carlton Estate 1 (46, pl. 8), Highlands County. Northeastward from the Carlton well, the beds of Trinity age thin rapidly on the flank of the arch where fluctuations of the shoreline are indicated by shoreward facies changes and unconformable relations of the beds of late Trinity age and the Punta Gorda Anhydrite and *Choffatella*-bearing limestone of early Trinity age.

Owing, possibly, to upwarping along the axis of the Peninsular arch, the sea evidently withdrew from the crest of the arch in east-central Florida after the deposition of the lower part of the beds of early Trinity age. During Punta Gorda (late early Trinity) time and late Trinity time, the sea again advanced onto the flank of the arch but did not reach its former borders. A shoreward facies of the Punta Gorda rests with probable unconformity on the *Choffatella*-bearing limestone in the Amerada Petroleum Corp., Marie Swenson well 1 (60, pl. 8), Okeechobee County, and wedges out updip between the Swenson well and the Amerada Fondren Mitchell well 1 (48, pl. 8), Indian River County. The undifferentiated mixed facies of the beds of late Trinity age overlaps the wedge edge of the shoreward facies of the Punta Gorda Anhydrite, thins progressively updip, and rests unconformably on the *Choffatella*-bearing limestone in the Mitchell well. Cutting samples of the beds of late Trinity age in the Mitchell well suggest that the sediments were deposited in a near-shore environment. They are, chiefly, fragments of sandy dolomite and limestone mixed with abundant fragments of fine- to coarse-grained poorly sorted sandstone and gray, red, and varicolored shale. The updip limit of the beds of late Trinity age is evidently between the Mitchell well and the Humble Oil & Refining Co., W. P. Hayman well 1 (63, pl. 8), Osceola County. As already pointed out, the youngest beds of Trinity age in the Hayman well are classified by us as the mixed facies of the lower part of the beds of early Trinity age.

In early Fredericksburg time, the northward encroaching sea evidently transgressed beds of early Trinity age on the crest of the Peninsular arch in east-central Florida, for, as already pointed out (p. 36), the beds of Fredericksburg age in several wells appear to overlie unconformably the lower part of the beds of early Trinity age.

The southwestern part of the cross section (pl. 8) provides a clue to the environmental conditions that prevailed during Sunniland time in the area of the south Florida shelf. The variations in thickness of the Sunniland Limestone and the marked changes in lithologic facies, mentioned in earlier paragraphs (p. 51), suggest that during Sunniland time the site of the Sunniland oil field was near the margin of a shelf that bordered the northeastern rim of a rapidly subsiding basin. The changes in thickness and lithofacies of this unit from the Sunniland field southwestward to the Collier Corp. well are analogous, in general, to changes in the Pennsylvanian rocks of west Texas described by Adams and others (1951) as originating in "* * * unfilled basins * * * surrounded by broad sediment-hoarding epicontinental shelves * * *." These basins, in which the rate of subsidence was materially greater than the rate of deposition, were termed "starved basins."

The available subsurface data indicate that a starved basin existed in southern Florida during Sunniland time. The greatly thickened "upper anhydrite" unit that overlies the thin Sunniland Limestone in the Collier Corp. well apparently filled the basin after the deposition of the Sunniland Limestone. Inasmuch as the Collier Corp. well provides the only evidence of a starved basin environment, data from additional deep test wells are needed to confirm this interpretation, to define the areal extent of the basin, and to determine the relation of the basin to relatively thick sections of the Sunniland Limestone in other parts of southern Florida (fig. 16).

BEDS OF FREDERICKSBURG AGE

Distribution and thickness

Beds of Fredericksburg age underlie the central and south parts of the Florida peninsula. Figure 35 shows the locations of the oil test wells that penetrated the unit, the approximate updip limit of the carbonate-evaporite facies (line *D–D′*), and the approximate updip limit of the marginal clastic facies of the undifferentiated beds of Fredericksburg and Washita age (line *F–F′*). The beds of Fredericksburg age in the updip wells overlap the beds of Trinity age. The marginal clastic facies of the Fredericksburg rests unconformably on the pre-Coastal Plain rocks in the Grace Drilling Co. Retail Lumber Co. 1 (69, pl. 6 and fig 35), Volusia County, and the Oil Development Co. of Florida J. Ray Arnold 1 (49, pl. 6 and fig. 35), Lake County. In the Ohio Oil Co. Hernasco Corp. 1 (44, fig. 35), Hernando County, Lower Cretaceous marginal clastic rocks overlie early Paleozoic sedimentary rocks at the depth of 7,720 feet and underlie carbonate rocks of the Fredericksburg at 6,240 feet. As already mentioned (p. 36), the Lower Cretaceous clastic rocks in the Hernasco well are tentatively separated at the depth of 6, 565 feet (table 1) into undifferentiated beds of Trinity age below and beds of Fredericksburg age above. The marginal clastic facies of the Lower Cretaceous rocks in the Sun Oil Co. Powell Land Co. 1 (70, pl. 9 and fig. 35), Volusia County, and the Warren Petroleum Co. George Terry 1 (61, pl. 9 and fig. 35), Orange County, as already mentioned (p. 36), are tentatively correlated with the lower part of the beds of early Trinity age. On the basis of this correlation, the beds of Fredericksburg age in the two wells named above rest unconformably on marginal clastic rocks of early Trinity age. In the Humble Oil & Refining Co., N. R. Carroll 1 (62, pl. 9 and fig. 35) and W. P. Hayman 1 (63, pl. 9 and fig. 35), both in Osceola County, the Fredericksburg unconformably overlies the mixed facies of the beds of early Trinity age. In downdip wells on the southwest flank of the Peninsular arch and on the south Florida shelf, the carbonate-evaporite facies of the beds of Fredericksburg age overlies without apparent unconformity the carbonate-evaporite facies of the beds of late Trinity age.

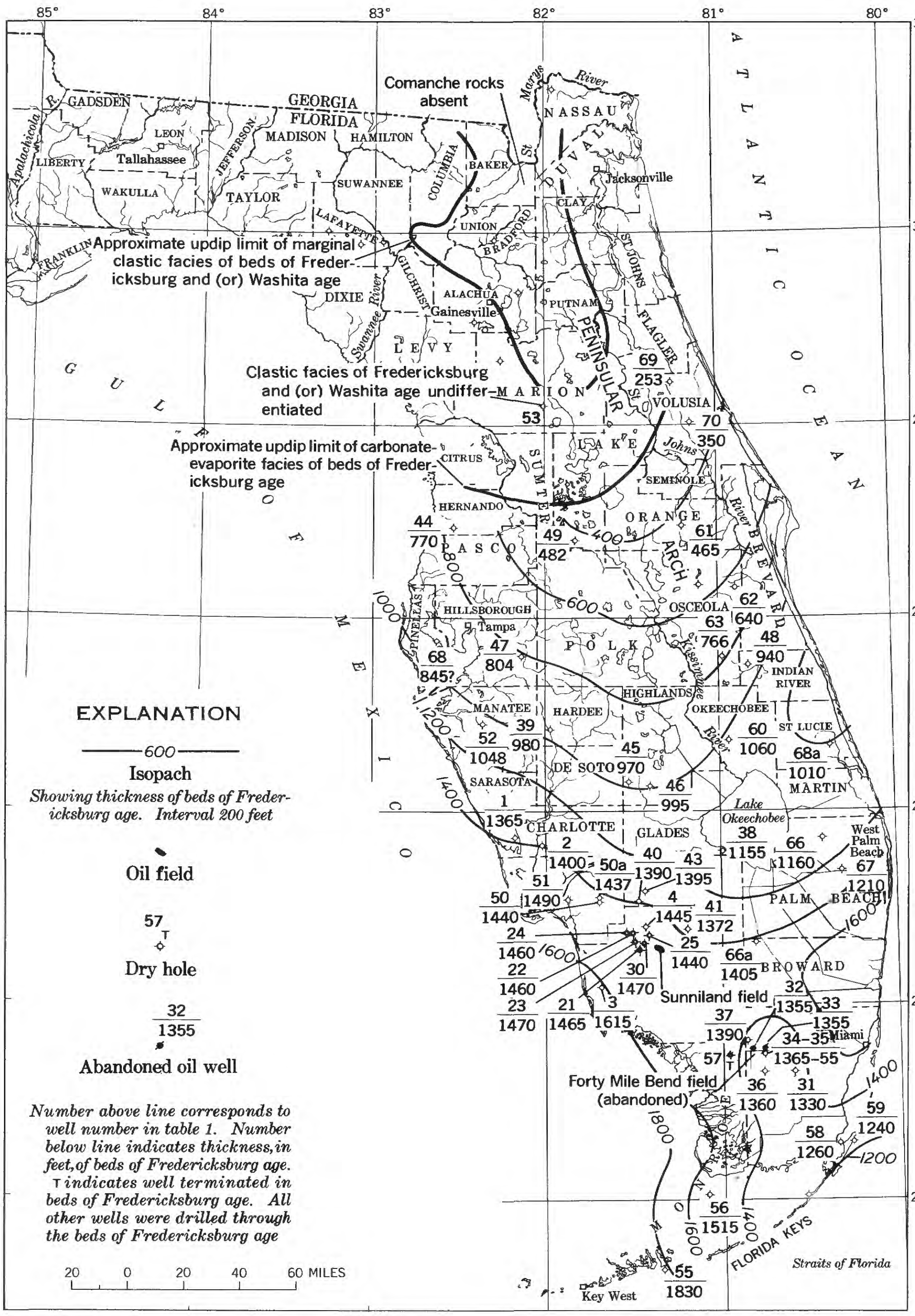

FIGURE 35.—Map of the Florida peninsula showing the areal distribution and thickness of the beds of Fredericksburg age in central and south Florida.

The thickness of the rocks of Fredericksburg age ranges from 0 at the updip limit of the unit (fig. 35, line *F′–F′*) to about 1,600 feet in the Humble Oil & Refining Co. Collier Corp. 1 (3, fig. 35), Collier County. In the wells of the Sunniland field, the beds of Fredericksburg age are from 1,430 to 1,460 feet thick, and in wells in the vicinity of the Forty Mile Bend field, the thickness is from 1,330 to 1,390 feet. About 1,250 feet of beds of Fredericksburg age were penetrated in the Sinclair Oil & Gas Co. H. R. Williams 1 (59, fig. 35) and the Republic Oil Co. O. D. Robinson-State of Florida 1 (58, fig. 35), both on Key Largo, Monroe County; but southwest of these wells, the unit is 1,800 feet thick in the Gulf Oil Corp. State of Florida Lease 373, 1 (55, fig. 35), on Big Pine Key, Monroe County.

Lithology

Dense tan to grayish-brown limestone and tan to brown microsucrosic dolomite are common in the lower and middle parts of the beds of Fredericksburg age; cream chalky limestone (fig. 36) occurs chiefly in the upper part. Traces of glauconite have been observed in a few carbonate rocks that also contain scattered oolitic lenses, mainly northward from the south Florida shelf.

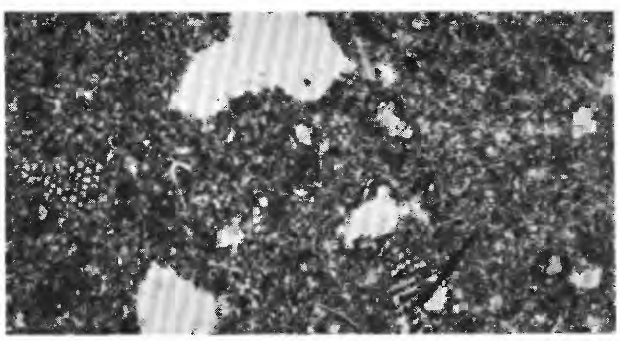

FIGURE 36.—Photomicrograph of a thin section of chalky limestone containing sections of *Coskinolinoides texanus*. White areas are recrystallized. Beds of Fredericksburg age. Humble Oil & Refining Co. G. C. Carlton Estate 1, Highlands County, Fla. Core, 9,055–9,065 feet. × 30.

Bioclastic limestone (fig. 37), irregularly distributed at different levels in the beds of Fredericksburg age, is composed mainly of angular to subangular fragments of megascopic fossils accompanied by some microfossils and varying amounts of comminuted fossil debris. Figure 37 is a typical example of the bioclastic limestone of Fredericksburg age. In the thin section, the matrix between the clastic units is in part sublithographic and in part crystalline, and the grain size ranges from 0.04 to 0.5 mm. The coarser calcite is replaced in irregular patches by a sulfate, probably barite. Narrow boundary pores, which commonly adjoin the clastic units, seem to be indigenous rather than due to sectioning. Mud pellets, appearing on the plate as small rounded black areas, range in diameter from 0.14 to 1.4 mm and are blocky, to elliptical, to irregular in outline; many are composites of smaller pellets and Foraminifera. In some bioclastic lenses, gastropods occur in place of the pelecypod fragments pictured in the typical example.

Anhydritic limestone and dolomite containing scattered blebs of anhydrite are fairly common in the rocks of Fredericksburg age. Beds of anhydrite, which are commonly penetrated in downdip wells, decrease in number and thickness updip. Shale lenses occur in the unit but are volumetrically unimportant except in far updip wells.

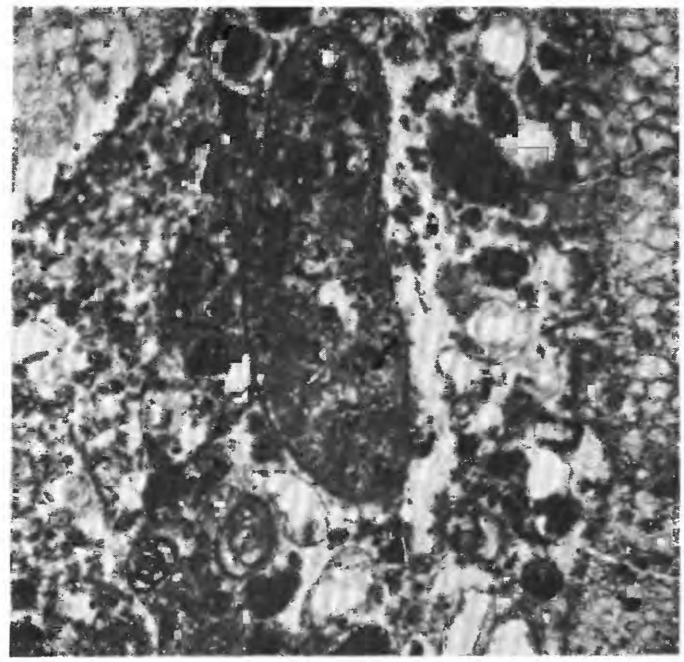

FIGURE 37.—Photomicrograph of a thin section of limestone composed mainly of coarsely broken fragments of megafossils and some miliolids embedded in a groundmass that is in part sublithographic and in part crystalline. Beds of Fredericksburg age. McCord Oil Co. Damoco 1, Dade County, Fla. Core, 10,608–10,631 feet. × 30.

One or more lenses containing abundant specimens of the foraminiferal genus *Lituola subgoodlandensis* (Vanderpool) (pl. 1, fig. 11 and text fig. 38) provide a diagnostic faunal marker for the top of the beds of Fredericksburg age in the carbonate-evaporite facies in central and south Florida. In addition, specimens of *Coskinolinoides texanus* Keijzer (pl. 1, figs. 3, 4, 9, 10) occur close to the top of the rocks of Fredericksburg age in wells in the southern part of the peninsula as far north as Highlands County and Osceola County. *C. texanus* is usally selected as the diagnostic faunal marker for the Fredericksburg equivalents in south Florida. Dolomitization, which frequently obliterates the fossils in the limestone of beds of late Fredericksburg age, near the contact with the overlying beds of Washita age, may cause variations in the apparent highest occurrence of the diagnostic microfossils. Consequently, we have selected as the top of the beds of Fredericksburg age, a persistent characteristic in the electric log curves (pl. 6) occurring at or above the highest occurrence of the diagnostic fossils.

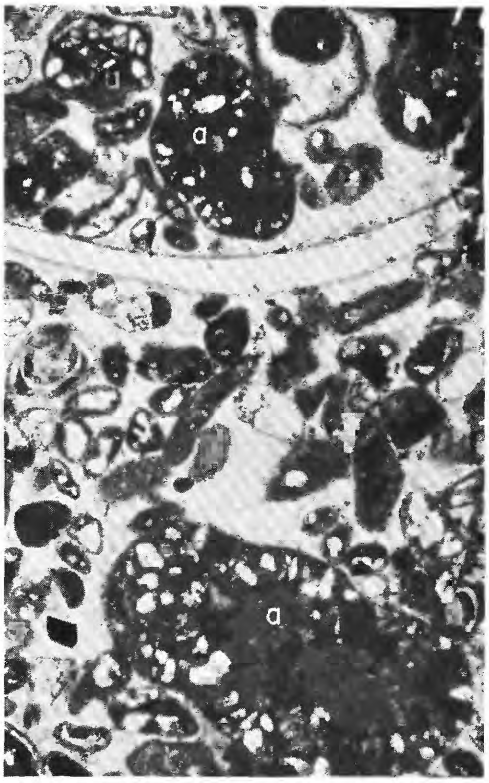

FIGURE 38.—Photomicrograph of a thin section of calcarenite showing many sections of *Lituola subgoodlandensis* (a). Beds of Fredericksburg age. The Ohio Oil Co. Hernasco Corp. 1, Hernando County, Fla. Core, 5,964–5,971 feet. × 30.

Core descriptions provided by oil companies and the study of samples in connection with the preparation of this report indicate the widespread occurrence of oil showings in the beds of Fredericksburg age. Oil showings at various levels in the carbonate rocks of Fredericksburg age have been reported in wells on the south Florida shelf, and we have observed tarry residue in drill cuttings from several wells on the southwest flank of the Peninsular arch. Nearly all the showings occur in the upper half of the beds of Fredericksburg age and the available data indicate that the greater part of them are near the top of the unit. A more precise zonation does not seem feasible. The showings, as reported, range from oil-stained limestone and tarry residue to "live" oil in pores and in fractures in the limestone.

Fauna

The diagnostic value of the foraminiferal species *Coskinolinoides texanus* Keijzer (pl. 1, figs. 3, 4, 9, 10) and *Lituola subgoodlandensis* (Vanderpool) (pl. 1, fig. 11; fig. 38a) in the beds of Fredericksburg age has already been mentioned. The known geographic distribution of *C. texanus* in Florida is from the Gulf Oil Corp. State of Florida Lease 373, 1 (55, fig. 35), on Big Pine Key, Monroe County, as far north as the Humble Oil & Refining Co. G. C. Carlton Estate 1 (46, fig. 35), Highlands County, and W. P. Hayman 1 (63, fig. 35), Osceola County. In Florida, the species seems to be limited in its vertical range to the beds of Fredericksburg age, and specimens generally occur in greatest abundance in the upper part of the unit. Frizzell (1954, p. 76), however, reported that in Texas, *C. texanus* ranges upward from the Glen Rose Limestone of the Trinity Group into the progressively younger Walnut Clay, Comanche Peak Limestone, and Goodland Limestone of the Fredericksburg Group.

Campbell (1940, p. 96; Applin and Applin, 1944, p. 1722) reported the occurrence of an isolated specimen of *Dictyoconus walnutensis* in a core from the Peninsular Oil & Refining Co. J. W. Cory 1 (57, fig. 35), Monroe County, at 9,995–10,006 feet—the total depth of the well. E. R. Applin, who studied the samples from the Cory well at the time it was being drilled, found no specimens of *D. walnutensis*. Subsequently, however, the Florida Geological Survey provided samples of a core from the Cory well at 9,750–9,765 feet, in which E. R. Applin identified many specimens of *Coskinolinoides texanus*.

Abundant specimens of *Lituola subgoodlandensis* (fig. 38) occur in one or more lenses near the top of the beds of Fredericksburg age, and the species is also frequently found at lower levels. Faunal populations characterized by *Coskinolinoides texanus* may also contain specimens of *Lituola*. Frizzell (1954, p. 66) reported that in Texas, *L. subgoodlandensis* ranges upward from the Glen Rose Limestone of the Trinity Group into the progressively younger Walnut Clay, Goodland Limestone, and Kiamichi Formation of the Fredericksburg Group. In Florida the geographic range of *L. subgoodlandensis* is somewhat wider than that of *C. texanus*, as abundant specimens occur in the wells farthest updip that penetrated the carbonate-evaporite facies (fig. 38), The Ohio Oil Co. Hernasco Corp. 1 (44, fig. 35), Hernando County; the Oil Development Co. of Florida J. Ray Arnold 1 (49, fig. 35), Lake County; and the Grace Drilling Co. Retail Lumber Co. 1 (69, fig. 35), Volusia County.

Specimens of a species of *Quinqueloculina* (fig. 39a) and a species of *Nummoloculina* (b) predominate in the miliolid assemblages of the Fredericksburg. The genera are about equally common in many of the miliolid limestones of the Fredericksburg, but one form or the other may occasionally be dominant. Other genera of miliolids (fig. 39c) and some specimens of *Cyclammina* (d) are also frequently present.

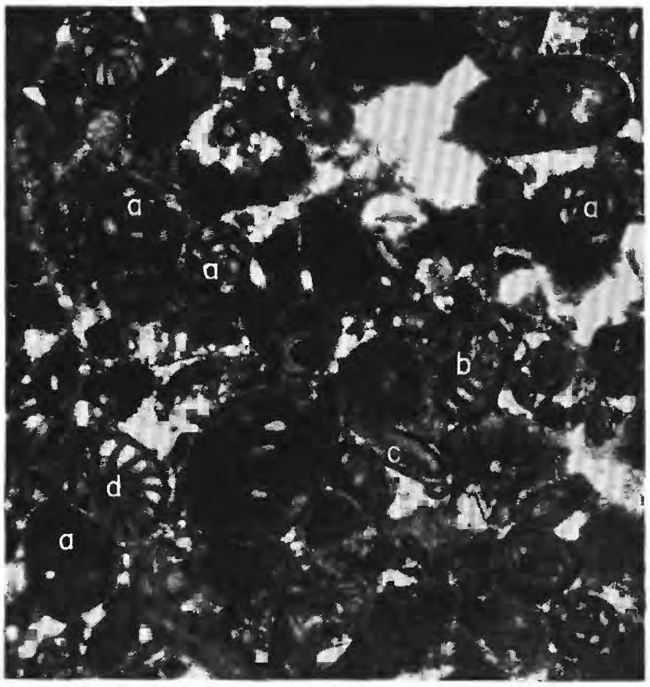

FIGURE 39.—Photomicrograph of a thin section of miliolid limestone showing sections of *Quinqueloculina* (a), *Nummoloculina* (b), *Triloculina* (c), and *Cyclammina*(?) (d). Beds of Fredericksburg age. Gulf Oil Corp. State of Florida Lease 373, 1, Big Pine Key, Monroe County, Fla. Core, 10,880–10,883 feet. × 30.

A species of *Cuneolina* and fragments of specimens of *Dicyclina* cf. *D. schlumbergeri* are common microfaunal features of the beds of Fredericksburg age in the southern part of the peninsula. *Dicyclina*, however, is not restricted to the rocks of Fredericksburg age in Florida. Its occurrence is apparently influenced by minor changes in depositional conditions, and it is found also in the carbonate rocks of Washita age in the northern part of the report area.

A few wells in the southern part of the peninsula contain abundant specimens of *Calcisphaerula innominata* Bonet in chalky limestone very close to the top of the beds of Fredericksburg age. The biologic relationships of these minute globular organisms are not clearly established, but their distribution is worldwide and they have been recorded under several different titles from Cretaceous formations. Lenses of limestone in which these fossils are exceedingly abundant appear in a few of the Cretaceous units of Texas, Mexico, and Florida. Both the Georgetown Limestone and the Edwards Limestone in Texas contain lenses composed chiefly of these organisms. Beds of Fredericksburg age in Florida are faunally related to the Edwards Limestone in Texas, and in both areas beds of Fredericksburg age contain lenses characterized by abundant specimens of *C. innominata*. Bonet (1956, p. 443–447, pl. 24) described *Calcisphaerula innominata* and presented photomicrographs of *Calcisphaerula*-bearing limestone from the Edwards in Texas.

Although specimens of pelagic Foraminifera rarely occur in the shallow-water carbonate deposits of the Comanche Series in Florida, tests of *Globigerina* sp. have been observed in limestone in the lower part of the beds of Fredericksburg age in wells near the southern end of the peninsula. This occurrence does not necessarily indicate an increase in the depth of the sea during this period of geologic time, because, according to Crickmay, Ladd, and Hoffmeister (1941, p. 81), "* * * under proper conditions these pelagic remains may accumulate in extremely shallow water, or even on a beach."

At the request of the Florida Geological Survey, Dr. L. W. Stephenson examined serveral specimens of macrofossils in cores from the Humble Oil & Refining Co. Collier Corp. 1 (3, fig. 35), Collier County. By permission of the Florida Geological Survey (R. O. Vernon, written communication, 1955), pertinent paragraphs of Stephenson's descriptions are quoted below.

Core, I–7456, 10,740–10,741 ft. Gray limestone speckled with great numbers of miliolid foraminifers; contains several incompletely preserved shells that appear to be juvenile samples of *Chondrodonta munsoni* (Hill). Age probably Edwards Limestone.

Core, I–7457, 10,920–10,921 ft. Gray limestone with *Nerita*(?) *apparata* (Craigin)?, Dr. Stanton records this species from the Edwards Limestone and from the Comanche Peak Limestone. I have compared the incomplete specimens with Stanton's figured specimens from the Edwards Limestone on the west bank of the Colorado River above the mouth of Barton's Creek near Austin (Texas) (Prof. Paper 211, pl. 47, fig. 14), and the available parts preserved appear to agree fairly closely with that specimen. Age probably Edwards Limestone.

The occurrence of *Chondrodonta munsoni* (Hill)? in core I–7456 (depth 10,740–10,741 ft) is interpreted to indicate the Edwards age of the core. In the next core I–7457 (depth 10,920–10,921 ft) the occurrence of *Nerita*? *apparata* (Craigin)? tends to confirm the Edwards age of the limestone in this part of the section.

BEDS OF WASHITA AGE

Distribution and thickness

The beds of Washita age in central and south Florida were penetrated in the wells shown in figure 40, which shows also the approximate updip limit of the carbonate-evaporite facies of the unit (line *E–E′*), and the approximate updip limit of the marginal clastic facies of the undifferentiated beds of Fredericksburg and Washita age (line *F–F′*). Shoreward overlap of rocks

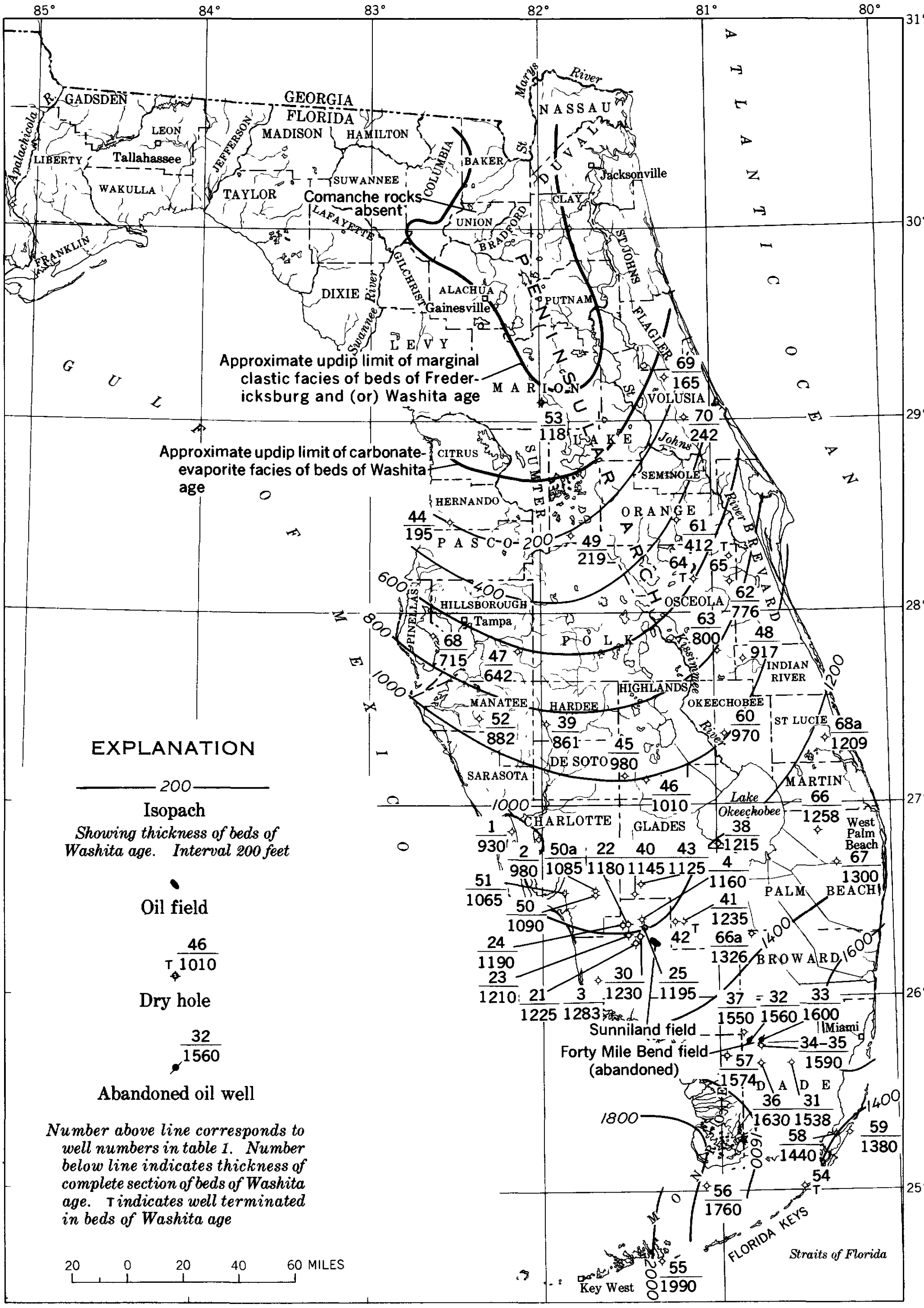

FIGURE 40.—Map of the Florida peninsula showing the areal distribution and thickness of the beds of Washita age in central and south Florida.

of Fredericksburg age by those of Washita age is not clearly shown by the available subsurface data, although we have adopted this interpretation as a working hypothesis in connection with several of the cross sections (fig. 41 and pl. 9). The carbonate-evaporite facies of the beds of Washita age in the wells shown in figure 40 overlies the carbonate-evaporite facies of the beds of Fredericksburg age.

From a featheredge at the updip limit (fig. 40), the beds of Washita age thicken gradually southward on the Peninsular arch to about a thousand feet in the Humble Oil & Refining Co. G. C. Carlton Estate 1

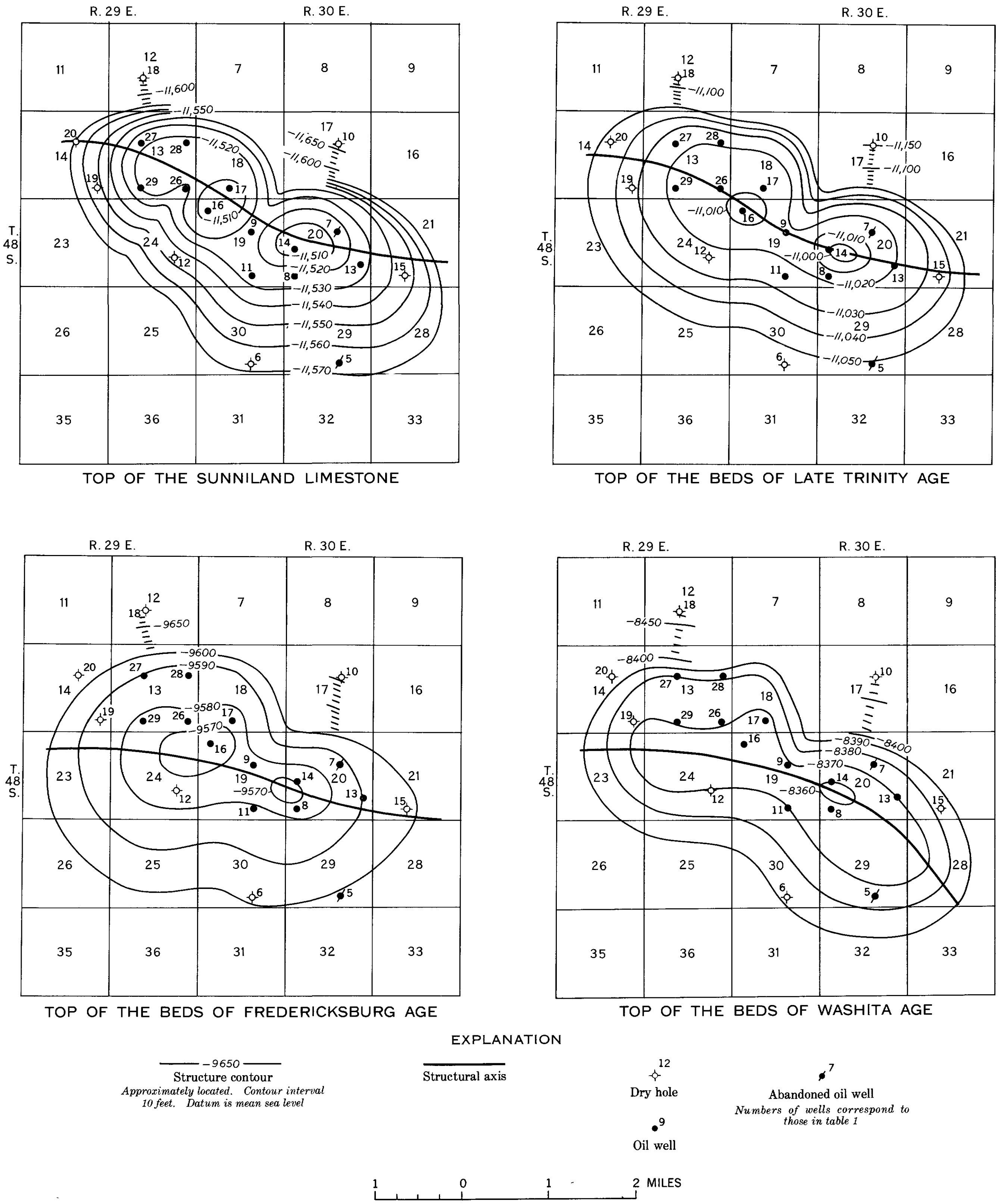

Figure 41.—Structure-contour maps of the Comanche rocks in the Sunniland oil field, Collier County, Fla.

(46, fig. 40), Highlands County. In the wells along the south Florida shelf, the thickness of the beds of Washita age ranges from 1,000 feet in Charlotte County to 1,200 feet in the Sunniland field, and to 1,600 feet in the Forty Mile Bend field. Southeastward from the Forty Mile Bend field, the unit thins to about 1,400 feet in the two wells on Key Largo, Monroe County, the Sinclair Oil & Gas Co. H. R. Williams 1 (59, fig. 40), and the Republic Oil Co. O. D. Robinson-State of Florida 1 (58, fig. 40). The thickest section of the beds of Washita age, nearly 2,000 feet, was penetrated in the Gulf Oil Corp. State of Florida Lease 373, 1 (55, fig. 40), on Big Pine Key, Monroe County.

Lithology

Uniformity of lithology and fauna characterizes the carbonate rocks in the beds of Washita age in the Florida peninsula. The carbonate rocks are composed chiefly of very fine grained calcitic dolomite (fig. 8) which, near the top of the unit, frequently contains interbedded lenses of anhydrite and chalky limestone. Traces of glauconite are a minor constituent, chiefly in updip wells. Beds of anhydrite that are significant constituents of the rocks of Washita age in the wells on the south Florida shelf decrease in number and thickness progressively northward in the wells on the Peninsular arch.

The photomicrograph in figure 8 exemplifies a typical dolomite from the beds of Washita age. The clear spaces in the picture are characteristic pores or pits that are probably due partly to dolomitization of the chalky miliolid limestone and partly to leaching of its original high microfaunal content. The sharply contrasting texture of the dolomite in the Comanche Series and of that in the younger Gulf Series in Florida is demonstrated by the comparison of figure 8 with figure 42 which shows a thin section of a characteristic sample of the lower member of the Late Cretaceous Lawson Limestone.

Scattered wells in the Florida peninsula apparently penetrated carbonate rocks of Washita age that had traces of oil at random levels from the lower part of the unit to the top. The data relating to the showings are derived chiefly from the study of cores and cuttings prepared for microscopic examination and consequently are here classified only as oil-stained limestone and dolomite and asphaltic or tarry residue.

Fauna

Abundant specimens of *Nummoloculina heimi* Bonet (fig. 43) are diagnostic of the microfauna of the rocks of Washita age and are commonly accompanied by a few specimens of other genera of Miliolids, several undescribed species of ostracodes, and a few specimens of other Foraminifera. Complete specimens of *N. heimi* were obtained from chalky limestone in beds of Washita age in a well drilled near the southern end of the Florida peninsula. Photographs of two of these specimens are shown on plate 1, figures 15 and 16.

Correlations

The correlation of the subsurface beds of Washita age in Florida and of the uppermost Comanche rocks that crop out in parts of Mexico and Texas is suggested on the basis of the occurrence in these widely separated areas of essentially the same miliolid fauna.

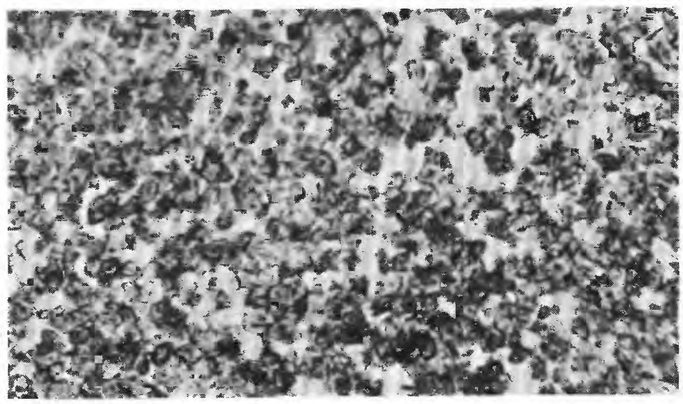

FIGURE 42.—Photomicrograph of a thin section of dolomite common in the Gulf Cretaceous of Florida. Shown for contrast with the typical dolomite of the Comanche Series. Mode of rhombs about 120 microns. Thin section from lower member of the Lawson Limestone. Hunt Oil Co. H. L. Hunt 1, Baker County, Fla. Cuttings, 2,370–2,380 feet. × 30.

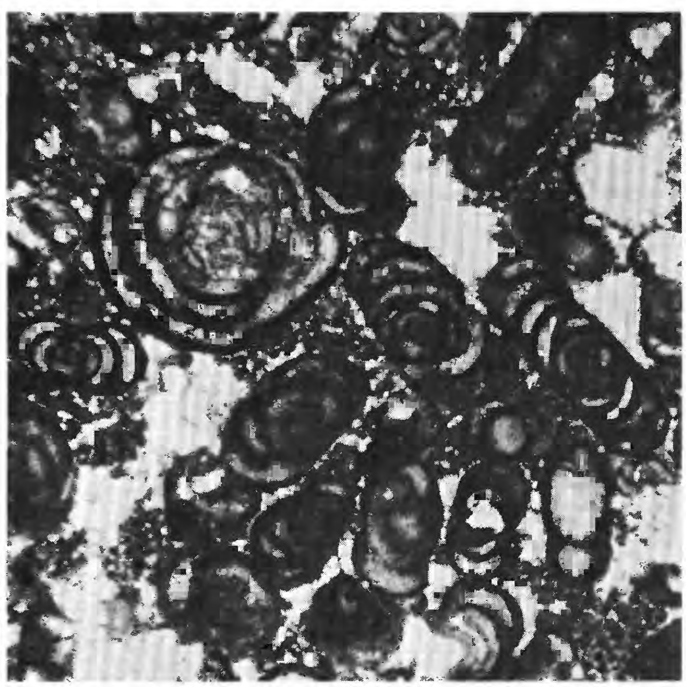

FIGURE 43.—Photomicrograph of a thin section of limestone showing abundant sections of *Nummoloculina heimi*. Beds of Washita age. Peninsular Oil & Refining Co. J. W. Cory 1, Monroe County, Fla. Core, 8,225–8,250 feet. × 30.

The faunal similarity of the miliolid limestone in the upper part of the Comanche rocks in the Oil Development Co. of Florida J. Ray Arnold 1 (49, fig. 40), Lake County, and the Peninsular Oil & Refining Co. J. W. Cory 1 (57, fig. 40), Monroe County, and the outcropping El Abra Limestone in Mexico has been pointed out by us (Applin and Applin, 1944, p. 1721–1722). The late Dr. J. A. Cushman also noted the faunal similarity of the limestone in Florida and Mexico. With reference to a core at 5,402–5,406 feet in the Arnold well, he stated (written communication, 1937) "It seems to me, unquestionably, that the small piece of hard rock is very similar to samples I collected at the El Abra Quarry in Mexico, in fact, I should have thought it came from there if you had not said otherwise."

Muir (1936, p. 36) pointed out that in Mexico

> The rocks exposed in the front range, named Sierra del Abra, west of Tampico, may be taken as representative of the character of the limestone reservoir rock in the Southern oil fields. The name El Abra has been applied to this group, but strictly speaking there are two facies: El Abra (miliolid) above and Taninul (rudistid) below. The latter belongs in part to the Albian ("Edwards" of Texas) and the former to the Lower Cenomanian (Buda and probably some Georgetown, of Texas).

In a discussion of the stratigraphy of the El Abra Limestone in the Southern fields in Mexico, Muir (1936, p. 41) reported

> *Pecten roemeri* Hill was identified by L. W. Stephenson in limestone fragments blown from the Mexican Gulf Oil Company wells No. 3 Tepetate and No. 23 Zacamixtle. * * * The horizon at which the oil was found in these two wells can be referred to the top, or close to the top of El Abra limestone. *P. roemeri* is a diagnostic fossil for the top of the "Buda" limestone of Texas.

The relationship of the miliolid fauna of the beds of Washita age in Florida and the miliolid facies of the El Abra Limestone in Mexico is strikingly demonstrated by the photomicrographs (figs. 43, 44). Figure 44 depicts a thin section of a sample from the outcrop at the top of the El Abra Limestone at El Abra quarry, the type locality; figure 43 shows a typical example of the miliolid limestone in a core at 8,225–8,250 feet in the Peninsular Oil & Refining Co. J. W. Cory 1 (57, fig. 40), Monroe County, Fla. The top of the beds of Washita age in the Cory well is at 8,106 feet.

The uniform faunal character of the rocks of Washita age in Florida is indicated by the occurrence of the *Nummoloculina* limestone in the Arnold well in Lake County, near the updip limit of the carbonate rocks, and in the Cory well (fig. 40) near the southern end of the peninsula. Wells on the Florida Keys also penetrated limestone containing this miliolid fauna. Figures 14 and 15 on plate 1 show complete specimens of *Nummoloculina heimi* from cuttings of soft dolomitic chalk at 8,300–8,320 feet in the Gulf Oil Corp. State of Florida Lease 373 well 1 (55, fig. 40), Big Pine Key, Monroe County. The beds of Washita age in this well are found stratigraphically from 7,550 to 9,540 feet.

Conkin and Conkin (1956, fig. 3) pointed out the close similarity of specimens of *Nummoloculina* that are dominant in the miliolid fauna at the top of the Devils River Limestone facies of the Washita in Val Verde County, Tex., to the *Nummoloculina* that are abundant at the top of the miliolid member of the El Abra Limestone in Mexico.

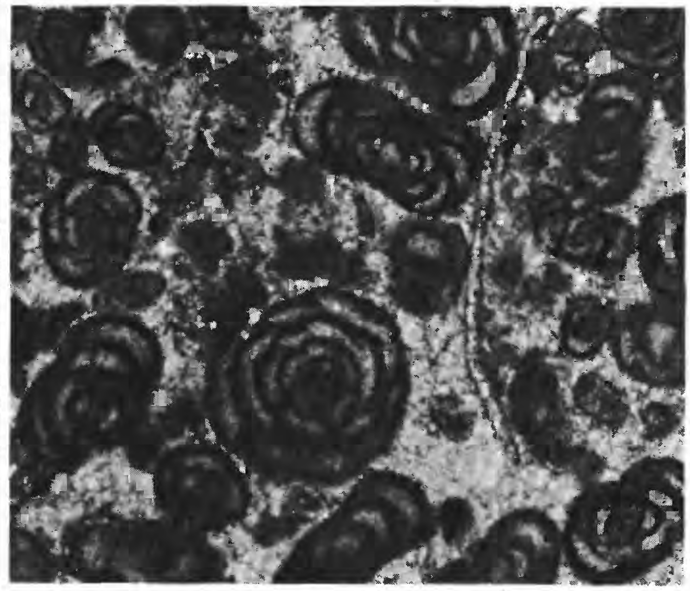

FIGURE 44.—Photomicrograph of a thin section of limestone from the "top of the El Abra" in Mexico. From "Entrada de la Cueva El Pachion Cera del Rancho del miso nombre. Sierra de El Abra." Collected by Federico Bonet, Petroleos Mexicanos: Institute Politecnico Nacional: Mexico, D. F. × 30.

Federico Bonet (1956, p. 402–406; pls. 3, 4) described and figured *Nummoloculina heimi* from the upper part of the El Abra Limestone in Mexico and pointed out that this species occurs in the subsurface in Florida and at localities in Texas designated by Conkin and Conkin (1956).

We have mentioned in this report the presence of *Nummoloculina* in miliolid assemblages in beds of Fredericksburg age in Florida. The specimens are not as large and are far less abundant, however, than in the beds of Washita age where the miliolid limestones are largely composed of tightly packed specimens of *Nummoloculina heimi.*

The Conkins (1958) revised the genus *Nummoloculina* and pointed out (p. 150) that

> the El Abra miliolid member is composed of innumerable * * * specimens of *Nummoloculina heimi.* * * * The writers' sample of the Devils River Limestone contains innumerable specimens of *Nummoloculina heimi* * * *; the Edwards and Glen Rose Limestones of Texas, and the Fredericksburg limestone of Florida do not contain specimens of *Nummoloculina heimi* in such great abundance * * *.

The sample of the Devils River Limestone mentioned by the Conkins (p. 150) was from the upper few feet of the unit, immediately below the Del Rio Clay, of former usage.

In a discussion of *N. heimi*, the Conkins (1958, p. 156) further report

Large individuals * * * are generally found only where there are abundant specimens present as in * * * the El Abra and Devils River Formations. * * * Only a few large specimens of *Nummoloculina heimi* were found in the other limestones.

The Washita age of the *Nummoloculina* limestone in Florida is supported by a megafossil in a core at 9,611–9,625 feet in the Peninsular Oil & Refining Co. Cory well. By permission of Dr. Herman Gunter (oral communication, 1955), an excerpt from a letter of November 7, 1939, from Dr. L. W. Stephenson is here quoted. Stephenson identified the fossil as "* * * a flat valve of *Neithea*, resembling *Pecten* (*Neithea*) *texanus* Roemer from the upper part of the Comanche Series." In Texas, the species is recorded only from beds of Washita age (Adkins, 1928, p. 127).

COMANCHE SERIES(?) OR GULF SERIES(?)
GREEN SHALE UNIT

Distribution and thickness

Nearly all the wells in south Florida penetrated a bed of green shale that lies between the carbonate-evaporite facies of the beds of Washita (Comanche) age below and the predominantly carbonate rocks of the Atkinson (Gulf) Formation above. The green shale unit is known to occur in wells in central Florida as far north as the Magnolia Petroleum Co. Schroeder-Manatee, Inc. 1 (52, fig. 40), Manatee County; Humble Oil & Refining Co. G. C. Carlton Estate 1 (46, fig. 40), Highlands County; Amerada Petroleum Corp. Cowles Magazines 2 (68a, fig. 40), St. Lucie County. The thickness of the green shale ranges from a few inches to not more than a few feet. Owing to the sharp lithologic contrast with the underlying and overlying rocks, it is a readily recognizable stratigraphic marker of considerable significance in subsurface investigations.

Lithology

The distinctive characteristic of the shale is its color, which in the different wells ranges through various shades of green, from grayish green and blue green to emerald. The shale is smooth and waxy, has a conchoidal fracture, and is noncalcareous to weakly calcareous. Except for a few thin layers of ostracode carapaces in cores from a few scattered wells, organic remains are rare to absent. When wet, the shale flakes readily and consequently is not recovered in some cores. Sets of consecutive cores from several wells, however, were available for study. The green-shale unit in most wells rests on finely granular anhydritic or silty dolomite containing specimens of *Nummoloculina heimi* Bonet, the diagnostic foraminiferal species of the Washita, but in the set of consecutive cores from the Humble Oil & Refining Co., Collier Corp. 1 (3, fig. 40), Collier County, the green shale overlies anhydrite. In the Collier Corp. well, gray to dark-gray argillaceous limestone at the base of the Atkinson Formation is underlain by 6 inches of green shale at 8,605–8,605½ feet. At 8,605½–8,606 feet, a core of anhydrite contained meandering narrow crevices filled with green shale, and at 8,606–8,607 feet, laminated anhydrite contained partings of green shale and microgranular dolomite. In downward sequence, the immediately underlying cores are composed of interbedded anhydritic dolomite, anhydrite, and dolomitic limestone. Specimens of *N. heimi* occurred in a core at 8,649–8,650 feet.

A laboratory study by the U.S. Geological Survey determined the mineral composition of samples of the shale in three wells, and on the basis of X-ray diffraction patterns, the minerals composing the different samples were indicated "* * * in the approximate order of estimated relative abundance."

Humble Oil & Refining Co., Gulf Coast Realties Corp. "C" 1 (22, fig. 40), Collier County.
- Core 49. 8,512–8,520 ft. Sample from middle 2 ft of core.
  - Major abundance, illite.
  - Minor abundance, calcite.
  - Trace, dolomite.

Amerada Petroleum Corp., Southern States Land and Timber Co. 1 (66, fig. 40), Palm Beach County.
- Core 7. 7,370–7,434 ft. Sample from 7,371–7,371 ft 8 in.
  - Major abundance, illite.
  - Minor abundance, dolomite.

Amerada Petroleum Corp., Cowles Magazines 2 (68a, pl. 7) St. Lucie County.
- Core 4. 6,720–6,846 ft. Sample from 6,789½–6,791 ft.
  - Major abundance, illite.
  - Minor abundance, siderite.

The green coloring is evidently due to illite inasmuch as other green pigmenting minerals, such as glauconite and chloritic minerals, were not reported. According to Grim (1951, p. 231), illite is green, yellow, or black, and Keller (1953, p. 6) reported "* * * the green clay mineral which is found to be common in marine sedimentary rocks is illite."

Fauna

Ostracode carapaces that were observed in cores from a few wells, as mentioned above, compose the known fauna of the green shale unit. A sample of core 7 at the depth of 7,371 feet in the Amerada Petroleum Corp. Southern States Land and Timber Co. 1 (66, fig. 40), Palm Beach County, showed the contact of the green-shale unit and the tan chalky limestone at the base of the overlying Atkinson Formation. A bedding plane in brownish-green shale at the top of the shale unit was covered with specimens of smooth ostracodes oriented at random. With reference to a sample of the core provided by Amerada, I. G. Sohn, U.S. Geological Survey, reported (written communication, 1956).

I do not know whether these ostracodes are marine, brackish, or fresh water. Marine ostracodes usually consist of many genera, this assemblage is apparently only one species. * * * A concentration of ostracodes can be obtained under at least two conditions, (1) shallow basins, (2) near mouths of rivers where organic material is plentiful.

Sohn did not give an age assignment to the ostracodes.

Contact green shale in Mexico and Texas

Thin beds of green shale at approximately the equivalent stratigraphic position of the green shale unit in Florida have been reported in Mexico and Texas. We by no means attempt to correlate the green shales in the different areas but call attention to the occurrences in the hope of stimulating further investigations.

Muir (1936, p. 45, 49, 53; fig. 8; table II) pointed out that in Mexico a bed of green shale at the base of the Agua Nueva overlies the Tamaulipas Limestone at several outcrop localities and in the wells in the Pánuco area. In regard to the Agua Nueva in wells in the northern fields, Muir (p. 49) reported

This basal black shale contains about 5 feet of "emerald green shale" (columnar section, fig. 8). * * * Its colour is due to a large proportion of altered volcanic tuff in its composition. * * * Generally in Topila, Isleta, and the crestal areas of Pánuco and Cacalilao this distinct green bed directly overlies the white limestone at the top of the Tamaulipas.

Lozo (1951, p. 67–69) discussed the "* * * historical background on outcrop Woodbine basal clays," and referred to the "Basal clay" that is one of three divisions into which J. A. Taff, in 1893, divided the "Dakota (Lower Cross Timbers) Formation." Lozo pointed out the repeated citation by Taff of a thin "greenish-blue contact clay" in the "Basal clay" division and added that this stratum is "* * * now thought to be a remnantal soil developed on the Grayson prior to Woodbine deposition."

GULF SERIES

ATKINSON FORMATION

The name Atkinson Formation (Applin and Applin, 1947) was introduced with three unnamed members (upper, middle, and lower) for the pre-Austin rocks of the Gulf Series in the subsurface in southern Alabama and Georgia and northern Florida. The Atkinson Formation is correlated with the Tuscaloosa Group and the lower part of the Eutaw Formation of the subsurface in Mississippi and Alabama and, in part, with the outcropping Tuscaloosa Group and the McShan Formation in west-central Alabama. In general, the upper member of the Atkinson Formation contains a microfauna of Eagle Ford age; the middle and lower members contain a microfauna of Woodbine age. The middle and lower members of the Atkinson Formation in Alabama and Georgia are differentiated, chiefly, on a lithologic basis. In that area, the middle member of the Atkinson is predominantly a shale of marine origin, correlated with the unit known as the marine shale zone of the Tuscaloosa. The nonfossiliferous littoral or nonmarine sandstone and the red shale, which compose the lower member of the Atkinson in the northern part of the Alabama and Georgia Coastal Plain, merge laterally southward into a fossiliferous marine facies. In the Florida peninsula, the distinguishing lithologic characteristics of the middle and lower members of the Atkinson Formation are indistinct. 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, the Atkinson Formation was redefined (Applin, 1955, p. 187) 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. In this report, discussion of the Atkinson Formation is confined to lithologically and faunally distinctive calcareous rocks at the base of the lower member.

These basal beds of the lower member of the Atkinson Formation in central and south Florida are separable into three distinct lithofacies that cross the peninsula in roughly parallel belts (fig. 45). In the order of occurrence from north to south, the calcareous lithofacies, which are fully described in paragraphs to follow, are classified as:

1. Oolitic limestone facies, a near-shore facies composed of white, gray-spotted, chalky limestone that varies abruptly in the proportions of its components but is generally sandy, oolitic, calcitic, and dolomitic. It contains shell fragments, microfossils, and nodules of glauconite, pyrite, and phosphate, many of which are coated with a secondary deposit of calcium carbonate. The physical and lithological heterogeneity of the facies indicate its near shore origin, possibly on a beach.
2. Sandy chalk facies, a hard white, light-gray, or brownish-gray dolomitic chalky silty or finely sandy limestone, containing abundant rounded fragments of fossil debris, microfossils, and sparse traces of glauconite. Significant lithologic characteristics that contrast sharply with the oolitic limestone facies are the predominantly fine grained sandy, the very finely comminuted fossil fragments, the relatively scarce occurrence of glauconite, and the absence of oolites. The sandy chalk facies was apparently deposited farther from shore than the oolitic limestone facies.

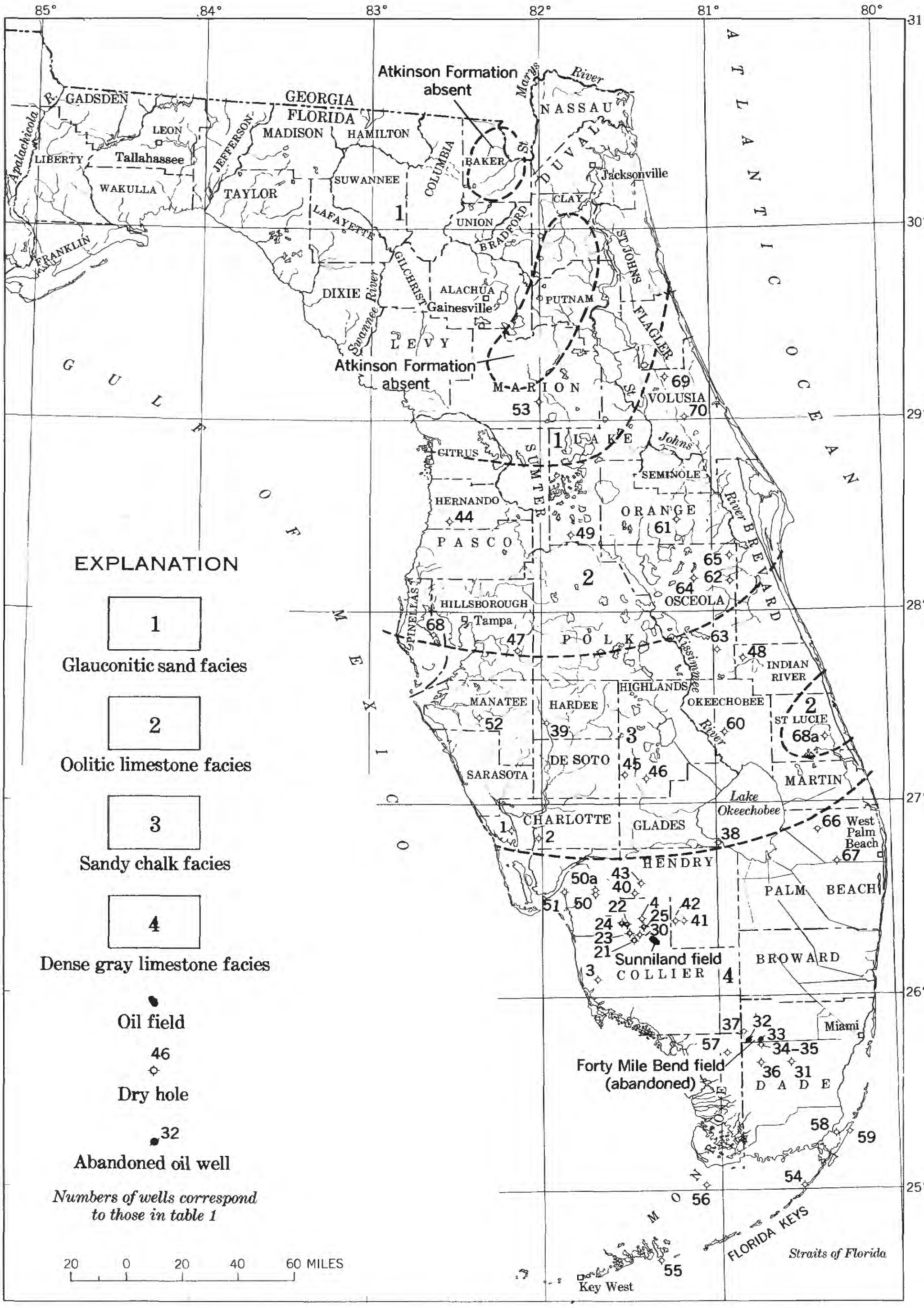

FIGURE 45.—Map of the Florida peninsula showing the approximate areal distribution of the lithofacies of the basal part of the lower member of the Atkinson Formation in central and south Florida.

3. Dense gray limestone facies, a distinctive dense limestone of uniform character, that is white to grayish buff, clayey, sparsely fossiliferous, and nonoolitic; it is generally silty or very finely sandy, containing some very thin lenses of dark shale and barite and dolomite crystals. The gray limestone facies, which contains much less sand and glauconite than the sandy chalk facies north of it, was apparently deposited in a deeper water environment farther from the source of terrigenous material.

The calcareous lithofacies just defined are here interpreted as lateral gradational variations of contemporaneous sediments. The calcareous lithofacies seem to change gradually shoreward into glauconitic sandstone and conglomerate at the base of the Atkinson Formation in the north third of the peninsula. The Atkinson Formation is absent in several wells drilled near the highest part of the Peninsular arch.

Oolitic limestone facies

The oolitic limestone facies, the northernmost of the calcareous facies of the lower part of the lower member of the Atkinson (fig. 45), has been penetrated in nine wells (44, 49, 61, 62, 64, 65, 68–70) in the north part of the central third of the peninsula. South of this group of wells, a well (68a) in St. Lucie County also penetrated a clearly characteristic sequence of the facies. In all but three of these wells, the identification of the oolitic limestone facies is based on cores. In Hillsborough County the samples of cuttings from the lower part of the Atkinson Formation in a well (47) are not sufficiently clear to definitely classify the facies.

The thickness of the oolitic limestone facies in the northern belt ranges from 19 feet in a well (49) in Lake County, about midway across the peninsula, to 100 feet in a well (44) in Hernasco County on the west coast, and 125 feet in a well (69) in Volusia County on the east coast. It is 24 feet thick in the well (68a) in St. Lucie County.

Graphic logs from samples (pl. 10) show the general lithologic and faunal characteristics of the oolitic limestone and its stratigraphic relations in six wells that penetrated typical examples of the facies.

In a well (49, fig. 45 and pl. 10) in Lake County and in wells (62, 69, 70, fig. 45 and pl. 10) near the east coast, the characteristic chalky limestone of the oolitic limestone facies is readily distinguished lithologically from the limestone, dolomite, and anhydrite of the underlying beds of Washita age. It is clearly separable, also, from the overlying part of the lower member of the Atkinson Formation that is composed of thinly interbedded very fine grained glauconitic argillaceous sandstone and dark sandy weakly calcareous shale. In the two wells (44, 68, fig. 45 and pl. 10) that penetrated the oolitic limestone facies on the west coast of the peninsula, the chalky limestone is interbedded with thin lenses of dark carbonaceous silty shale and fine-grained calcareous glauconitic sandstone. Many of the shale and sandstone lenses are fossiliferous.

The white, gray-spotted, chalky limestone of the oolitic limestone facies is generally sandy, oolitic, highly calcitic, and dolomitic and contains shell fragments, microfossils, and nodules of glauconite, pyrite, and phosphate. Although uniform in general aspect, the limestone shows abrupt and repetitious variations in the distribution and relative abundance of sand, oolites, microfossils, and shell breccia. The nuclei of the oolites are commonly sand grains and a few Foraminifera, ostracodes, and particles of other types of organic debris, such as shell, algal, and echinoid fragments. Glauconite nodules, which are unevenly distributed in the unit, are generally bright green and irregular to rounded. In some samples of the oolitic limestone facies, sand grains about the size of small pebbles and calcitic molds of small fossils are evenly incrusted with a thin hard layer of calcium carbonate.

Typical examples of the lithologic variations of the oolitic limestone are shown in figures 46 and 47. Figure 46 shows a part of a thin section in which irregularly

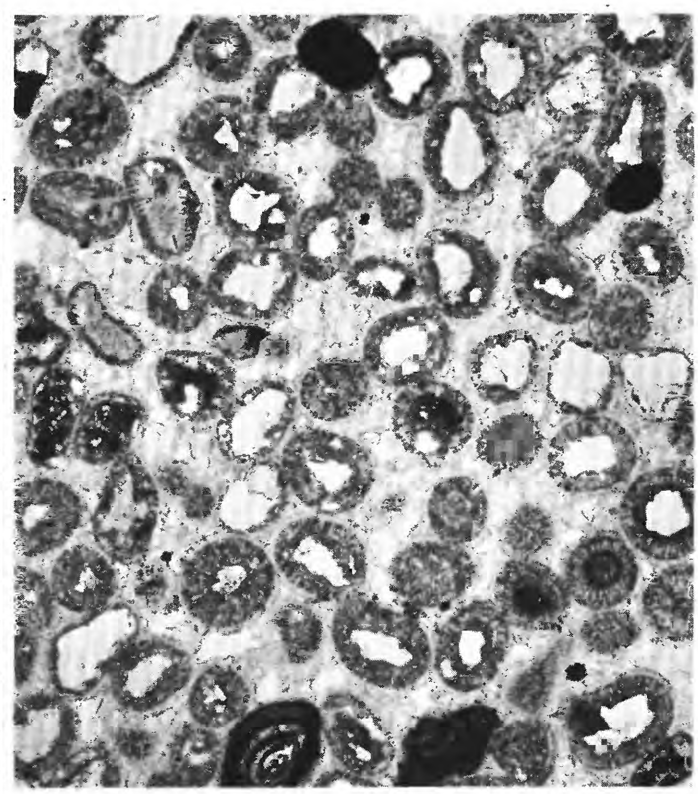

FIGURE 46.—Photomicrograph of a thin section, showing abundant oolites, many having sand grains as nuclei; little fossil material present. Oolitic limestone facies of the lower part of the lower member of the Atkinson Formation. (All specimens from The Ohio Oil Co. Hernasco Corp. 1, Hernando County, Fla. Core, 5,528–5,533 feet. × 30.)

and closely packed oolites occur in a coarse-grained matrix that has a sugary texture. Grain size of the matrix ranges from 0.35 to 0.008 mm. The oolites, which are generally round, show concentric and well-defined radial structure. They are principally in the size range of 0.1–0.6 mm in maximum dimensions and have an oolitic shell about 0.99 mm thick. The nuclei are generally angular, irregular, or blocky sand grains, although some nuclei are fossil fragments. The sand grains forming the nuclei are principally quartz, about half of it characterized by undulatory extinction; a few of the nuclei are glauconite and others are grains of feldspar. Both microline and plagioclase feldspar are fairly common; some of the feldspar is characterized by subhedral overgrowths. Some of the quartz has secondary enlargements, and some of the grain outlines are so irregular that they suggest postdepositional enlargements. Some of the plagioclase is rimmed by authigenic overgrowths in different orientation. A few of the sand grains are not centers of oolites but are scattered in the matrix, and in a few of these a pale green mineral, either chlorite or glauconite, has grown in fissures.

Pyrite is chiefly concentrated in very small specks in the glauconite, but some larger grains are present in the matrix. Glauconite, pyrite, and brown carbonate occur together; some of the carbonate seems to fill fissures in the glauconite.

Figures 46 and 47, which are photomicrographs of thin sections cut from different parts of the same 5-foot core, clearly demonstrate the abruptness of the variations in the proportion of the components of the oolitic limestone.

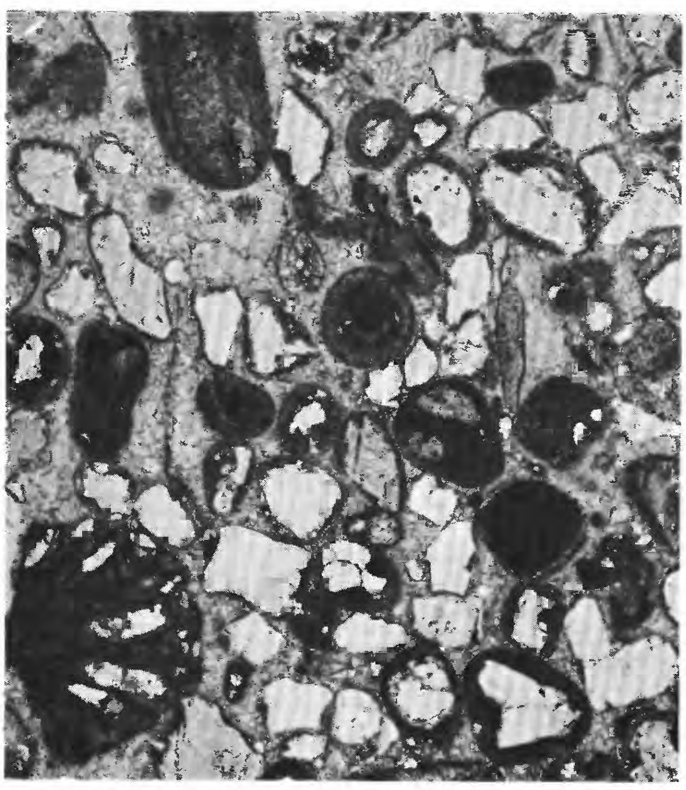

FIGURE 47.—Photomicrograph of a thin section of a very sandy sparsely oolitic limestone. Oolitic limestone facies of the lower member of the Atkinson Formation. (All specimens from The Ohio Oil Co. Hernasco Corp. 1, Hernando County, Fla. Core, 5,528–5,533 feet. × 30.)

The microfauna of the oolitic limestone facies of the lower member of the Atkinson is composed mainly of specimens of *Trocholina floridana* Cushman and Applin (pl. 2, figs. 3, 4a, b), accompanied by a few specimens of *Cuneolina walteri* Cushman and Applin (pl. 2, figs. 1a, b, 2) and *Palmula* cf. *P. leai* Loeblich and Tappan, and several undetermined species of Ostracoda and Miliolidae. *Trocholina fluoridana* is the distinctive microfossil of the oolitic limestone facies; specimens are common to abundant in chalky lenses, but the fossil has not been recorded from other stratigraphic units or from other geographic areas. In the published description of the holotype of *T. floridana* (Cushman and Applin, 1947, p. 30), the age of the containing beds are classified as "* * * the upper part of the Lower Cretaceous." On the basis of additional subsurface data that later became available, however, the age assignment of the species is changed in the present report to the basal part of the lower member of the Atkinson Formation.

Abundant fragments of pelecypods and gastropods and some immature specimens of these fossils compose the larger part of the megafauna of the oolitic limestone facies, which contains, in addition, a few specimens of the bivalve, *Exogyra woolmani* Richards, the small echinoid, *Porpitella micra* H. L. Clark, and fragments of echinoid plates and spines.

Small echinoids found in cores at 5,502–5,505 feet and 5,528–5,533 feet in The Ohio Oil Co. Hernasco Corp. 1 (44, fig. 45 and pl. 10), Hernando County, were identified by C. W. Cooke, U.S. Geological Survey, (written communications, 1947, from J. B. Reeside, Jr.) as *Porpitella micra* H. L. Clark. The genotype of *Porpitella* is a European species attributed to the Eocene. Clark (1937) described *Porpitella micra* from specimens found in cuttings at 3,800–4,000 feet from the Rice Oil & Gas Co. Oakley Estate 2 (sec. 9, T. 3 N., R. 29 E.), Houston County, Ala., and assigned to it an Eocene age because of the age of the genotype and other related European species. He (1937, p. 249) pointed out that Miss Winnie McGlamery, Alabama Geological Survey, questioned the Eocene age assignment. Our later subsurface investigations in southeastern Alabama and adjacent parts of Georgia and Florida indicate that the specimens of *Porpitella micra* from the Oakley well are of early Atkinson (early Gulf) age.

A core of dark-gray shale at 7,156–7,158 feet near the top of the oolitic limestone facies in the Coastal Petroleum Co. E. C. Wright 1 (68, fig. 45 and pl. 10), Pinellas County, contained specimens of an *Exogyra* which Dr. L. W. Stephenson (written communication, 1952) reported "* * * appear to be good examples of *Exogyra woolmani* Richards."

Specimens of *Exogyra woolmani* Richards that occur in the carbonate lithofacies of the lower member of the Atkinson Formation in several wells in central

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and south Florida aid in confirming the Woodbine age of the unit. Richards (1947, p. 35–36) described the type found at a depth of 755 feet in a water well near Norfolk, Va., reported the species from other wells along the Atlantic Coast, and recorded its age as "Upper Cretaceous (Tuscaloosa)." Stephenson (1952, p. 18, 19, 78) discussed the occurrence of *E. woolmani* in subsurface beds of probable Woodbine (Tuscaloosa) age in north Florida and the Carolinas and pointed out the close relation of the species to *E. columbella levis* Stephenson, a larger and broader form that occurs in the upper part of the Woodbine Formation in Texas.

Detailed lithologic and faunal descriptions of cores of the oolitic limestone facies have not been published previously. Continuous or nearly continuous sets of cores from three wells provided typical examples of the oolitic limestone facies and associated rocks and amplify the graphic logs of these wells (N. 44, 68, 70, pl. 10). The descriptions by E. R. Applin follow.

Oolitic limestone facies of lower member of Atkinson Formation and associated rocks in the Ohio Oil Co. Hernasco Corp. 1, sec. 19, T. 23 S., R. 18 E., Hernando County, Fla. (44, pl. 10)

Gulf Series:
Atkinson Formation:
Lower member (upper part):

Core		Depth (feet)
11–14	Shale, gray, calcareous, micaceous; with thin partings of fine-grained sandstone and specimens of arenaceous Foraminifera characteristic of beds of Woodbine age: *Ammobaculites agrestis*, *Ammobaculites bergquisti*, *Haplophragmoides advenus*, *Haplophragmoides langsdalensis*, *Globigerina* cf. *G. cretacea*, pyritized diatom molds. The shale grades rapidly downward into gray micaceous glauconitic sandstone	5, 470–5, 498
15	Recovered 7 ft: Top 4 ft, shale, dark-gray, hard, flaky, somewhat carbonaceous. Thin lenses in the shale are highly sandy, micaceous, and glauconitic. Oolitic limestone facies: Bottom 3 ft, limestone, light-gray, hard, dense, oolitic, sandy, glauconitic; contains abundant fragments of fossil bivalves and specimens of *Porpitella micra*. (p. 69)	5, 498–5, 505

Oolitic limestone facies, Hernasco well 1—Continued

Core		Depth (feet)
16	Recovered 3.9 ft: Top, like bottom part of core 15. Middle and bottom, sandstone, gray, calcareous, fine to very fine grained, micaceous, carbonaceous, glauconitic; contains small fragments of shells	5, 505–5, 509
17	Recovered 8.1 ft: Top and middle, sandstone, light-gray, calcareous fine- to medium-grained, carbonaceous, glauconitic. Bottom, limestone, light-gray, silty, glauconitic	5, 509–5, 519
18	Recovered 6.9 ft: Top, siltstone, light-gray, micaceous, carbonaceous; contains lenses of fine-grained light-gray glauconitic, calcareous sandstone. Middle and bottom, sandstone, gray, fine- to coarse-grained, glauconitic; contains lenses of chalk and micaceous carbonaceous siltstone. Chalk lenses contain specimens of *Cuneolina walteri* (pl. 2, figs. 1a, b, 2) and *Trocholina floridana* (pl. 2, figs. 3, 4a, b)	5, 519–5, 628
19	Recovered 4.6 ft: Top, limestone (fig. 46), white, sandy, oolitic, glauconitic; contains a small Echinoid (*Porpitella micra*), *Trocholina floridana*, fragments of *Turritella* sp., fossil bivalves, and sections of miliolids, ostracodes, and echinoid spines. Middle, similar to preceding sample, but more finely sandy and less fossiliferous and oolitic; glauconite rare (fig. 48). Bottom, chalk, white, hard, finely sandy, micaceous, glauconitic, oolitic	5, 528–5, 533
20	Recovered 4.0 ft: Top, chalk, light-gray, finely sandy, oolitic, glauconitic, micaceous; contains fragmental fossils and sections of miliolids. Middle, sandstone, light-gray, chalky, fine-grained, glauconitic; contains a few shell fragments and sections of miliolids.	

Oolitic limestone facies, Hernasco well 1—Continued

Core		Depth (feet)
	Bottom, oolite, chalky, sandy, glauconitic; contains fragments of fossil shells, sections of miliolids, and streaks of gray unctuous micaceous calcareous shale	5, 533–5. 537
21	Recovered 8.3 ft:	
	Top, sandstone, moderately coarse grained, micaceous, glauconitic, calcareous; contains fragmental fossil shells and some pebbles.	
	Middle and bottom, sandstone, light-gray, glauconitic, calcareous, moderately fine to coarse-grained; contains worn fragments of fossil shells	5, 537–5, 547
22	Recovered 1.0 ft:	
	Top, middle, and bottom, like middle and bottom of core 21	5, 547–5, 549
23	Recovered 3.9 ft:	
	Top, middle, and bottom, like core 22	5, 549–5, 553
24	Recovered 3.3 ft:	
	Top, sandstone, micaceous, glauconitic.	
	Middle, sandstone, light-gray, soft, glauconitic, micaceous, moderately fine grained.	
	Bottom, sandstone, hard, moderately fine to very coarse grained, glauconitic; contains fragments of fossil bivalves and streaks of dark-gray micaceous shale	5, 553–5, 558
25	Recovered 8.3 ft:	
	Top, sandstone, moderately fine grained, glauconitic, micaceous, calcareous.	
	Middle, siltstone, hard, calcareous, micaceous, slightly glauconitic; contains fragments of fossil bivalves.	
	Bottom, dolomite, brown, dense; contains veinlike stringers of anhydrite and calcite	5, 558–5, 568
26	Recovered 5.0 ft:	
	Top, shale, light-bluish-green, unctuous; contains irregularly distributed fine-grained sand and many worn fragmental fossils.	
	Middle, siltstone, light-gray, hard, calcareous.	
	Bottom, limestone, white, hard, sandy, glauconitic; contains worn fragments of fossil shells and irregular areas of finely crystalline, white anhydrite	5, 568–5, 578
27	Recovered 5.0 ft:	
	Top, limestone, like bottom of core 26 but contains more glauconite and dolomite.	

Oolitic limestone facies, Hernasco well 1—Continued

Core		Depth (feet)
	Middle and bottom, limestone, like preceding sample; contains fragmental fossils and inclusions of dark-gray shale	5, 578–5, 584
	Cuttings, limestone, cream to white, dense, dolomitic; contains a little fine-grained sand and a trace of glauconite	5, 584–5, 600
	Comanche Series:	
	Beds of Washita age:	
28	Top, microsucrosic dolomite, cream, hard; contains some poor molds of *Nummoloculina heimi* Bonet and a few fragments of macrofossils	5, 600–5, 602½

Oolitic limestone facies of lower member of Atkinson Formation and associated rocks in Coastal Petroleum Co. E. C. Wright 1, sec. 7, T. 30 S., R. 17 E. Pinellas County, Fla. (68, pl. 10)

Gulf Series:
Atkinson Formation:
Lower Member (upper part):

Core		Depth (feet)
1–4	Shale, dark-greenish-gray, hard, calcareous, micaceous. Contains shell fragments, phosphatic and siderite nodules, and many specimens of species of arenaceous Foraminifera characteristic of beds of Woodbine age: *Ammobaculites agrestis*, *Haplophragmoides advenus*, *Ammobaculites* cf. *A. stephensoni*, *Ammobaculoides plummerae*, *Globigerina* sp., *Reophax deckeri*, and undetermined Ostracoda	7, 100–7, 137
5	Recovered 10 ft:	
	2½ ft, shale, dark-greenish-gray, hard, marly; contains a few specimens of *Globigerina* sp.	
	2½ ft, marl, dark-brownish-gray; contains many minute fragments of fossil shells.	
	2½ ft, shale, moderately hard, dark-greenish-gray marly. The shale contains some phosphatic fragments of bones, and many rolled and etched small fragments of fossil bivalves similar to *Ostrea* sp.	
	1 ft, shale, similar to the above, but the shell fragments are more abundant and coarser; moderately coarse grains of quartz sand are scattered in the shale. The shale seems to be interbedded with tan, argillaceous sandstone composed, chiefly, of moderately coarse grained, roughly angular quartz, a few fragments of shells, and a little pyrite.	

Oolitic limestone facies, E. C. Wright well 1—Continued

Core		Depth (feet)
	Oolitic limestone facies:	
	1½ ft, sandstone similar to that in preceding part of core but less argillaceous	7,137–7,147
6	Recovered 4 ft:	
	2 ft, sandstone, tan, hard, calcareous, moderately fine grained; sand grains are roughly angular clear quartz. Sample contains fragments of fossil bivalves.	
	1½ ft, sandstone, hard, calcareous, glauconitic, moderately fine grained; contains irregularly shaped, dolomitic areas and fragments of fossil bivalves.	
	½ ft, sandstone, light-tan and gray, argillaceous, fine-grained to moderately coarse grained, angular; contains fragments of fossil bivalves	7,147–7,154
7	Recovered 6 ft:	
	2 ft, sandstone, light-tan and gray, hard, calcareous, glauconitic, micaceous; sand grains are fine to moderately fine and roughly angular. Sample contains fragments of fossil bivalves.	
	2 ft, sandstone, like the preceding sample, interbedded with streaks of hard dark-brownish-gray and greenish-gray shale; contains a well-preserved specimen of *Exogyra woolmani* (p. 69). Shale has speckled appearance due to abundant finely broken and crushed fossil shells, some of which are *Globigerina* sp. A thin streak of light-bluish-gray bentonitic shale cuts this part of the core.	
	2 ft, sandstone, hard, calcareous, shaly; contains abundant fragments of fossil bivalves	7,154–7,160
8	Recovered 6 ft:	
	1½ ft, shale, gray, hard, calcareous, micaceous; contains worn fragments of fossil bivalves.	
	2½ ft, limestone, white, hard, dense, oolitic, glauconitic, contains some pyrite, a few moderately large grains of quartz, phosphatic bone fragments, and specimens of *Trocholina floridana*.	
	2 ft, limestone, light-gray, oolitic, finely sandy, glauconitic; contains fragments of fossil bivalves and some phosphatic nodules	7, 160–7, 169

Oolitic limestone, facies E. C. Wright well 1—Continued

Core		Depth (feet)
9	Recovered 2½ ft:	
	1½ ft, sandstone, calcareous, glauconitic, fine- to very fine-grained.	
	1 ft, sandstone, argillaceous, fine-grained, glauconitic; contains streaks of brownish-black flaky shale	7, 169–7, 174
10	Recovered 2½ ft:	
	Top, sandstone, light-gray, soft, very fine grained, glauconitic; contains thin lenses of dark-gray flaky carbonaceous shale.	
	Bottom, shale, dark-gray, flaky, carbonaceous, silty	7, 174–7, 180
11	Recovered 6 ft:	
	Top, sandstone, light-gray, hard to soft, glauconitic, calcareous. Sand is poorly sorted, fine-grained to moderately coarse grained; contains phosphatic nodules, fragments of fossil bivalves, and lenses of dark-gray, flaky, micaceous, glauconitic shale.	
	Middle and bottom, siltstone, light-gray, soft, glauconitic, micaceous; contains lenses of dark-gray cabonaceous shale	7, 180–7, 190
12	Recovered 5½ ft:	
	Top, siltstone and shale like the bottom of core 11; contains lenses of light-gray, moderately fine grained, glauconitic micaceous sandstone.	
	Middle, shale, dark-gray, flaky, carbonaceous; contains irregular lenses of light-gray fine grained glauconitic siltstone.	
	Bottom, shale, as in preceding sample, interbedded with irregular lenses of soft, micaceous siltstone	7, 190–7, 200
13	Recovered 7½ ft:	
	4 ft, shale and siltstone like the bottom part of core 12.	
	2 ft, shale, dark-gray, flaky, carbonaceous, micaceous; contains a small amount of light-gray fine-grained glauconitic sandstone.	
	1½ ft, shale and sandstone like the preceding sample	7, 200–1, 210
	Comanche Series:	
	Beds of Washita age:	
	Limestone, cream, gray-spotted; contains a few sections of *Nummoloculina heimi* Bonet.	

Oolitic limestone facies of lower member of Atkinson Formation and associated rocks in Sun Oil Co. Powell Land Co. 1, sec. 11, T. 17 S., R. 31 E., Volusia County, Fla. (70, pl. 8)

Gulf Series:
  Atkinson Formation:
    Lower member (upper part)

Core		Depth (feet)
125–139	Sandstone, gray, glauconitic, and occasionally phosphatic; contains irregularly distributed lenses of dark-gray flaky sandy to silty micaceous shale	4, 960–5, 080
140	Recovered 6 ft: 2 ft, shale, gray, silty, micaceous, glauconitic. 2 ft, shale, like preceding part of core. 1½ ft, shale, gray, hard, micaceous, somewhat glauconitic; contains silty areas. Oolitic limestone facies: ½ ft, limestone, gray-spotted, hard, pyritic, slightly glauconitic and sandy; contains fragments of fossil bivalves, specimens of *Cuneolina walteri*, undetermined Ostracoda and sections of miliolids	5, 080–5, 090
141	Recovered 3 ft: 3 ft, limestone, white, gray-spotted, hard, glauconitic; contains abundant fragments of fossil shells, specimens of *Cuneolina walteri* and miliolids	5, 090–5, 100
142	Recovered 2½ ft: Top, limestone, white, gray spotted, hard, glauconitic, slightly dolomitic; contains fragmental fossils. Bottom, limestone, cream, black-spotted, hard, dense; contains quartz inclusions	5, 100–5, 106
143	Recovered 2 ft: 10 in., like bottom of core 142. 2 in., shale, dull green, carbonaceous; contains fragments of calcitized macrofossils. 1 ft, limestone, cream	5, 106–5, 115
144	Recovered 2 ft: 4 in., limestone, gray-spotted, dolomitic, carbonaceous; contains fragmental fossils. 20 in., limestone, gray-spotted, hard, dolomitic; contains abundant fragmental fossils	5, 115–5, 125
145	Recovered 1½ ft: Limestone, like preceding sample	5, 125–5, 135

Comanche Series:
  Beds of Washita age:
    Limestone, cream, dense, microfossiliferous; sections of *Nummoloculina heimi* Bonet common.
    Top of beds of Washita age in this well is placed at 5,130 ft on basis of electric-log characteristics.

Sandy chalk facies

The sandy chalk facies of the lower member of the Atkinson Formation has been identified by us in the samples from six scattered wells (2, 39, 46, 48, 52, 63, fig. 45) in the belt crossing the southern part of the central third of the peninsula and was questionably identified in the samples from one well (38, fig. 45). The thickness for the facies ranges from 10 feet in one well to possibly 50 feet in several others.

In most of the wells, the sandy chalk rests on the green shale unit (Comanche Series(?) or Gulf Series(?)) described in this report, but in three wells (39, 48, 63, fig. 45) it directly overlies the sequence of carbonate rocks and evaporites at the top of the beds of Washita age. The sandy chalk facies underlies a sequence of microfossiliferous shale and marl in the upper part of the lower member of the Atkinson Formation. Typical cores of the sandy chalk facies in several wells were available for study. A core at 7,778–7,779 feet (fig. 48) from a well (39, fig. 45) in Hardee County is composed of hard light-gray silty glauconitic limestone containing specimens of Foraminifera and Ostracoda and fragments of macrofossils. In a well (63, fig. 45) in Osceola County at the depth of 6,353–6,383 feet, cores of the facies are hard brownish-gray dolomitic chalky limestone interbedded with white-speckled marl containing fragmental fossils and small elliptical apparently arenaceous bodies. Cores from the depth of 6,402–6,413 feet in a well (48, fig. 45) in Indian River County are composed of hard white bioclastic chalk and chalky limestone that contain microfossils, abundant small rounded fragments of fossil debris, a small amount of fine-grained sand, and a trace of glauconite. Chalky limestone similar to that in the cores just mentioned was identified in cuttings at 8,500–8,550 feet in a well (2, fig. 45) in Charlotte County; at 7,840–7,870 feet in a well (46, fig. 45) in Highlands County; at 7,850–7,860 feet in a well (52, fig. 45) in Manatee County.

The petrographic study of a thin section (fig. 48) from a core of the sandy chalk facies indicates that the sand, which includes both quartz and feldspar, has a grain size ranging from 0.085 to 0.34 mm. Many of the quartz grains have undulatory extinction. Almost all of the feldspar, which includes plagioclase, orthoclase, and microline, is fresh and unaltered; many of the grains have authigenic overgrowths and imperfect but recognizable crystal outlines. The crystal size of the matrix is generally less than 2 microns, but some coarser streaks and fillings in fossils in the matrix have a crystal size that ranges from 4 to 25 microns.

Fragments of echinoid plates and spines (fig. 48a) are common in the comminuted fossil debris of the sandy chalk facies of the lower part of the lower member of the Atkinson, and specimens of *Guembelina* sp. (fig.

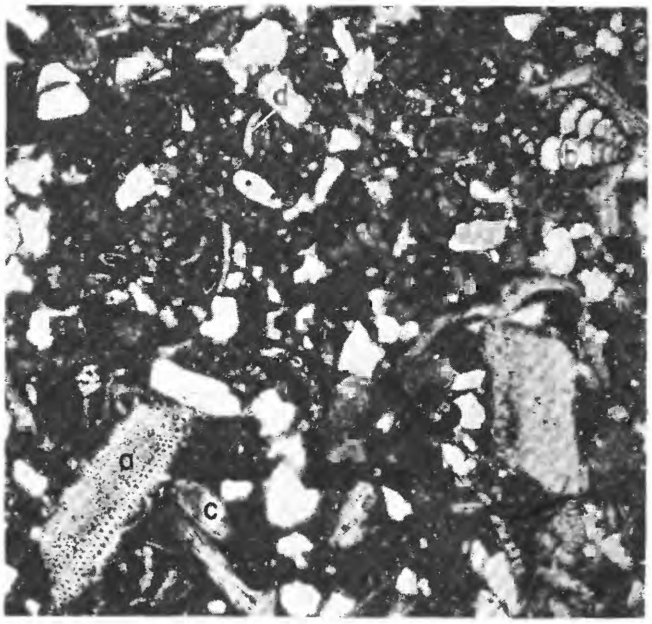

FIGURE 48.—Photomicrograph of a thin section of a sandy chalk showing echinoid fragments (a), *Guembelina* sp. (b), ostracode (c), and *Massilina* (d). Lower part of the lower member of the Atkinson Formation. Humble Oil & Refining Co. B. T. Keen 1, Hardee County, Fla. Core, 7,778–7,779 feet. × 30.

48b) are characteristic features of the faunal assemblage. Several species of ostracodes (fig. 48c) and sections of a small *Massilina* sp. (fig. 48d) in a core of the sandy chalk facies in the B. T. Keen well 1 (39, fig. 45), Hardee County, are closely similar to forms in the oolitic limestone facies already discussed.

With reference to specimens of an *Exogyra* in a core at 7,769–7,779 feet in the Keen well, Dr. L. W. Stephenson reported (written communication, 1955) that he had compared them with topotypes of *Exogyra woolmani* Richards (p. 69), and "* * * they appear to agree in every essential detail with the topotypes and I would therefore refer them to Richards' species." This fossil also occurs in the updip oolitic limestone facies of the lower part of the lower member of the Atkinson (p. 69).

In the Amerada Petroleum Corp. Fondren Mitchell 1 (48, fig. 45), Indian River County, the basal beds of the lower member of the Atkinson are hard white slightly sandy chalk and contain common to abundant fragments of macrofossils, many specimens of several genera and species of the foraminiferal family Ophthalmidiidae, some small textularian forms, and specimens of several species of small miliolids. A segment of a core at 6,404–6,406 feet in the Mitchell well contained sections of *Trocholina floridana*, the distinctive microfossil of the oolitic limestone facies (p. 69).

Dense gray limestone facies

A distinctive dense gray limestone, the southernmost of the calcareous facies of the basal part of the lower member of the Atkinson, has been identified in many of the wells in Lee, Hendry, and Collier Counties, and in the Peninsular Oil & Refining Co. J. W. Cory 1 (57, fig. 45), Monroe County. In wells near the southeast coast of the peninsula and on the Keys, the available data indicate that the gray limestone facies is lighter colored, more chalky, and possibly more fossiliferous than in the southwestern part of the peninsula. The average thickness of the facies is about 50 feet. The lithologic and faunal descriptions that follow refer to the typical dense gray limestone in the southwestern part of the peninsula.

The gray limestone, which rests on the thin stratum of green shale that lies between the Comanche Series and the Gulf Series in south Florida, is lithologically and faunally distinct from the older carbonate rocks of the underlying Comanche Series and is clearly differentiated from the overlying thick chalk sequence of the upper part of the Atkinson Formation and the successively younger units of the Gulf Series.

The characteristic dense gray to grayish-buff clayey limestone, which is fossiliferous and nonoolitic, contains a few thin lenses of silt or very fine grained sandstone, some very thin lenses of dark brownish-gray shale, and scattered barite and dolomite crystals. Fossil fragments are relatively rare, irregularly distributed, and poorly sorted, but close to the base of the section, a few wells cored several closely spaced layers of a muddy shell breccia composed of the tightly packed crushed and broken shells of an oysterlike bivalve. In one core, the inner sides of the shells were coated with a tarry residue.

According to petrographic study, the limestone matrix contains abundant specks of pyrite, which also fills the chambers of the Foraminifera. In the thin sections, scattered dolomite rhombs, a small amount of quartz, and a trace of feldspar are exposed in the limestone matrix. Angular to irregular grains of both quartz and feldspar range from 0.008 to 0.12 mm in maximum dimension and the mode is about 0.34 mm. The thin sections show subparallel aggregates of barite containing vermicular inclusions of a sulfide; the shape of the aggregates suggest that they are replacements of shell fragments.

Thin sections of the gray limestone reveal its otherwise obscure microfaunal content. The fauna is similar, in general, to that of the sandy chalk facies described previously, but differs from it by being less abundant, and by being composed of smaller microfossils and more finely comminuted fossil fragments that are irregularly distributed in the limestone matrix. Small miliolid Foraminifera and fragments of *Globigerina* (fig. 49) are fairly common in the gray limestone and are accompanied by a few sections of small specimens of *Guem-*

belina and *Bolivina*?. Fragments of echinoid spines and plates, small fragments of fossil bivalves, and fragments and specimens of ostracode carapaces make up the bulk of the fossil debris.

Dr. R. O. Vernon kindly provided us with the macrofossiliferous parts of the core at 8,502–8,592 feet in the Humble Oil & Refining Co. Collier Corp. 1 (3, fig. 45), Collier County. At our request, Dr. L. W. Stephenson (written communication, 1955) examined the fossils and stated that he questionably referred the specimens of *Exogyra* at 8,538–8,539 feet in this well to the species *Exogyra aquillana* described by him from the base of the Woodbine Formation in Hill County, Tex. (Stephenson, 1952, p. 78, pl. 18, figs. 4–6; 1953, p. 60, pl. 13, figs. 5–8).

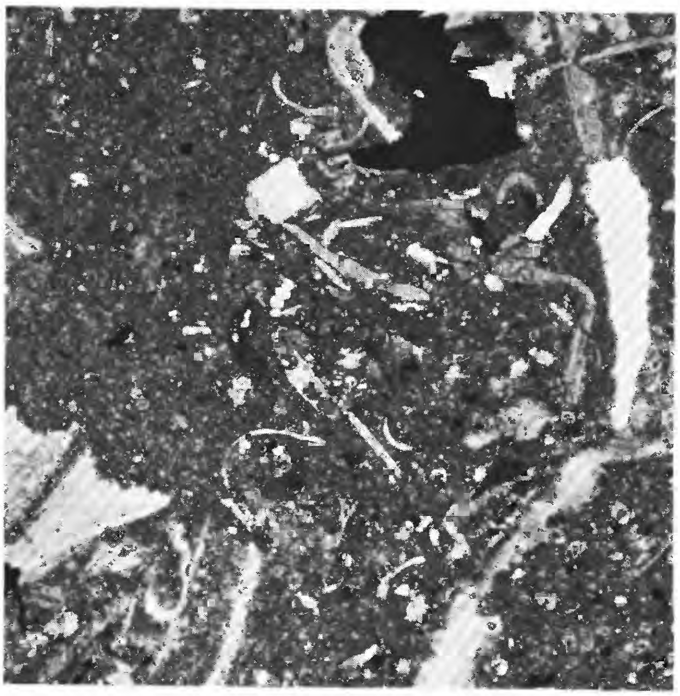

FIGURE 49.—Dense limestone that contains irregularly distributed and highly fragmental fossil debris. Irregularly shaped black areas are concentrations of pyrite particles. Gray limestone facies of the lower part of the lower member of the Atkinson Formation. Humble Oil & Refining Co. Gulf Coast Realties Corp. "C" 1, Collier County, Fla. Core, 8,487–8,497 feet. × 30.

STRUCTURE

REGIONAL STRUCTURE

The regional structure of the Comanche rocks in central and south Florida is shown by means of contour maps drawn on the tops of five stratigraphic units. From oldest to youngest, the units are the beds of early Trinity age (pl. 7), the Sunniland Limestone (fig. 50), the beds of late Trinity age (pl. 7), the beds of Fredericksburg age (fig. 51), and the beds of Washita age (fig. 52). Cross sections (pl. 9), as well as the thickness maps already discussed, further amplify the structural maps. Major structural features shown on the maps and cross sections are the southeastern part of the Peninsular arch, the south Florida shelf, the south Florida embayment, and the Broward syncline.

The Coastal Plain floor (fig. 3), on which the Comanche rocks were laid down in central Florida, slopes much more steeply toward the southeast, south, and southwest than the dip of the overlying rocks of the Gulf Series. Rocks of the Gulf Series rest unconformably on the Coastal Plain floor in the area in the north part of the peninsula in which the Comanche rocks are absent (figs. 51, 52), but away from this area the Comanche rocks thicken wedgelike down dip. The gradient of the Coastal Plain floor is about 45 feet per mile southeastward from Marion County to Cape Canaveral; southwestward from Marion County, the gradient is nearly 90 feet per mile. Near the southernmost occurrence of the pre-Coastal Plain rocks in Highlands County, the Coastal Plain floor slopes southward at about a hundred feet per mile.

The shape and position of the regional features mapped at the top of the different units of the Comanche Series coincide, in general, but the rate of dip, which is greatest in the beds of early Trinity age, decreases progressively in the younger units. The dip of the Comanche units on the Peninsular arch, like the gradient of the Coastal Plain floor, is steepest toward the southwest. On the southwest flank of the arch, the rate of dip ranges from about 60 feet per mile at the top of the early Trinity beds to about 40 feet per mile at the top of the beds of Washita age. The rate of the southwestward dip on the south Florida shelf ranges from about 20 feet per mile at the top of the early Trinity beds to about 6 to 10 feet per mile at the top of the beds of Washita age.

In contrast to the northwestward-trending axes of the Peninsular arch, the south Florida shelf, the south Florida embayment, and the Broward syncline, as shown by the structure maps of the beds of Trinity age (pl. 7), an upwarped axis trends southwestward in the vicinity of the Amerada Petroleum Corp. Cowles Magazines well 2 (68a), St. Lucie County. Local thinning of the Comanche units in the Cowles well was also mentioned in earlier paragraphs in this report, and is shown on the thickness maps of the different units (figs. 11, 13, 35, 40 and pl. 7). The apparently anomalous occurrence of the oolitic limestone facies of the lower member of the Atkinson Formation in the Cowles well (fig. 45), which has already been pointed out, is regarded as additional evidence for the upwarp.

SUNNILAND OIL FIELD

The data from 20 relatively closely spaced wells in the Sunniland oil field in T. 48 S., R. 29 and 30 E.,

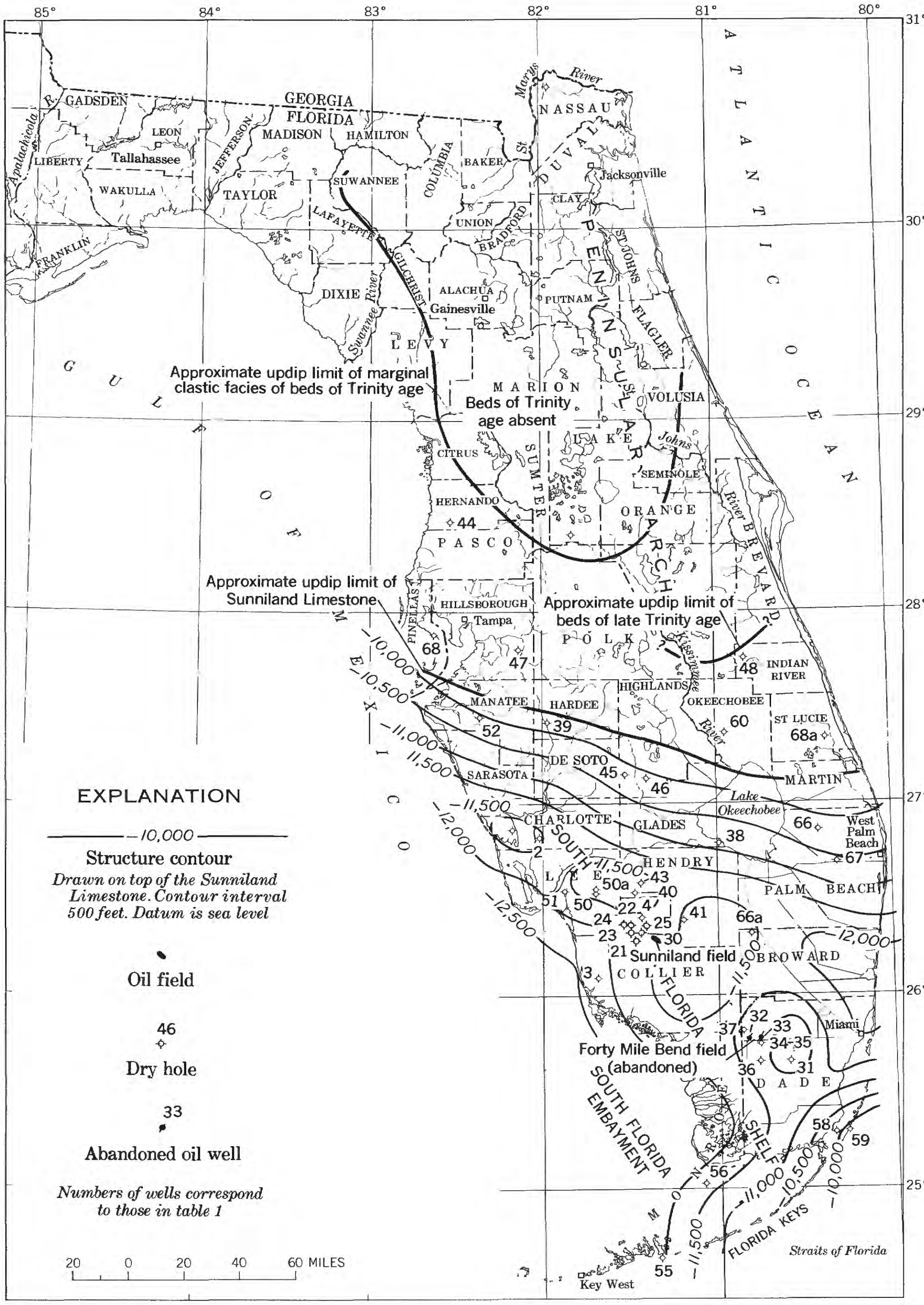

FIGURE 50.—Map of the Florida peninsula showing the structure on the top of the Sunniland Limestone in central and south Florida.

Collier County, provide the basis for detailed mapping of the subsurface structure in a localized area. Seven dry holes and thirteen oil wells, two of them abandoned, define the productive area of the field which is about 3½ miles long and 1 mile wide and covers an estimated 2,250 acres. A set of four contour maps (fig. 41) shows the structure of the Sunniland field at different horizons in the Comanche rocks—the top of the Sunniland Limestone, the top of the beds of late Trinity age, the top of the beds of Fredericksburg age, and the top of the beds of Washita age.

The structure contour maps (fig. 41) show that the

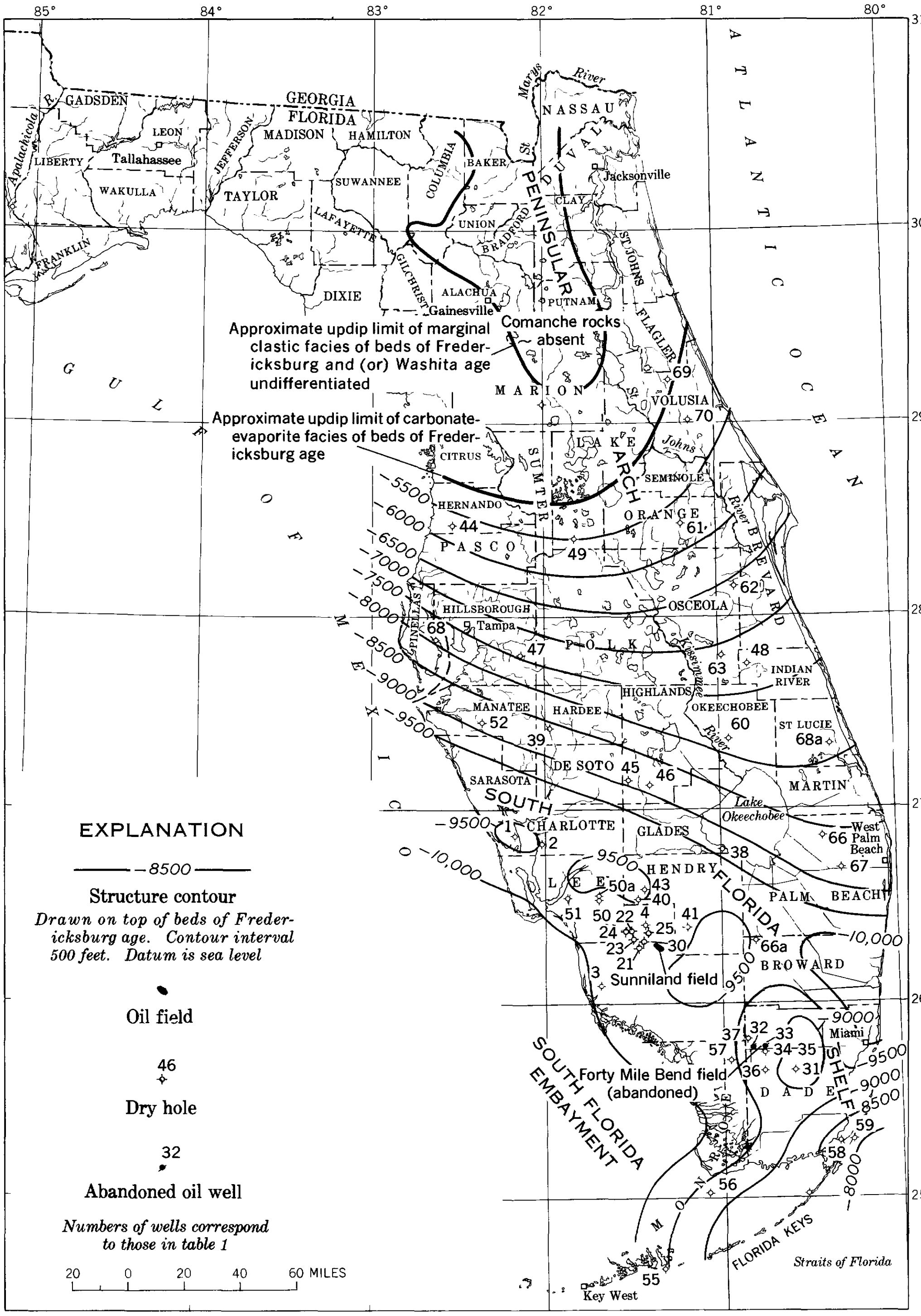

FIGURE 51.—Map of the Florida peninsula showing the structure on the top of beds of Fredericksburg age in central and south Florida.

Sunniland field is situated along the crest of a west-northwestward-trending asymmetrical anticline having the steeper dip toward the northeast. Local closures of 10 or 20 feet occur on the somewhat flattened crest. On the basis of the available data, the total amount of closure on the Summiland Limestone is estimated to be from 60 to 100 feet. The rate of dip on the different datums is greatest at the top of Sunniland Limestone and decreases progressively in the younger units of the Comanche Series. The dip of the Sunniland Limestone on the southwestern flank of the structure is about 50 feet per mile and about 150 feet per mile on the north-

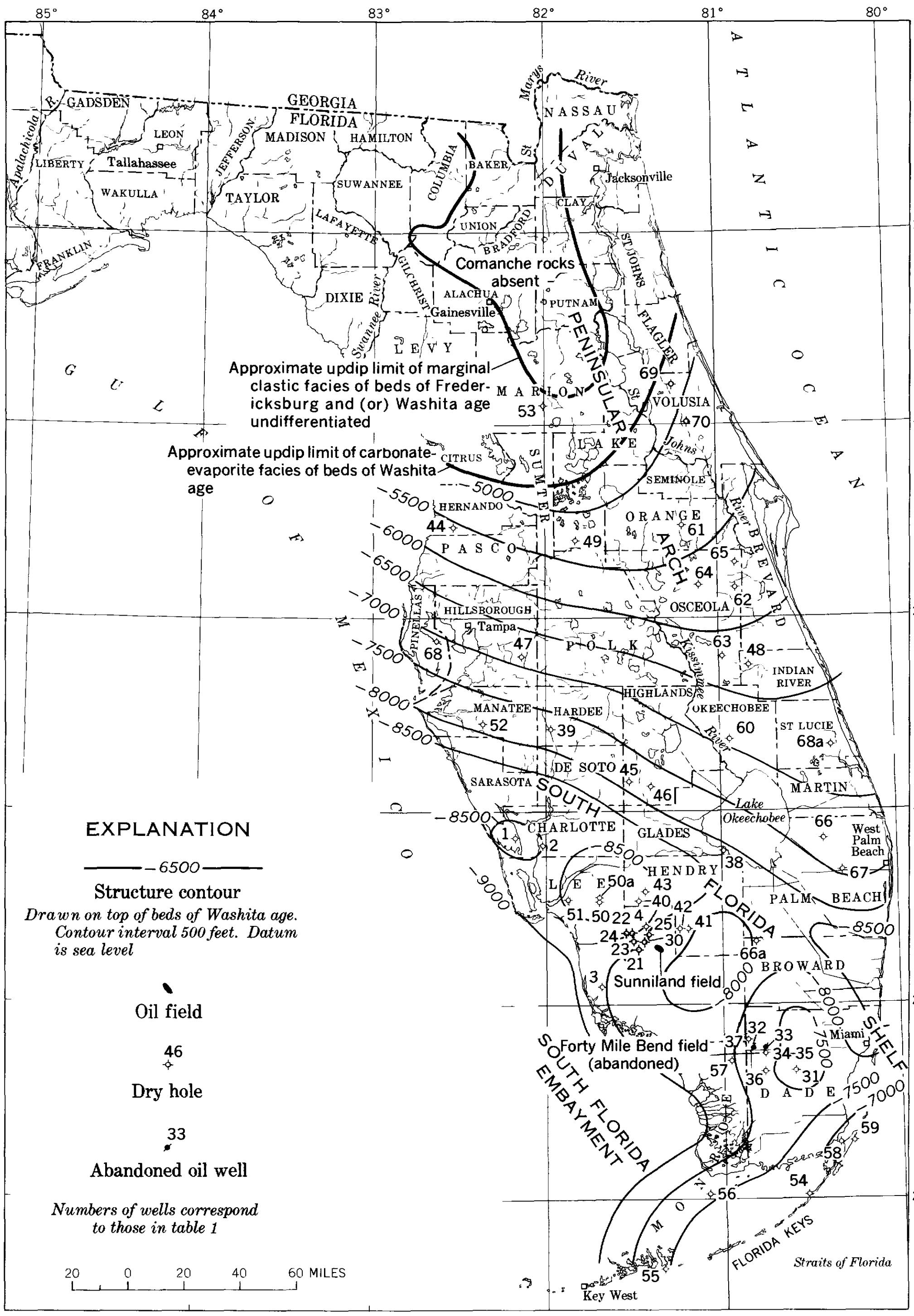

FIGURE 52.—Map of the Florida peninsula showing the structure on the top of beds of Washita age (top of the Comanche Series) in central and south Florida.

eastern flank. At the top of the beds of Washita age, however, the rate of dip toward the southwest is between 20 and 30 feet per mile but is about 90 feet per mile toward the northeast. The anticlinal structure of the Sunniland Limestone is relatively sharp in contrast to the broad structures of low relief in the younger beds of Fredericksburg age and in the beds of Washita age.

Three maps of the Sunniland oil field (fig. 53) show the local variations in thickness of the post-Sunniland beds of Trinity age, of Fredericksburg age, and of Washita age. Each map shows a thinning of the beds over the productive area of the Sunniland field, and each seems to indicate a somewhat greater rate of thickening on the southwestern or basinward slope of the structure than on the northeastern slope.

The structure maps (fig. 41) and the thickness maps (fig. 53) suggest that the long axis of the anticline shifted during Comanche time, so that at the top of the beds of Washita age the axis is about half a mile southwest of its position at the top of the Sunniland Limestone of late Trinity age.

Gradual and continuous growth of the anticline during Comanche time is suggested by the sharp structure in the Sunniland Limestone in contrast to the broad low folds in the younger units, by the thinning of in-

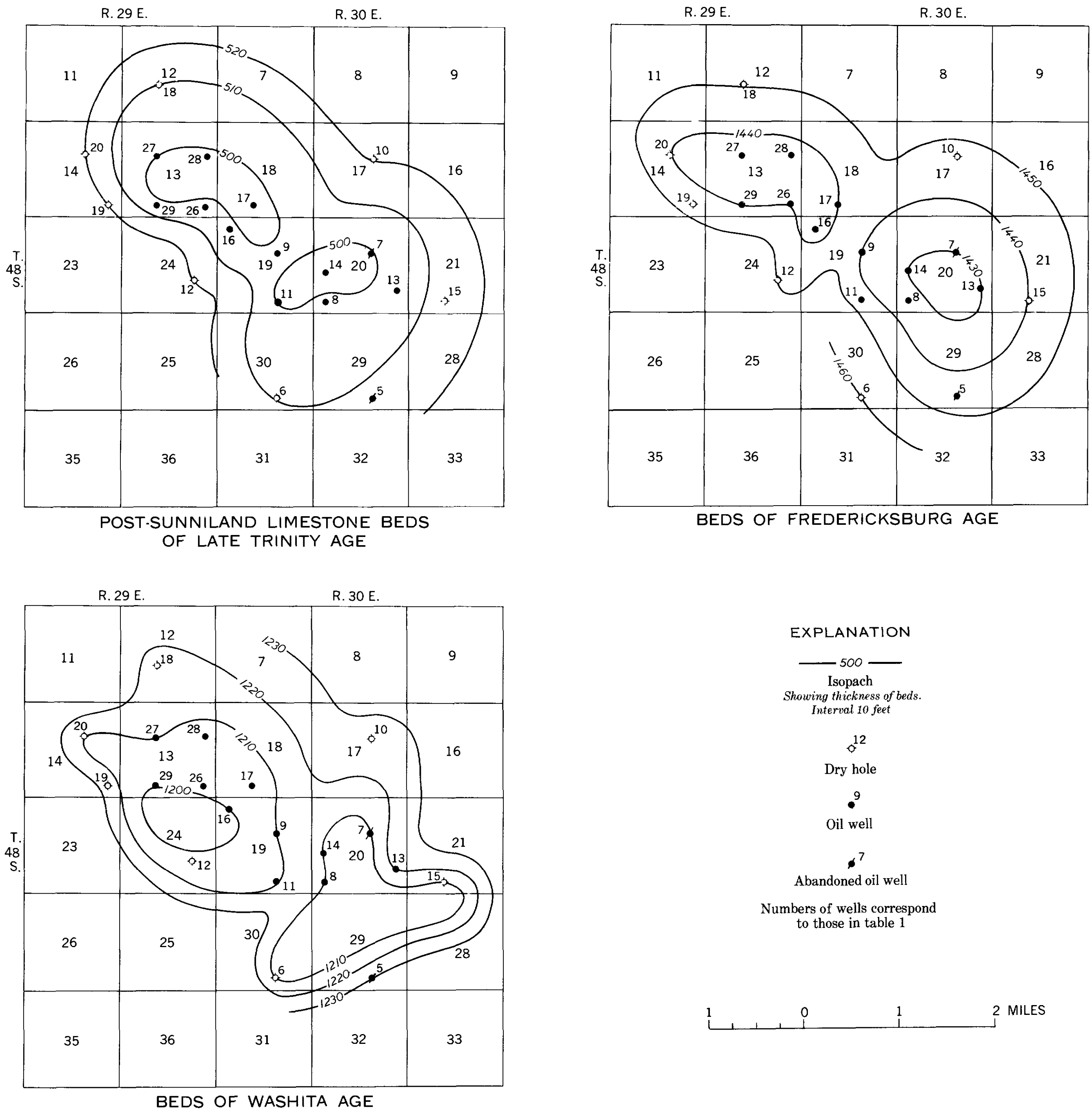

FIGURE 53.—Thickness of the post-Sunniland units of the Comanche Series in the Sunniland oil field, Collier County, Fla.

terval over the crest of the anticline, and by the basinward shift of the axis in progressively younger stratigraphic units.

The steep dip northeast of the Sunniland field suggests that the anticline is bounded by a northwestward-trending fault, but subsurface data are lacking to show displacement in the beds of Comanche age.

TECTONIC HISTORY

The relatively mild tectonic movements that formed the present-day regional structure of the Coastal Plain rocks in the Florida peninsula apparently began early in the Mesozoic and continued through the later Mesozoic and the Cenozoic. Six diagrammatic cross sections (pl. 11) through wells from Marion County at the north to Big Pine Key, Monroe County, at the south show our interpretation of the structure at different stages in the tectonic history of central and south Florida from early Trinity time to the present. Because the wells in south Florida were not drilled sufficiently deep to reach the Coastal Plain floor, and because only six scattered wells have penetrated the Fort Pierce Formation, the structural relations of the pre-Trinity rocks in that area are conjectural.

As a preliminary interpretation, we suggest that early in the Mesozoic the area now occupied by the Florida peninsula was a truncated and eroded surface of ancient rocks that stood a little above sea level. Downwarping of this surface at the south end of the peninsula progressed northward with the passage of time, accompanied by the gradual encroachment of a shallow sea. In this northward transgressing sea, the Coastal Plain sediments of the Fort Pierce Formation, the successive units of the Comanche Series, and the Atkinson (Gulf) Formation were deposited in a series of onlaps that wedge out against the Coastal Plain floor. Beginning with the beds of Austin (Late Cretaceous) age, the successively younger units of the Gulf Series, which for the most part are undifferentiated on the cross sections, apparently blanket the peninsula. The units of Cenozoic age, which are undifferentiated on the cross sections, were apparently deposited over most of the area.

An earlier statement of a somewhat similar nature was made by Schuchert (1943, p. 465). Schuchert stated

> * * * it appears that all of Florida was land during the Permian and Triassic periods, and for most of Jurassic time as well. It may be, however, that late Jurassic seas began to invade the southern end of what is now Florida, spreading across the entire peninsula and into Georgia and lapping upon Appalachia by the middle of Upper Cretaceous time.

The principal structural and stratigraphic features shown by the set of cross sections (pl. 11) are:

1. The progressive downwarping of the Coastal Plain floor and the successive units of the Comanche Series and younger rocks in central Florida to form the southwest flank of the Peninsular arch. From early in the Mesozoic until the end of Comanche time, at least, the north-central part of the peninsula remained a stable area in contrast to the gradually subsiding southern and central parts.
2. The facies changes and onlap of the units of the Comanche Series on the southwest flank of the Peninsular arch.
3. The development of the South Florida embayment. Data from additional deep test wells are needed to clarify the tectonic history of the embayment, but the available information indicates that the most pronounced structural development took place in post-Comanche time, apparently during the Cenozoic.

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PLATES 1-4

PLATE 1

FIGURE 1. *Dictyoconus floridanus* (Cole) (p. 53).
Oblique basal section of specimen from Sunniland Limestone. Humble Oil & Refining Co. Gulf Coast Realties Corp. "C" well 1, Collier County, Fla. Core, 11,795–11,800 ft. × 30.

2. *Dictyoconus floridanus* (Cole) (p. 53).
Deeply cut subaxial section of specimen from the Sunniland Limestone. Humble Oil & Refining Co. Gulf Coast Realities Corp. "C" well 1, Collier County, Fla. Core, 11,795–11,800 ft. × 30.

3. *Coskinolinoides texanus* Keijzer (p. 58).
Transverse section near base, specimen from beds of Fredericksburg age. Humble Oil & Refining Co. Gulf Coast Realties Corp. well 12, Collier County, Fla. Core, 9,895–9,900 ft. × 30.

4. *Coskinolinoides texanus* Keijzer (p. 58).
Section slightly oblique to base, specimen from beds of Fredericksburg age. Humble Oil & Refining Co. G. C. Carlton Estate well 1, Highlands County, Fla. Core, 9,055–9,065 ft. × 30.

5. *Dictyoconus floridanus* (Cole) (p. 53).
Basal section of specimen from the Sunniland Limestone. McCord Oil Co. Damoco well 1, Dade County, Fla. Core, 11,684–11,687 ft. (Measured depth; not corrected for deviation of hole.) × 30.

6. Photomicrograph of thin section of oolitic limestone from the Fort Pierce Formation, showing distribution of *Favreina*? Bronnimann in the limestone. Coastal Petroleum Co. John Tiedtke and William Schroeder well 1, Glades County, Fla. Core, 13,016 ft. × 10.

7. *Dictyoconus floridanus* (Cole) (p. 53).
Random axial section of specimen from Sunniland Limestone. McCord Oil Co. Damoco well 1, Dade County, Fla. Core, 11,684–11,687 ft. × 30.

8. *Dictyoconus floridanus* (Cole) (p. 53).
Random axial section of specimen from Sunniland Limestone. Humble Oil & Refining Co. Gulf Coast Realties Corp. "C" well 1, Collier County, Fla. Core, 11,850–11,859 ft. × 30.

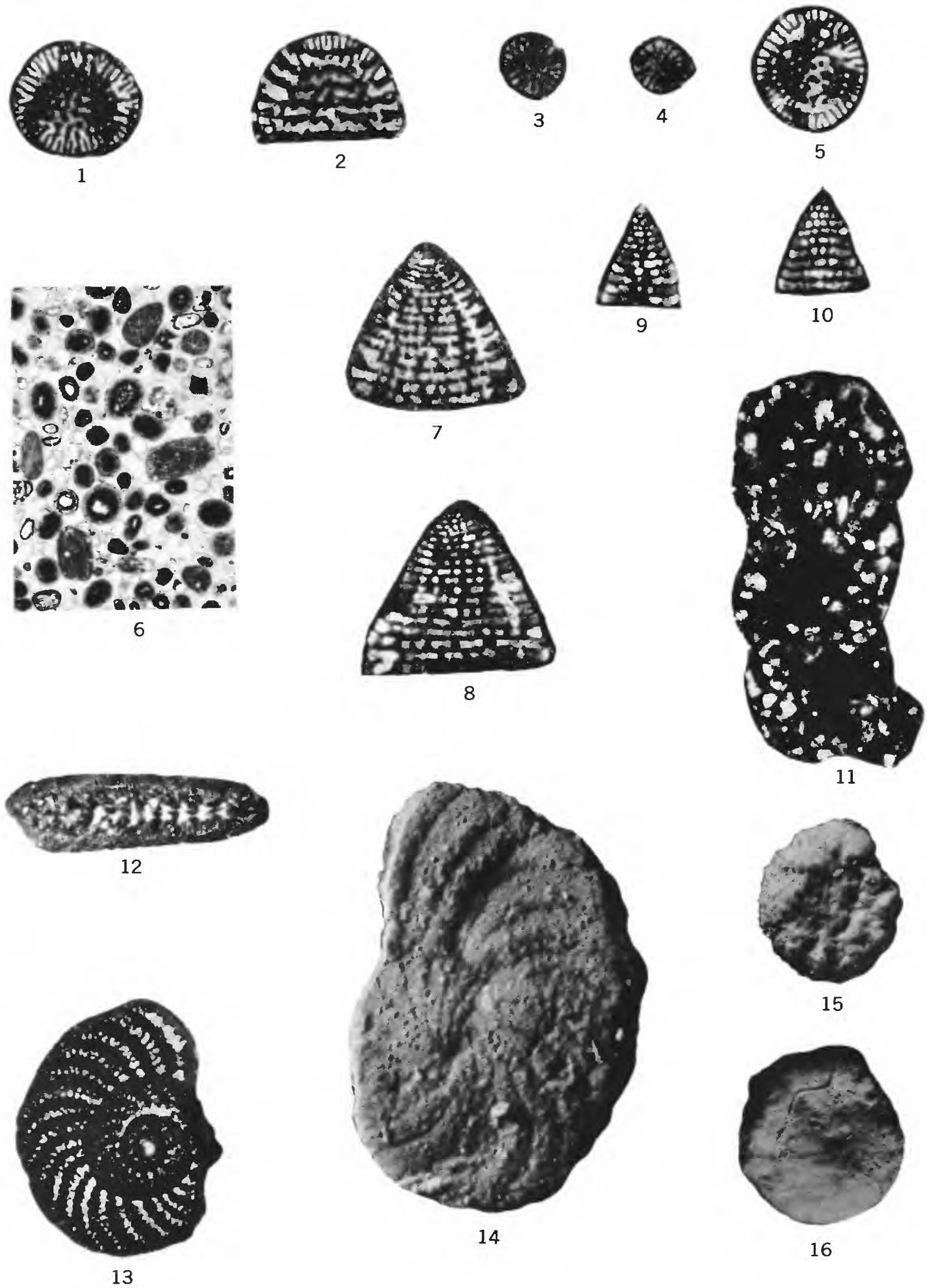
9, 10. *Coskinolinoides texanus* Keijzer (p. 58).
Specimens from beds of Fredericksburg age. Humble Oil & Refining Co. G. C. Carlton Estate well 1, Highlands County, Fla. Core, 9,055–9,065 ft.
9. Random axial section × 30.
10. Random subaxial section × 30.

11. *Lituola subgoodlandensis* (Vanderpool) (p. 58).
Median section, specimen from beds of Fredericksburg age. The Ohio Oil Co. Hernasco Corp. well 1, Hernando County, Fla. Core, 5,964–5,971 ft. × 30.

12. Tangential section of *Choffatella decipiens* (p. 28).
Schlumberger from beds of early Trinity age. Coastal Petroleum Co. E. C. Wright well 1, Pinellas County, Fla. Core, 10,050–10,060 ft. × 30.

13, 14. *Choffatella decipiens* Schlumberger (p. 28).
Specimens from Coastal Petroleum Co. E. C. Wright well 1, Pinellas County, Fla. Core, 10,045–10,050 ft.
13. Subequatorial section showing part of subepidermal, reticulate layer. From beds of early Trinity age. × 30.
14. Exterior view of specimen. × 40.

15, 16. *Nummoloculina heimi* Bonet (p. 64).
Specimens from beds of Washita age. Gulf Oil Corp. State of Florida Lease 373 well 1, on Big Pine Key, Monroe County, Fla. Cuttings, 8,300–8,320 ft.
15. Side view of specimen.
16. Side view of specimen with etched surface.



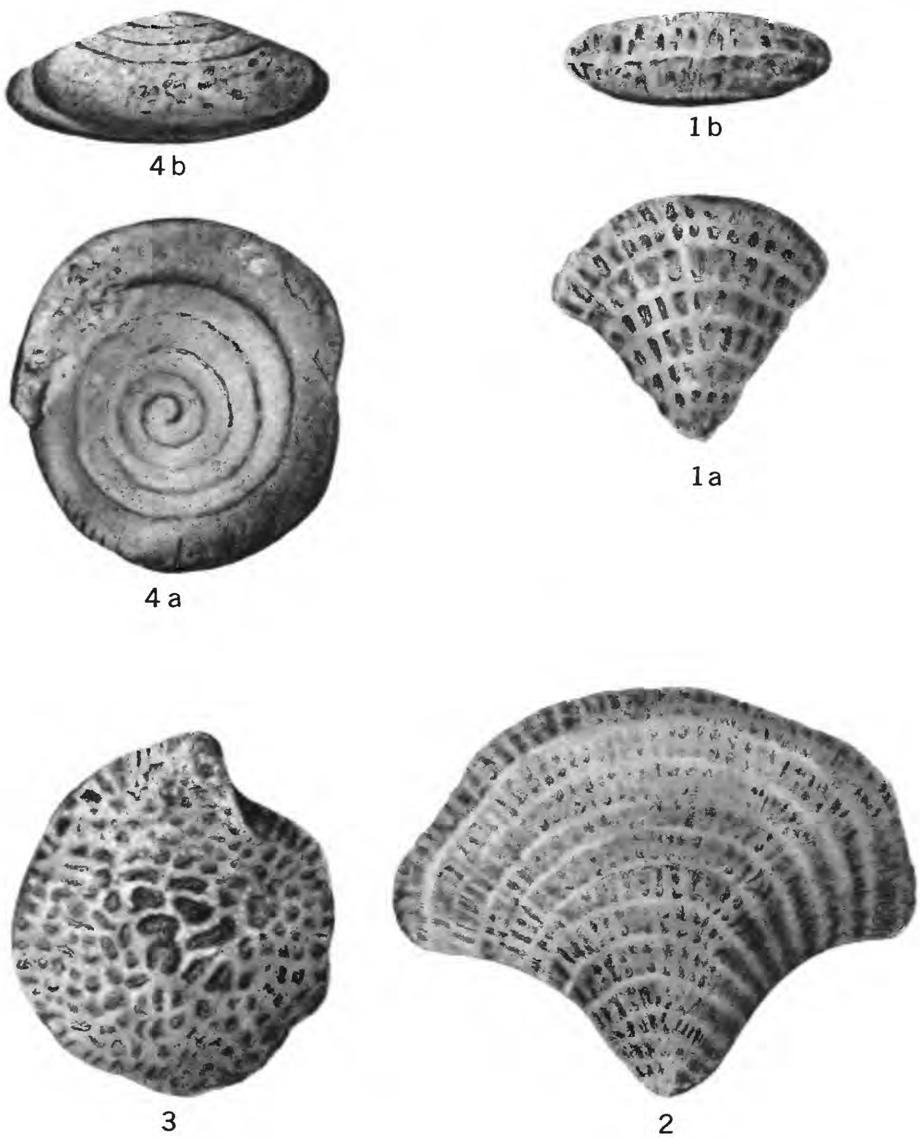
SOME MICROFOSSILS FROM MESOZOIC CARBONATE ROCKS OF SOUTHERN FLORIDA

PLATE 2

[Specimens from The Ohio Oil Co. Hernasco Corp. 1, Hernando County, Fla. Middle Core 18, 5,519–5,528 ft]

FIGURE 1, 2. *Cuneolina walteri* Cushman and Applin (p. 69).
1. Paratype redrawn. Cushman colln. no. 47366, early stage. × 70. a, front view; b, apertural view.
2. Holotype redrawn. Cushman colln. no. 47365. × 50.

3, 4. *Trocholina floridana* Cushman and Applin (p. 69).
3. Paratype redrawn. Cushman colln. no. 47370. Ventral view. × 50.
4. Holotype, redrawn. Cushman colln. no. 47367. × 50. a, dorsal view; b, peripheral view.



FORAMINIFERA FROM OOLITIC LIMESTONE FACIES OF LOWER PART OF LOWER MEMBER OF THE ATKINSON FORMATION

PLATE 3

Coastal Petroleum Co. John Tiedtke and William Schroeder 1, Glades County, Fla.

Cuneotina sp. (× 30) core 12,964 ft, a and a5 vertical sections; a2 deeply cut vertical section; a3 transverse section; h, fine chamberlets. Core 13,043 ft, a1 transverse section, a4, a6, and a7 vertical sections. Unidentified form × 3, core 12,964 ft (× 30). *Pseudocyclammina*? sp., b and b1 (× 30) core 12,966 ft. Unidentified forms × 4 and × 5 (× 30) core 12,966 ft. *Lituola*? c, c1, and c2 (× 30) core 12,966 ft. *Ovalveolina*? sp., d (× 30) core 12,966 ft. *Ophthalmidium*, j (× 30) core 13,043 ft. Miliolids, m and m1 (× 30) core 13,043 ft. Unidentified form, x (× 30) core 13,043 ft.

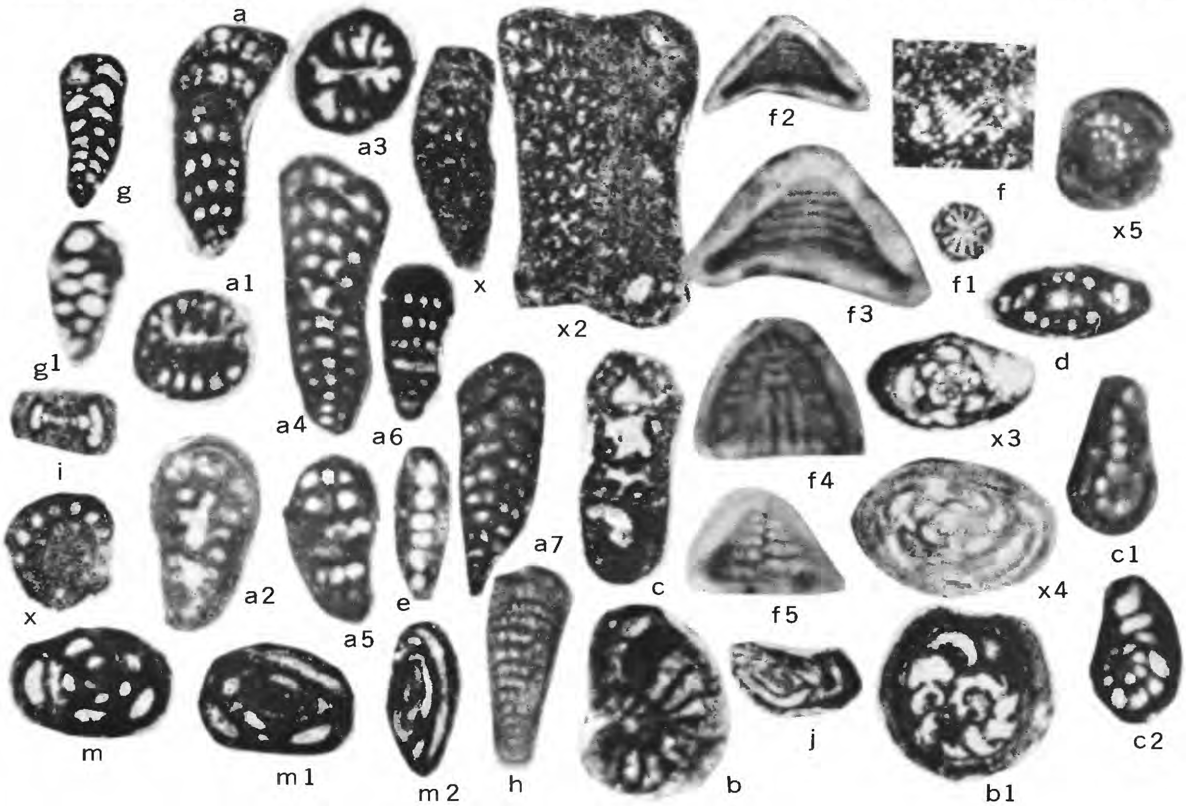
Gulf Oil Corp. State of Florida Lease 373, 1, Big Pine Key Monroe County, Fla.

Small *Coskinolina*-like form core 14,526–14,533 ft, f2 (× 40) approximate axial section; f3 (× 60) approximate axial section; f4 (× 60) deeply cut axial section; f5 (× 60) showing biserial chamber arrangement. Core 14,533–14,548 ft, f (× 30) section in dolomitic limestone; f1, (× 30) tranverse section near initial end.

Textularian form, g1, core 14,543–14,551 ft. Textularian form, g (× 30) core 14,594–14,602 ft. Miliolids, m2 (× 30) core 14,594–14,602 ft. *Conuspira*?, i (× 30) core 15,439–15,449 ft. Uniserial form, e (× 30) core 15,449–15,459 ft.

Humble Oil & Refining Co. Tucson Corp. 1, Palm Beach County, Fla.

Unidentified forms (× 30) core 12,736–12,742 ft, x1, free specimen; x2 attached to rock fragment.

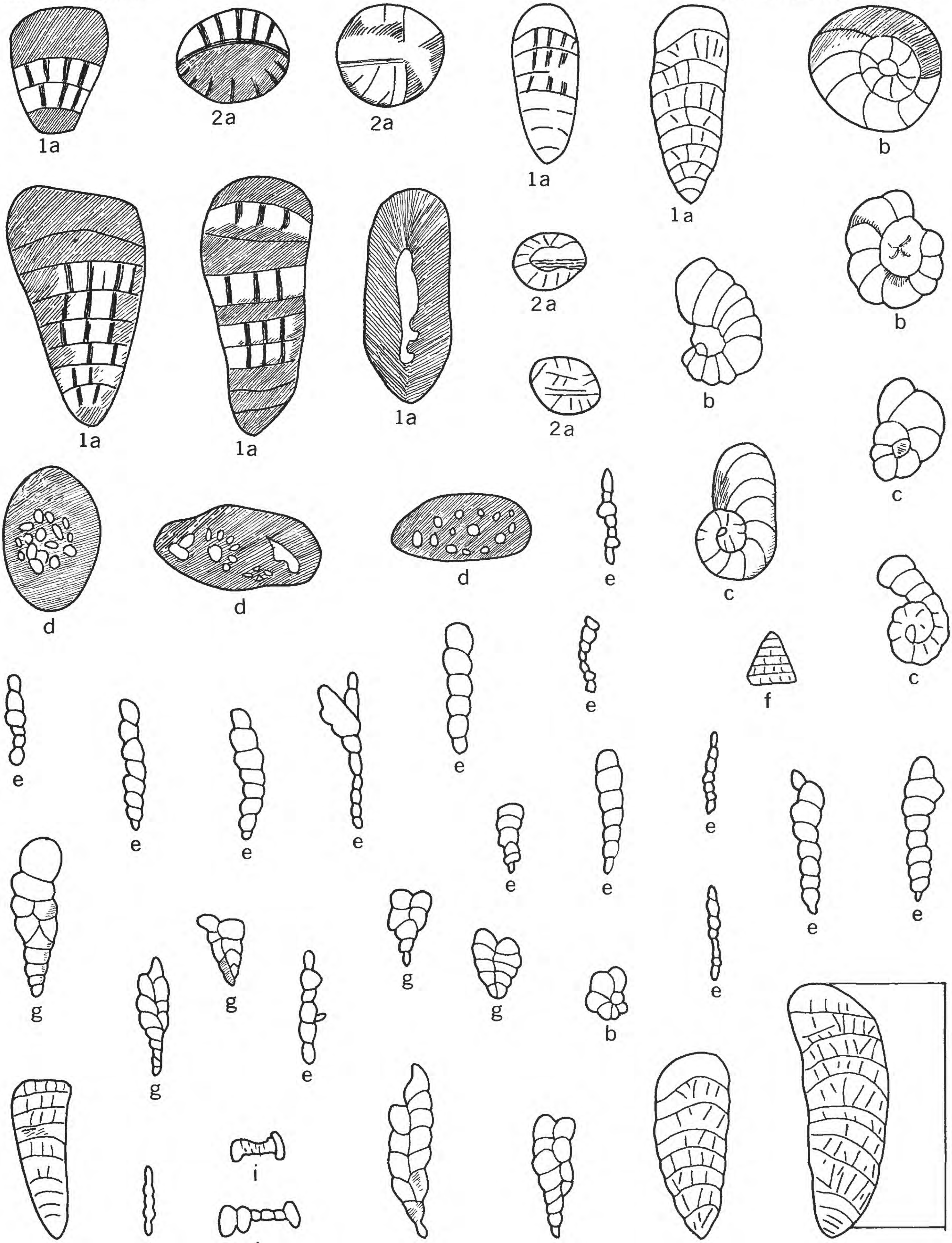


RANDOM SECTIONS OF MICROFOSSILS COMMON IN THE FORT PIERCE FORMATION

PLATE 4

[All specimens from thin sections of rock samples from the Fort Pierce Formation]

FIGURE 1a, 2a. *Cuneolina* sp. (× 50). 1a. Vertical section. 2a. Transverse section. b. *Pseudocyclammina?* sp. (× 40). c. *Lituola?* sp. (× 40). d. *Ovalveolina?* sp. (× 40). e. Uniserial forms, possibly attached (× 50). f. *Coskinolina*-like form (× 60). g. Textularian forms (× 50). h. *Cuneolina* sp. B (× 40). i. *Ammodiscus?* sp. (× 40). x, x1. Unidentified forms (× 40); x is a free specimen and x1 is attached specimen.



SEEOSCOPE DRAWINGS OF MICROFOSSILS