

**STATE OF FLORIDA  
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**FLORIDA GEOLOGICAL SURVEY**

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**GEOLOGICAL BULLETIN NO. 45**

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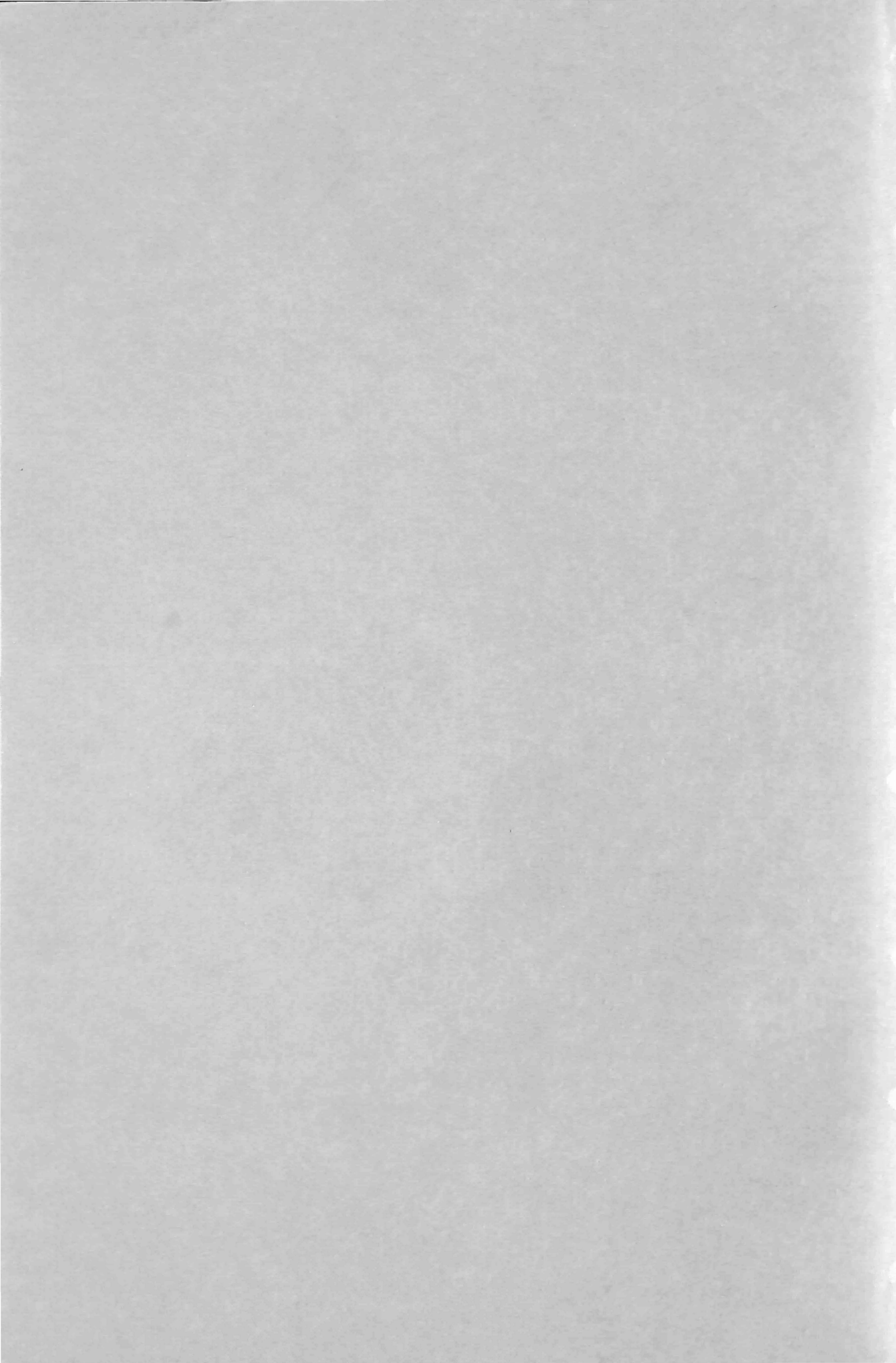
**THE REGIONAL LITHOSTRATIGRAPHIC ANALYSIS  
OF PALEOCENE AND EOCENE ROCKS  
OF FLORIDA**

**By**  
Chih Shan Chen

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Published for  
**THE FLORIDA GEOLOGICAL SURVEY**

**TALLAHASSEE  
1965**





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By  
Chih Shan Chen

**TALLAHASSEE  
1965**

**FLORIDA STATE BOARD  
OF  
CONSERVATION**

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## LETTER OF TRANSMITTAL



### *Florida Geological Survey*

Tallahassee

July 20, 1965

Honorable Haydon Burns, *Chairman*  
Florida State Board of Conservation  
Tallahassee, Florida

Dear Governor Burns:

The Florida Geological Survey will publish, as Bulletin No. 45, an extensive report covering detailed analyses on the types of rock and strata deposited during the Paleocene and Eocene periods in Florida. This report was prepared by Dr. Chih Shan Chen, as part of his doctoral program at Northwestern University, and it provides data on the basis of which it is possible to understand the distribution of these important rocks in Florida.

By studying the environments in which these rocks were formed and by relating these environments to the regional mountain-building movements and to the major rock units of Florida, it is hoped that a greater understanding of the rocks that contain oil can be had. With this knowledge, new oil fields can be discovered and developed in Florida.

Respectfully yours,

Robert O. Vernon,  
*Director and State Geologist*

Completed manuscript received  
April 29, 1965

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## ABSTRACT

Lithologic and thickness data of the successive Paleocene and Eocene stratigraphic units in panhandle and peninsular Florida were obtained by investigating cuttings, cores, and electric logs of a total of 164 wells selected for this study. These data were employed for constructing isopach-lithofacies maps, structure maps, and lithologic cross sections. These maps and cross sections together with the paleontologic information make possible more reliable interpretations of sedimentary petrogenesis and of the regional tectonics of Paleocene and Eocene time in Florida.

Two distinct sedimentary facies, clastic (panhandle Florida) and nonclastic (peninsular Florida), have been recognized and differentiated on a series of isopach-lithofacies maps of the successive stratigraphic units of the Paleocene and Eocene Series in the area studied. These two sedimentary facies were separated by the Suwannee Channel, which acted as a natural barrier, both sedimentational and faunal, and occupied a narrow belt along southern Georgia and northern Florida with a northeast-southwest trend during the time from late Upper Cretaceous to Upper Eocene. The barrier nature of the Suwannee Channel gradually became less effective and finally disappeared near the end of Eocene time.

On the basis of lithologic and paleontologic data together with the ecologic and environmental conditions inferred in this study, the following interpretations concerned with the regional sedimentation were made. In peninsular Florida, nonclastic sediments, carbonates and evaporites, were formed on a stable carbonate bank or shelf in warm, shallow-water, and open marine environment which could be comparable to those existing today in the Great Bahamas, Florida Bay and Keys, and Campeche Banks. In panhandle Florida, clastic sediments were laid down on a relatively unstable shelf in transitional or deltaic and shallow water marine environments. Isopach-lithofacies maps indicate that clastic sediments become coarser and more dominant northward toward the Appalachian Piedmont, while carbonates and finer clastics are the major lithologies southeastward near the Suwannee Channel and southward toward the Gulf. The principal source area of those terrigenous materials is considered to be the Southern Appalachians.

Stratigraphic analysis indicates that only epeirogenic movements affected the area during Early Tertiary time. Several minor disconformities have been recognized at the outcrop area, but they are generally not recognizable in the subsurface in panhandle and

peninsular Florida, except at the contacts of the Ocala Group which show unconformable relationships with beds lying above and below.

The fact of gradual but steady spreading of the nonclastic facies northerly and northwesterly over the clastic facies during Early Tertiary time may be the result of continued marine transgression. Some sporadic regressions occurred during Paleocene and Eocene time as manifested by the presence of local and regional unconformities.

Paleogeographic maps of the successive Paleocene and Eocene stratigraphic units studied are reconstructed on the basis of the series of isopach-lithofacies maps, lithologic and paleontologic data, and ecologic and environmental conditions inferred in this study.



## ACKNOWLEDGMENTS

The writer is indebted to L. L. Sloss of Northwestern University for directing this study through its various stages to completion. Thanks are due to W. C. Krumbein for advice and suggestions on analyses of lithologic data; further thanks are due to other members of the faculty in the Department of Geology, Northwestern University for their interest, suggestions, and criticism, and to H. G. Goodell of the Florida State University for suggesting the problem and for assistance when the writer was a graduate student at that university.

Grateful acknowledgment is rendered to the Florida Geological Survey for permitting the writer unrestricted use of well samples, cores, and mechanical logs at its well sample library and providing a part of the expense of the study; and to R. O. Vernon, director of the Florida Geological Survey, for helpful suggestions and kind assistance; to the Society of Sigma Xi and RESA Research Fund for awarding a research grant during the summer of 1962; to Sun Oil Company in Tallahassee, Florida, particularly D. J. Munroe, for allowing the writer use of electric logs; to John Pressley, technician at the Department of Geology, Northwestern University for grinding thin sections; and to the Graduate School of Northwestern University for providing research funds.



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# THE REGIONAL LITHOSTRATIGRAPHIC ANALYSIS OF PALEOCENE AND EOCENE ROCKS OF FLORIDA

By  
Chih Shan Chen

## INTRODUCTION

The sedimentary rocks of Florida range in age from Cambro-Ordovician to Recent (Applin, 1951a, 1951b), although rocks of Cretaceous and Tertiary age are dominant, volumetrically and areally. Cenozoic sediments in Florida range in age from Paleocene to Recent, but only post-Eocene rocks are exposed over most of the state (fig. 1). Crystalline rocks of possible Precambrian age have been encountered in several deep test wells in central Florida (Applin, 1951a, 1951b), but the oldest rocks exposed at the surface are late Middle Eocene in age and occur in Citrus and Levy counties in the northwestern part of the peninsula, on the crest of the Ocala Uplift (figs. 1 and 2). Upper Eocene rocks crop out around these Middle Eocene strata and outline the periphery of this uplift, other Upper Eocene exposures are in the area of the Chattahoochee Arch near the common boundary of Alabama, Florida, and Georgia (figs. 1 and 2).

This paper is in the nature of a reconnaissance study or a progress report on investigations of the complex stratigraphy of the Paleocene and Eocene strata in peninsular and panhandle Florida. Interpretations as here presented are tentative and subject to modification as new data emerge from further drilling and geophysical surveys.

In the preparation of this study, lithological and other geological data were obtained by examining well cuttings, cores, and mechanical logs from a total of 164 selected wells (fig. 3), most of them penetrating Mesozoic or older rocks. The information obtained was used for the following purposes: (1) to construct regional lithofacies, isopach, and structure maps, (2) to determine the vertical and lateral relationships among the major lithologic units, and (3) to interpret the depositional environments in the light of regional tectonics.

Two distinct sedimentary facies have long been recognized by many geologists who have worked in the area: the land derived-clastic facies of the Florida panhandle and the facies of the allochemical rocks of the Florida Peninsula. Such Paleocene-Eocene rocks of the peninsula are composed almost entirely of carbonates

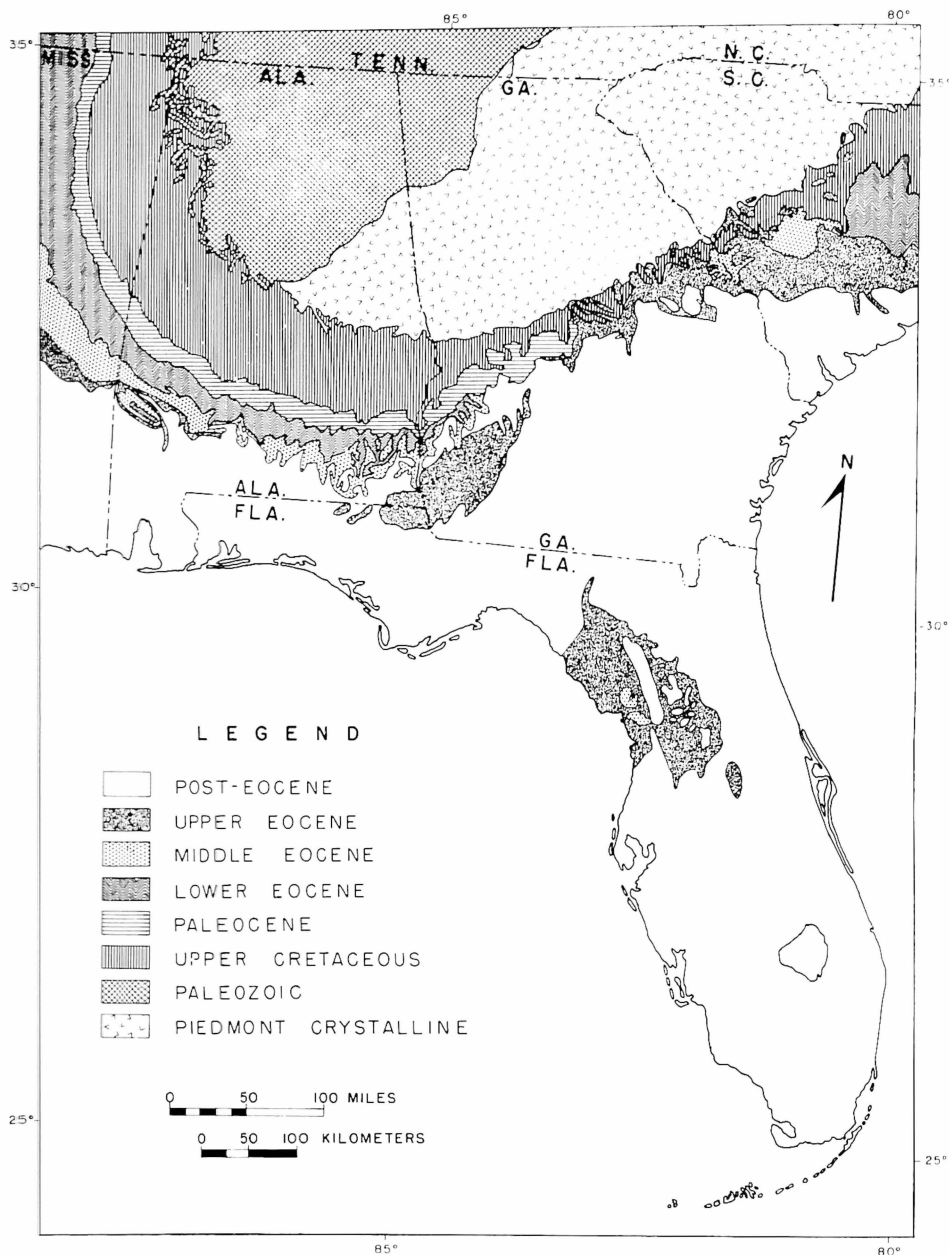


Figure 1. Regional geological map of southeastern United States (compiled from Geological Map of North America, 1960, and Surface Occurrences of Geological Formations in Florida, 1959).



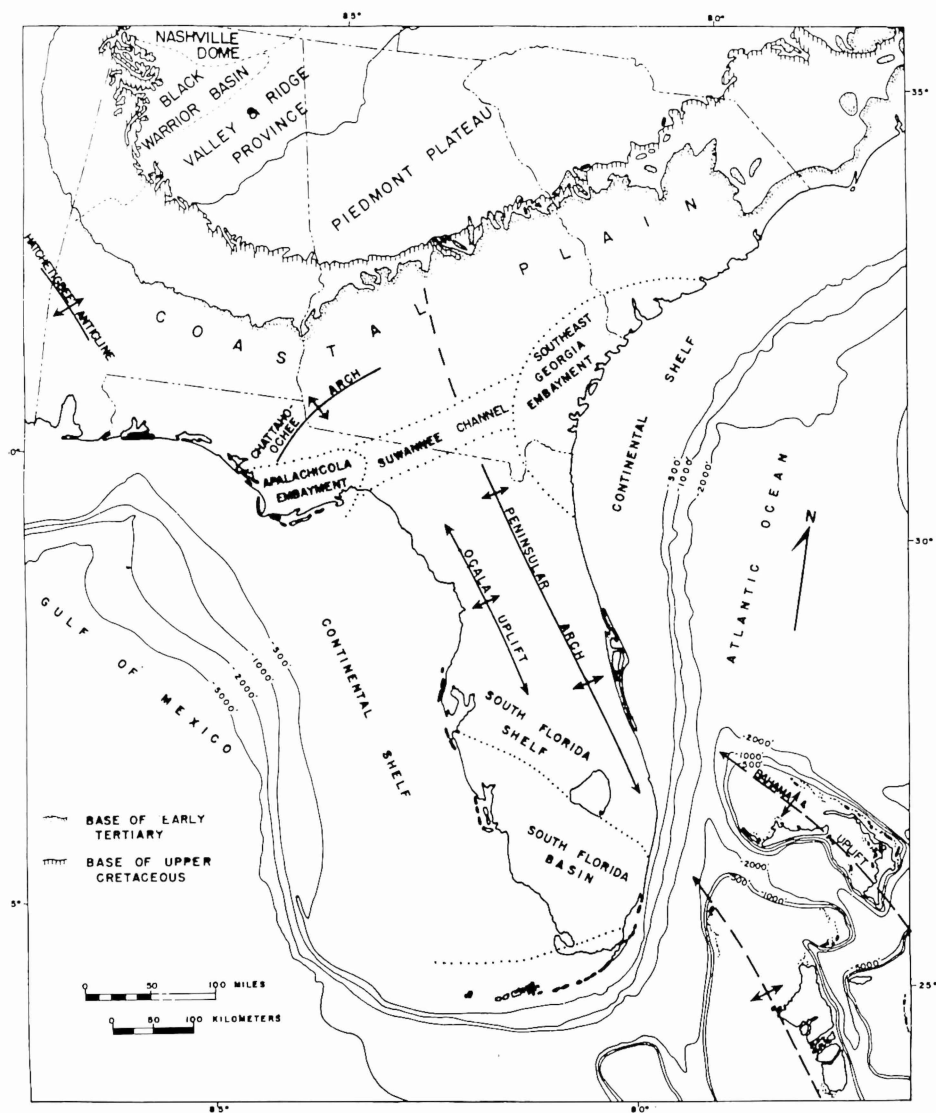


Figure 2. Major structural features of southeastern Coastal Plain and the Bahamas (modified after the Tectonic Map of the United States, 1962, and Pressler, E. D., 1947).

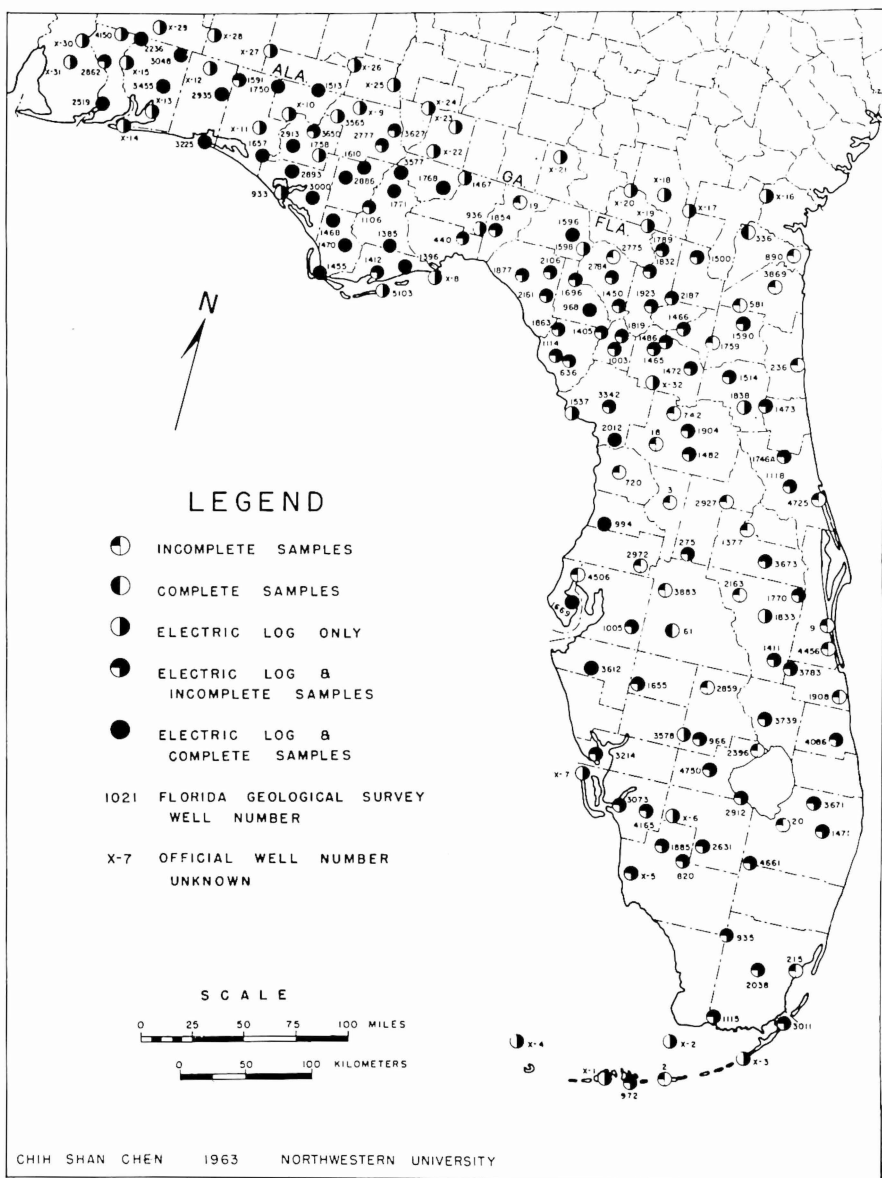


Figure 3. Well location map.

and evaporites. Dolomite, anhydrite, and gypsum are the principal lithologic components of the Paleocene rocks; dolomite and fossiliferous limestone are predominant in the Eocene rocks. In panhandle Florida the clastic facies comprises sandstone, shale, and limestone for the entire Paleocene-Eocene succession. The facies boundary between silicate fragment clastic and the nonclastic facies is rather sharply defined throughout all the stratigraphic units studied, however, it is reasonable to suggest that the relations between these two sedimentary facies are in interfingering rather than knife-edge contact.

A complete review of previous studies in the area up to 1944 is well summarized by Applin and Applin (1944). Some of the most significant contributions to the knowledge of the regional subsurface geology of the area completed since 1944 are briefly reviewed here.

Applin and Applin (1944, 1947) have studied the regional subsurface stratigraphy, paleontology, and structure of Florida and southern Georgia and have presented much information as cross-sections, maps, and paleontological studies. New local formation names assigned to rocks of the nonclastic facies in peninsular Florida have been introduced, and relationships between the clastic facies of the Florida panhandle and the nonclastic facies of the peninsula have been discussed and correlations suggested.

Cole (1944, 1945) has made valuable contributions to our knowledge of the subsurface stratigraphy and micropaleontology of the area. He named the Cedar Keys Formation a stratigraphic unit of Lower Eocene age (now considered by the Coastal Plain geologists as Paleocene) in peninsular Florida (Cole, 1944).

Applin and Jordan (1945) made an extensive study of foraminifers from which they described and listed fossils characteristic of formations ranging in age from Upper Cretaceous to Oligocene.

Recently, Cheetham (1963) studied the abundance and distribution of marine fossils, particularly cheilostome bryozoans, in the Upper Eocene sediments in the eastern Gulf Coast region (including panhandle Florida and central peninsular Florida). He interprets a shoal-water tropical environment of water depth probably less than 150 feet to have existed over most of the Florida Platform during the Upper Eocene.

Applin (1951b), in his investigation of pre-Mesozoic rocks in Florida and adjacent states, recognized a deeply buried structure,

the Peninsular Arch, in rocks older than the Mesozoic; he also grouped these rocks into three major categories: (1) plutonic and metamorphic rocks of possible Precambrian and/or Paleozoic age, (2) possible Precambrian or Early Paleozoic rhyolitic lavas and pyroclastic rocks, and (3) Paleozoic sedimentary rocks. His conclusions contribute important and fundamental knowledge not only of the early geologic history of Florida, but also of the regional tectonics of the southeastern United States.

Pressler (1947), on the basis of subsurface stratigraphy, designated the area covering the region of South Florida, the Bahamas, Cuba and the intervening areas as the South Florida Embayment; Carsey (1950) named the same feature the South Florida Basin. Vernon (1951) suggested that the Ocala Uplift probably was initiated during Early Miocene time, resulting in a gentle flexure in Tertiary sediments on the west flank of the Peninsular Arch.

Applin (1952) and Toulmin (1952) estimated the total volume of the Mesozoic and Cenozoic sediments in Florida and Georgia respectively, on the basis of the data obtained primarily from the oil test wells and secondarily from the outcrop measurements. Toulmin (1955) made a regional stratigraphic study of the Cenozoic sediments of the southeastern Coastal Plain. He also suggested that the two distinct sedimentary facies, the clastic facies of panhandle Florida and southern Georgia and the nonclastic facies in peninsular Florida, are separated structurally by the Peninsular Arch. Puri (1957), on the basis of a study of the stratigraphy and biostratigraphy of Upper Eocene rocks in Florida, used the term "Ocala" as a group name and assigned three formations to it, from oldest to youngest, Inglis Formation, Williston Formation, and Crystal River Formation.

Recently Goodell and Yon (1960) demonstrated the lateral complexities of post-Eocene sediments in Florida by lithofacies maps and cross sections; these authors treated the lithologic data quantitatively, and discussed the facies patterns and the parameters of sedimentation in the light of regional tectonics. Most recently Toulmin and LaMoreaux (1963) have made a detailed study of the section of Upper Cretaceous and Tertiary strata exposed along the Chattahoochee River in the southeastern Coastal Plain and they consider the section to be a significant connecting link between the Atlantic and Gulf Coastal Plains.

A considerable amount of geophysical information reflecting the structural trends of magnetically heterogeneous Paleozoic and Precambrian rocks beneath rocks of Mesozoic and Cenozoic age in

the southeastern Coastal Plain of the United States has appeared in print (Drake and others, 1963; E. R. King, 1959; Lee and others, 1945; Lyons, 1950 and 1957; and Miller and Ewing, 1956). Lee and others (1945) have made a magnetic survey of the Florida Peninsula. Drake and others (1963), King (1959), and Lyons (1950), on the basis of studies of geophysical data represented by the regional magnetic and gravity maps in the area of Florida and the Bahamas, state that two distinguishable regional magnetic trends or provinces exist: a northern province of predominant northeast trends, and a southern province of northwest trends cutting with discordance across the northeast trends.

### GEOLOGIC SETTING

The term "Florida Platform", as here used, covers peninsular Florida, the broad continental shelves off the west and east coasts of the Florida Peninsula extending seaward to the -500-foot contour, and the Great Bahama Bank (fig. 2). Owens (1960) proposed the term "Florida-Bahama Platform" encompassing the Bahama Islands and most of the Florida Peninsula and shelf. The platform is bounded on the south by the overthrust sheet or high angle tilted fault blocks of the Great Antilles (Owens, 1960; Pressler, 1947), on the west by the West Florida Scarps, and on the east by the North Atlantic Ocean Deep. This platform has been considered by many geologists (King, 1950, 1961, 1964; Murray, 1961, 1963) as a significant seaward extension of the Appalachian and/or Ouachita structural belts, although definite relations are still undetermined.

Recently, Drake and others (1963) and E. R. King (1959), on the basis of the regional pattern of the magnetic anomaly map of Florida and the Bahamas together with the gravity and seismic results, suggest that two rather distinctive regional magnetic trends or provinces exist in the area: northeast-trending anomalies in northern Florida which parallel and presumably reflect buried segments of the Appalachian system, and northwest-trending anomalies in southern Florida and the Bahamas apparently truncating the northeast trends. Such northwest structural trends may reflect an extension of the Ouachita system and may indicate that the Ouachita system is younger. However, Woollard (1958), on the basis of the distribution of earthquake epicenters, suggested that these two systems are independent, but contemporaneous, intersecting with a "T" relationship somewhere beneath the Mississippi-Alabama Coastal Plain.

Several measurements of total magnetic intensity have been made by Miller and Ewing (1956) in the region west of peninsular Florida, from the continental shelf, across the West Florida Escarpment to the deep basin of the Gulf of Mexico. The geophysical data indicate that the magnetic field over the west Florida Platform has numerous strong anomalies which are apparently not linear. Although a further survey of the area is needed to make a more reliable interpretation, it seems to the writer that the result reported by Miller and Ewing gives no direct support to the statement made by King (1959) and Drake and others (1963) that a strong southeasterly trend passing through southern Florida into the Bahamas is probably an extension of the Ouachita system.

Lyons (1950) has published a gravity map of the United States. His regional gravity map of Florida is very similar to that of King's (1959) magnetic map of the same area both in overall trends and in individual features. However, the well-marked positive and negative trends of the Appalachian and Ouachita structural belts disappear in the Atlantic and Gulf Coastal Plains and Mississippi Embayment as shown on the gravity map of southeastern United States. The linear trends of gravity anomalies may indicate the extension of Appalachian system in southwestern Alabama and southern and central Mississippi. It is rather surprising that the geophysical evidence is quite contradictory to the result revealed by the subsurface drill data which indicate that both structural belts extend unchanged for a long distance beneath the coastal plain cover.

Evidence and inferences, both geologic and geophysical, so far as we know currently are insufficient to solve the problem of the relations between the Ouachita and Appalachian systems. It seems to the writer that the knowledge of the relationship between these two major structural belts and of the regional distribution of the basement rocks beneath the southeastern Coastal Plain of the United States could be further clarified by detailed investigation in the critical regions of the continental shelf off the west coast of Florida and the Mississippi Embayment.

Two distinct sedimentary facies, clastic and non-clastic, have been recognized in stratigraphic units ranging in age from Lower Cretaceous to Upper Eocene in the area (Applin, 1951a). However, the position of the facies boundary has shifted northward and northwestward through geologic time as indicated by studies of the regional subsurface geology of the area (fig. 4).

Applin and Applin (1944), in their study of subsurface strati-

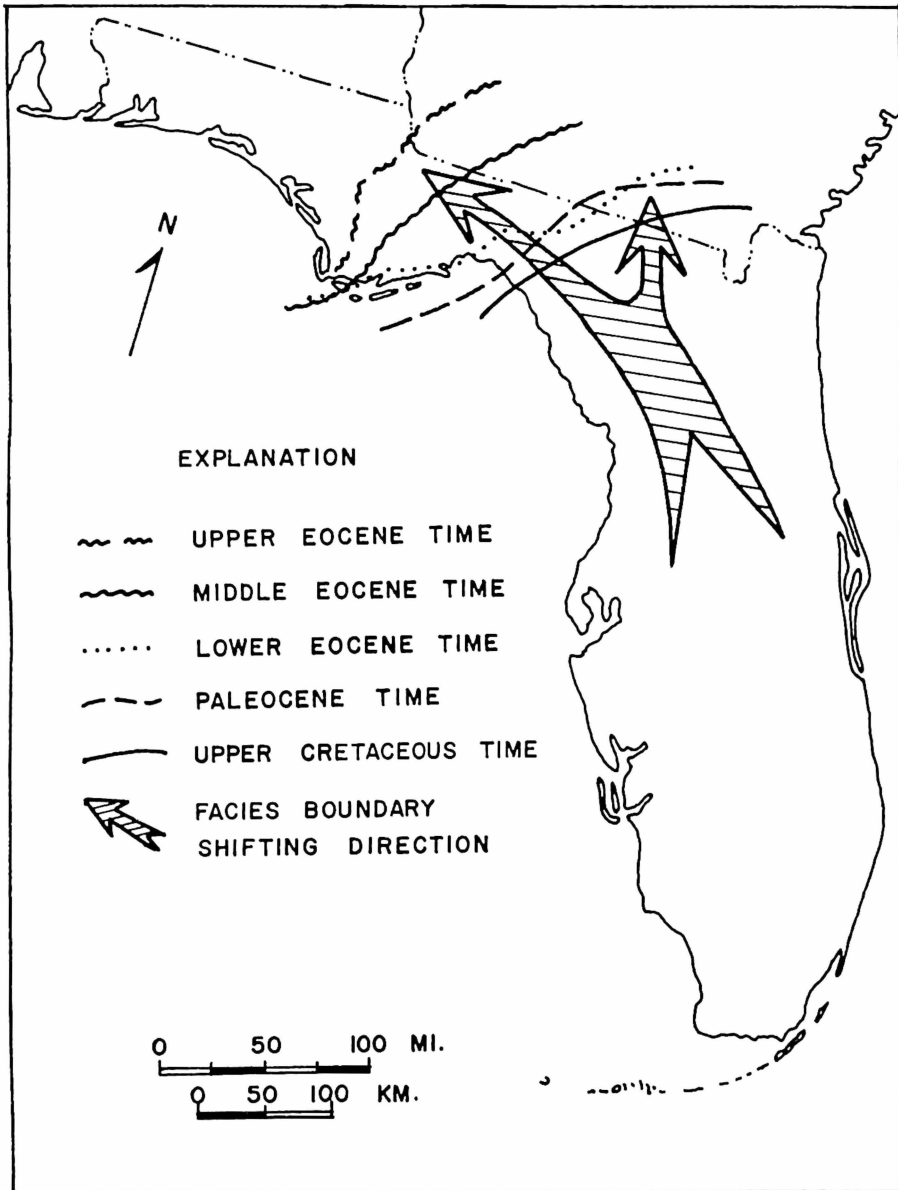


Figure 4. Map showing the shifting of clastic-nonclastic facies boundary through the geologic time from Upper Cretaceous to Upper Eocene.

graphy ranging in age from Upper Cretaceous to Early Tertiary in Florida and southern Georgia, have suggested that there was "a channel or trough extending southwestward across Georgia through the Tallahassee area of Florida to the Gulf of Mexico." This channel cut nearly at right angles to the trend of the Peninsular Arch and lay between the carbonate-evaporite facies to the southeast and the terrigenous clastic facies to the north and northwest.

The term "Suwannee Strait" was first coined by Jordan (1954) to designate the same feature and this usage was further amplified by Hull (1962). The paleogeographic feature was a slightly deeper passage across a shallow shelf as discussed in a later chapter. Therefore, the term "channel" is more descriptive than "strait" and is adopted in this report for the prominent belt of rapid facies changes that is apparent throughout the time span of the strata here considered.

The continuous existence of the Suwannee Channel, at least through Early Tertiary time, has been recognized by the writer and illustrated in figures 5 and 6 (also see p. 42). The relatively thin deposition within the channel during Paleocene and Lower Eocene time is suggestive of continued elevated current action through the channel during that time. The currents could have considerably reduced the rate of accumulation of fine sediments within the channel and would have prevented the spread of fine terrigenous sediments over the peninsula area to the southeast.

The Peninsular Arch, forming the backbone of the Florida Platform, is one of the major regional subsurface structures in the area (fig. 2). The arch trends south-southeast and extends from southeastern Georgia through Florida into the Great Bahamas. Applin (1951b) interprets the presence of pre-Mesozoic rocks forming the core of the Florida Peninsula, to indicate an area of nondeposition during post-Silurian Paleozoic time, and that the subsequent regional movements during the post-Paleozoic time were responsible for shaping the present configuration of the Peninsular Arch and the South Florida Basin. It has been suggested by Murray (1963) that the arch is a mobile "swell or welt" in the developing Gulf-Atlantic Coastal geosynclinal province.

An oil test well has been drilled to more than 14,500 feet on Andros Island of the Bahamas. Lithologic data indicate that the whole section penetrated is composed entirely of relatively pure carbonates (limestone and dolomite) of Upper Mesozoic age. Recently, a second test, the California-Gulf, Cay Sal 4 No. 1, was



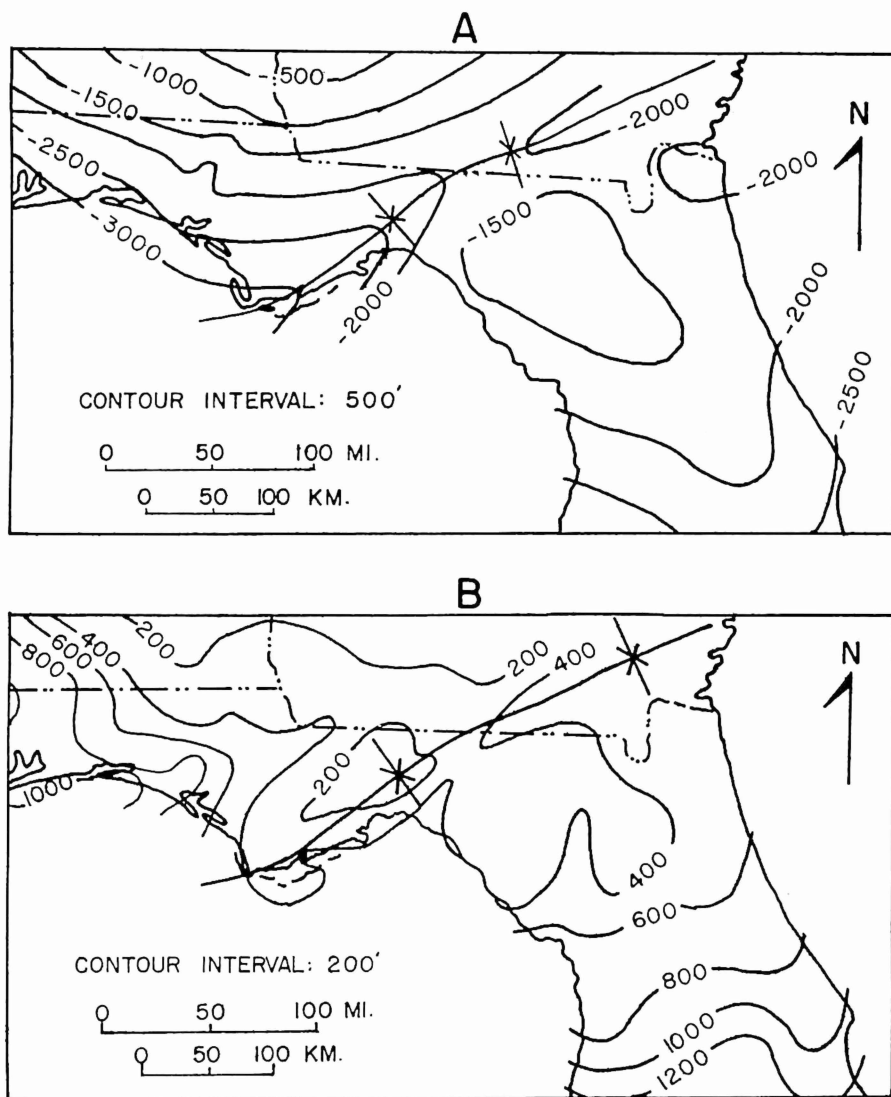


Figure 5. A. Structure map, contoured on top of Paleocene Series, showing the location of Suwannee Channel (synclinal axis). B. Isopach map of Paleocene Series showing thin accumulation within the Suwannee Channel (synclinal axis.)

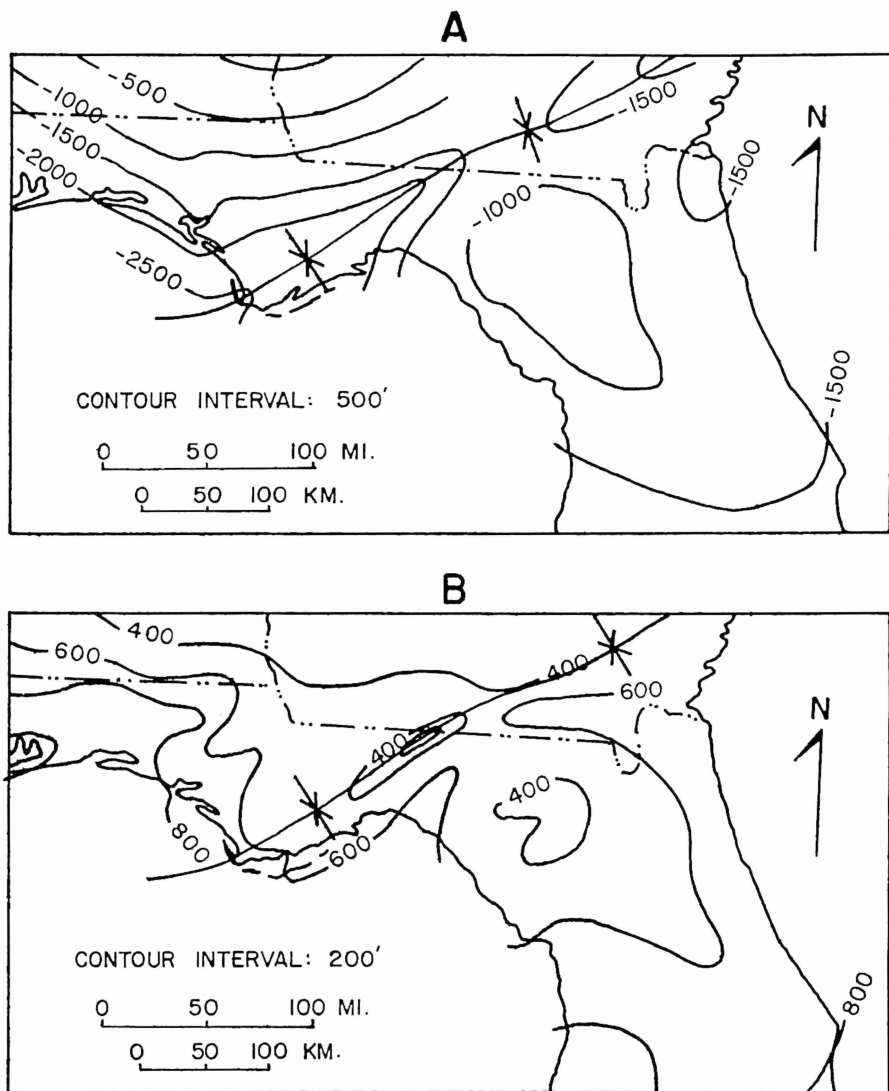


Figure 6. A. Structure map, contoured on top of Lower Eocene rocks, showing the location of Suwannee Channel (synclinal axis). B. Isopach map of Lower Eocene rocks showing thin accumulation within the Suwannee Channel (synclinal axis).

drilled by Bahama California Oil Company and Bahama Gulf Oil Company on Cay Sal Bank in the southwestern Bahamas, which is approximately 131 miles due south of Miami, Florida (Wassall and Dalton, 1959). The well was abandoned at 18,906 feet early in 1959 because it had failed to locate the section of porous, dolomitized, limestones intercalated in anhydrite beds, which is the producing section in Sunniland field in South Florida. Neither lithologic nor stratigraphic data pertaining to this test have been released. However, such fragmental subsurface data as have been provided prove to be valuable information for this little known region. Geologists have suggested that the Bahama Banks, although at present separated from peninsular Florida by the Florida Strait with moderate depth (about 2500 feet), are an extension of peninsular Florida, and that the present-day existing conditions of sedimentation may have prevailed for a long time (Eardley, 1951, 1962; Newell, 1955).

The term "Ocala Uplift" as here used is intended to mean the local and younger (Late Tertiary) structural feature as distinct from the "Peninsular Arch" previously described. It should not be used as a synonym for the Peninsular Arch as is current in much of the literature. Vernon (1951) stated that the Ocala Uplift was developed during post-Oligocene and Lower Miocene time in the Tertiary sediments as a gentle and rather local flexure in central peninsular Florida. The uplift centers around the outcrops of the Ocala Group (Upper Eocene) and Avon Park Limestone (late Middle Eocene) in Citrus, Dixie, and Levy counties on the west coast of the Peninsula, and its axis lies parallel to, but not coincident with, the axis of the Peninsular Arch (figs. 1 and 2). Both surface and subsurface geological information also indicates that there are no close structural relations between these two features (Applin, 1951b).

A series of structure maps representing lithologically correlative surfaces in successive stratigraphic units is presented as figures 7-12. These maps show the structural relationships through time between the Peninsular Arch and the Ocala Uplift. It is quite apparent that the Peninsular Arch is the major structural element, the core of the Florida Peninsula and possibly of the Bahamas, since at least late Upper Cretaceous time and even much older. Applin (1951b) concludes that this structure dates back to the Paleozoic.

Figure 7 is a structure map contoured on the top of the so-called "Taylor kick" (Upper Cretaceous). This is a very distinctive and prominent electric log characteristic in which both resistivity

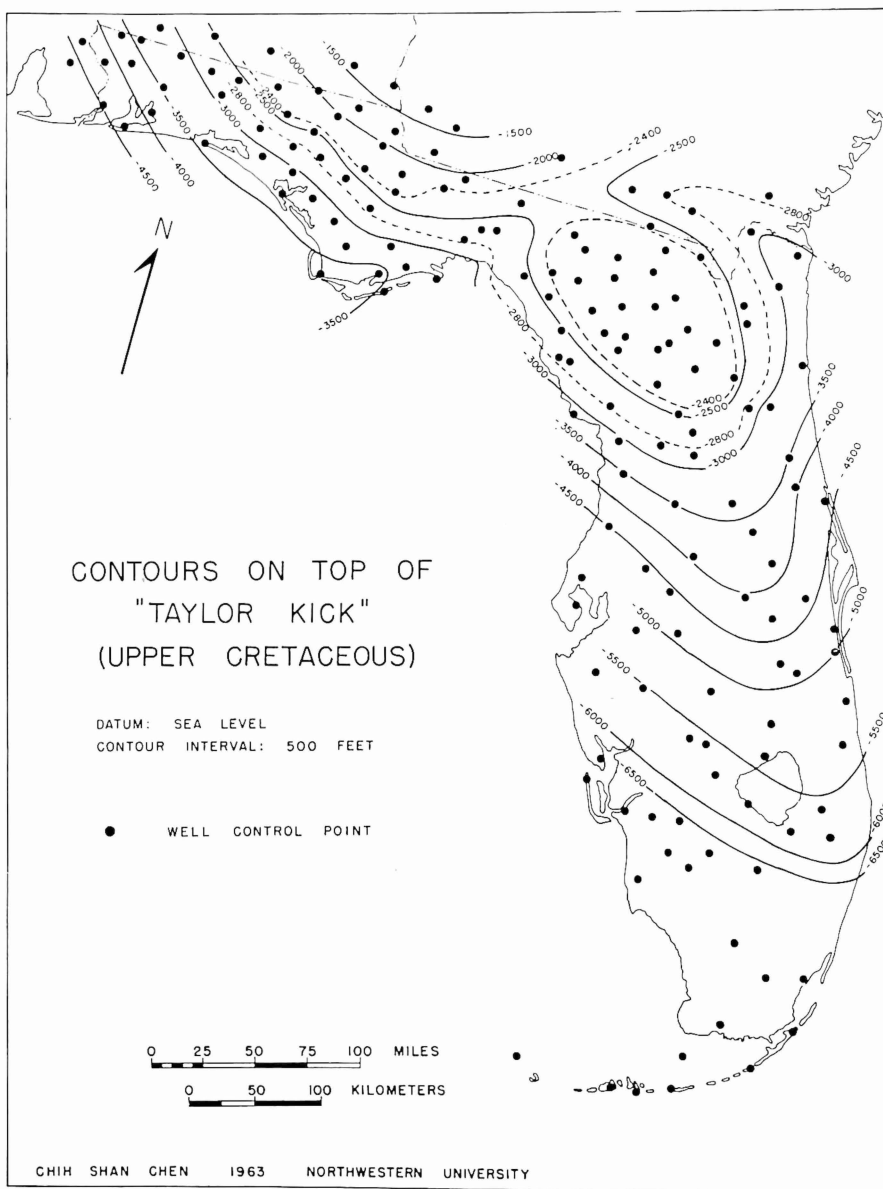


Figure 7. Structure map of Florida showing contours on top of "Taylor kick" (Upper Cretaceous).

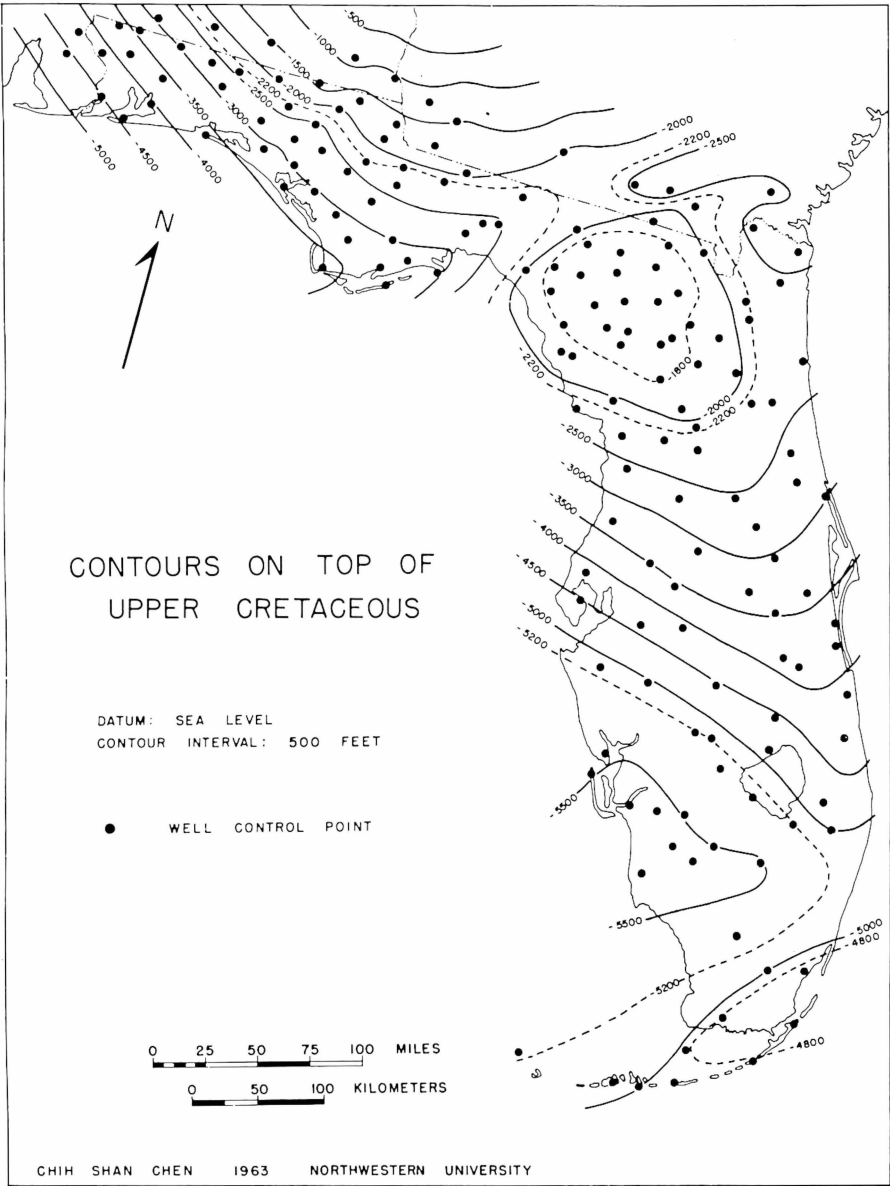


Figure 8. Structure map of Florida showing contours on top of Upper Cretaceous.

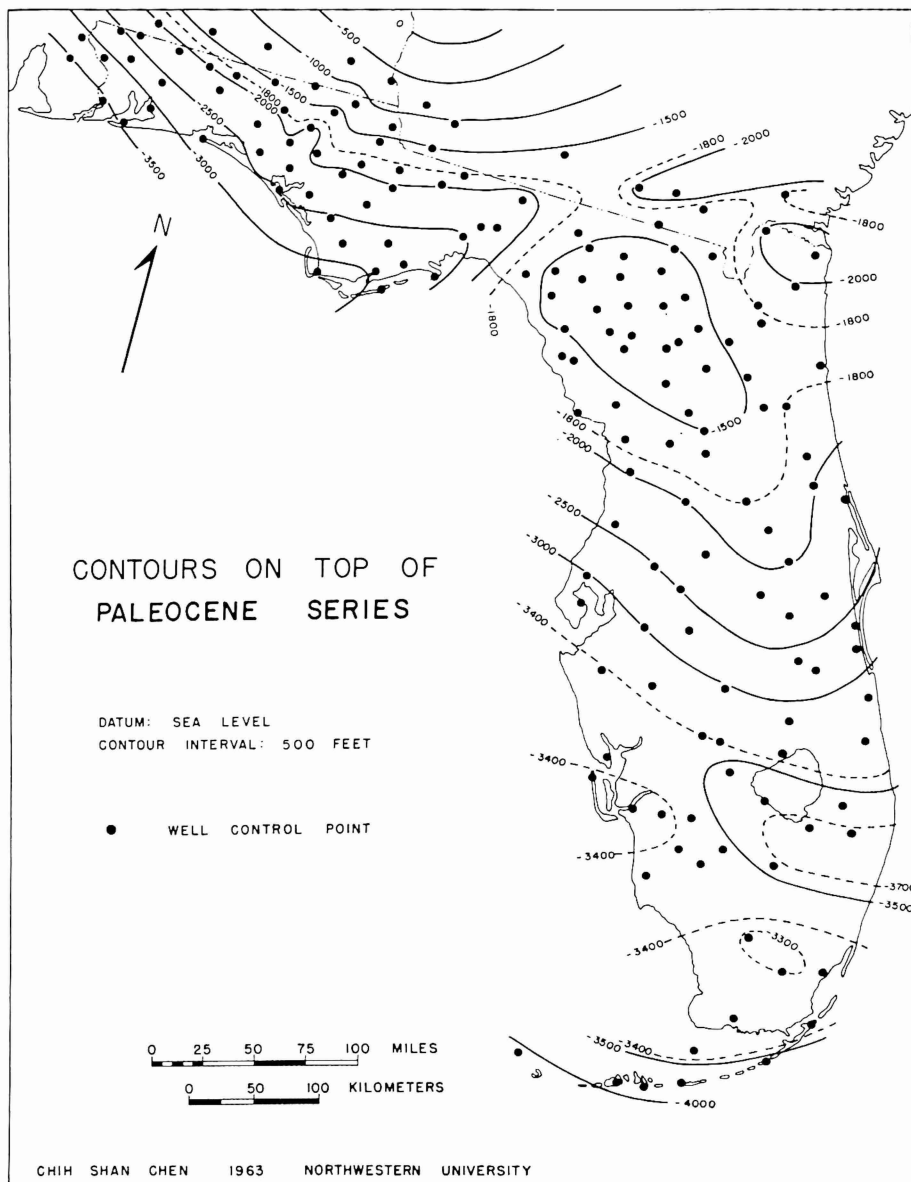


Figure 9. Structure map of Florida showing contours on top of Paleocene Series.

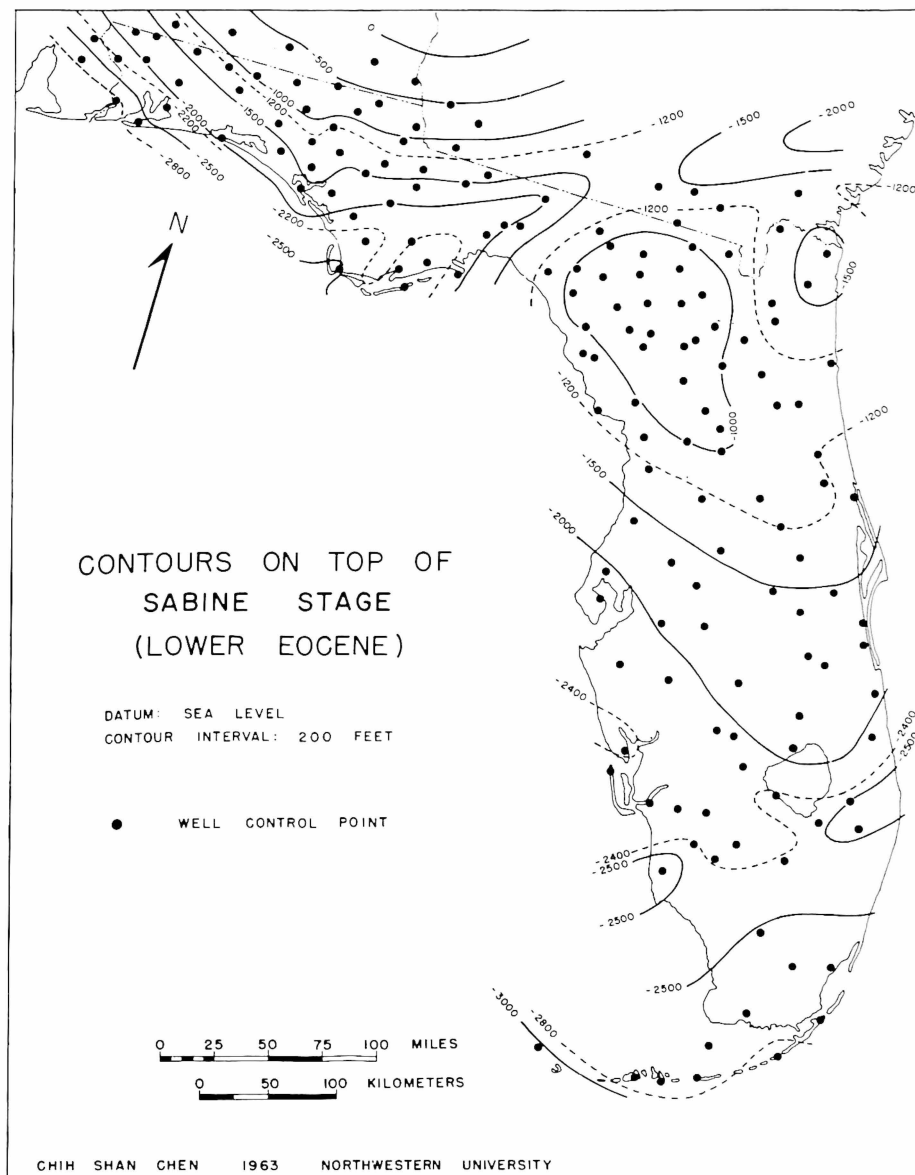


Figure 10. Structure map of Florida showing contours on top of Sabine Stage (Lower Eocene).

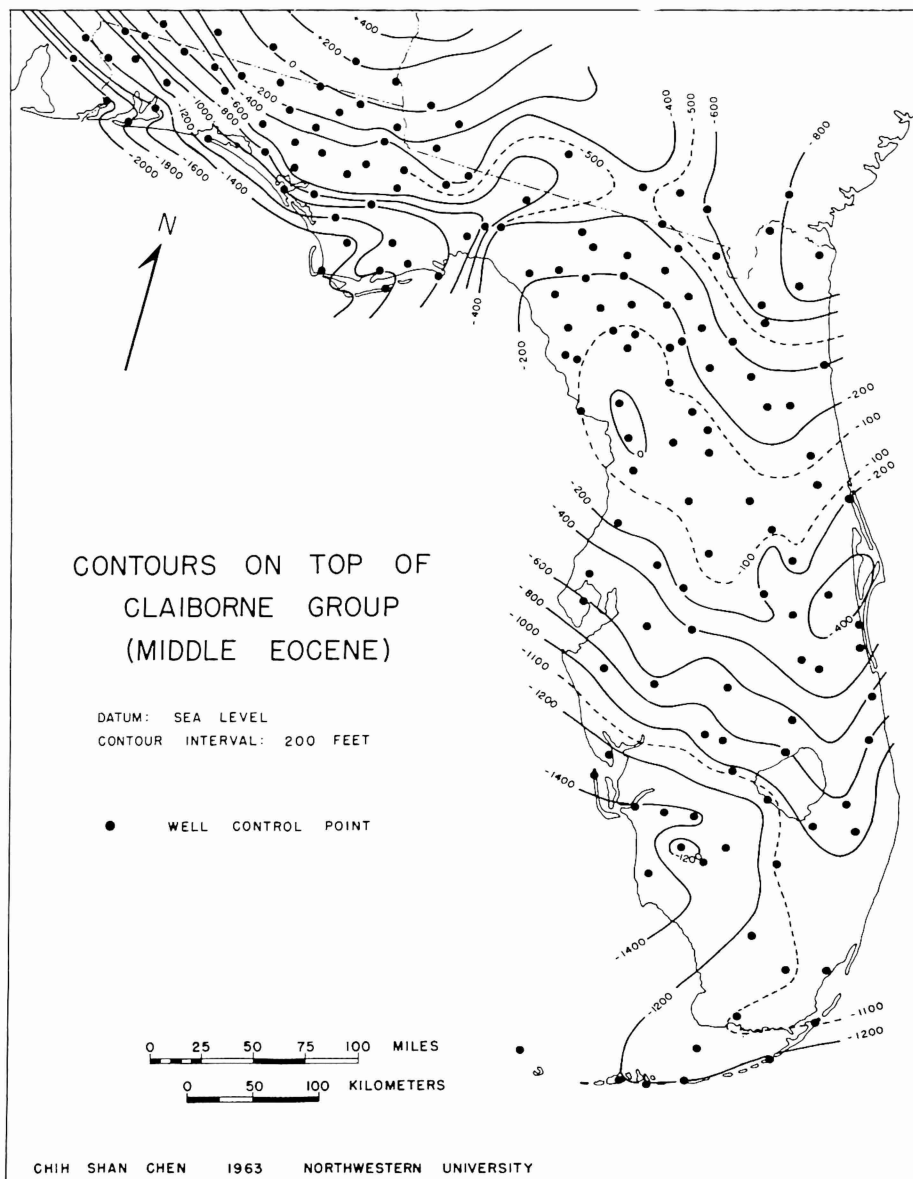


Figure 11. Structure map of Florida showing contours on top of Claiborne Group (Middle Eocene).



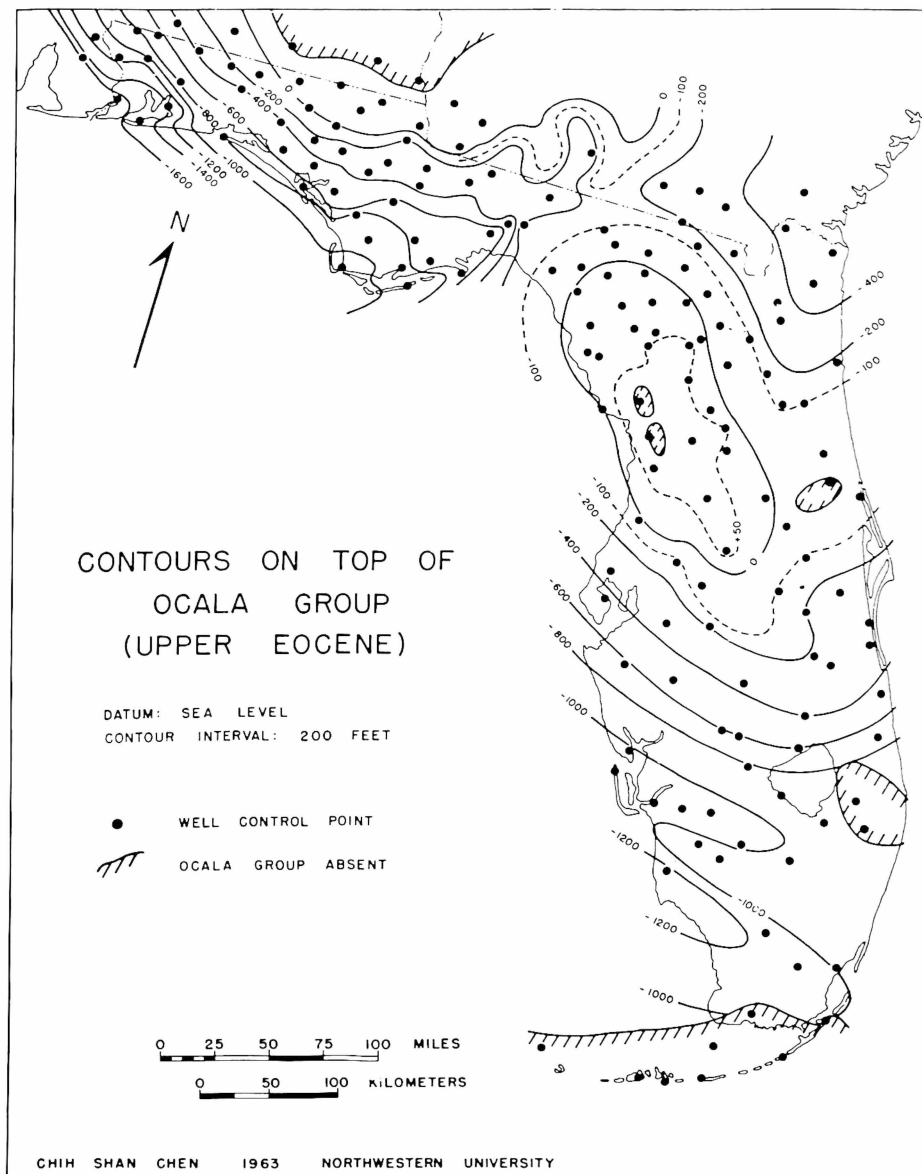


Figure 12. Structure map of Florida showing contours on top of Ocala Group (Upper Eocene).

and self potential curves are very low. This strong depression as shown on the potential curve can be easily recognized since the potential curve throughout most of the Upper Cretaceous section of peninsular Florida exhibits a rather flat and almost straight line. The inflection of the electrical responses is believed to represent a thin shale bed and, except for the southern end, is present in almost all of the wells which penetrate the basal Taylor beds in peninsular Florida. In panhandle Florida this electric-log departure is rather obscure, so that the contours shown on the map (fig. 7) are highly interpretive in this area.

As has been pointed out, the Peninsular Arch has been the dominant structural feature in peninsular Florida since at least Paleozoic time, and persisted through the Eocene and perhaps even later. The Ocala Uplift, on the other hand, is comparatively a much younger structure, first beginning to develop in post-Oligocene or probably Lower Miocene time. Two isopach maps (figs. 13 and 14) of the Claiborne Group (Middle Eocene) and Ocala Group (Upper Eocene) indicate that there is no thinning of these strata along the crest of the Ocala Uplift, although these isopach maps may not represent the actual pattern because of the effect of post-Claiborne and post-Ocala erosion. The position of the thin areas shown on these maps (figs. 11-14) strongly suggest that it is unlikely that the original geometry of the units has been radically changed by post-depositional erosion. In addition the attitude of Miocene beds which directly overlie the Ocala Group along the crest of the uplift suggests that the Ocala Uplift was formed during post-Oligocene or Lower Miocene time.

The Chattahoochee Arch, a minor structural feature along the Appalachian and Chattahoochee rivers, is a feature in which Paleozoic sediments are encountered below red beds of probable Jurassic age. The crest of the arch trends northeast near the common boundary of Alabama, Florida, and Georgia (fig. 2).

The term "South Florida Embayment" of the Gulf of Mexico Basin was originally proposed by Pressler (1947) to include the area of southern Florida south of the Ocala Uplift (the Peninsular Arch in the writer's usage), the Bahamas, Cuba, and the intervening submerged areas. The synclinal axis of the embayment plunges toward the Gulf and trends northwestward between Cuba and the Bahamas, across the Bahama Banks to the Florida Keys, and across Dade and Monroe counties to the southwest coast of Florida. Carsey (1950) used "South Florida Basin" to designate this regionally downwarped area. He placed its synclinal axis east-west through

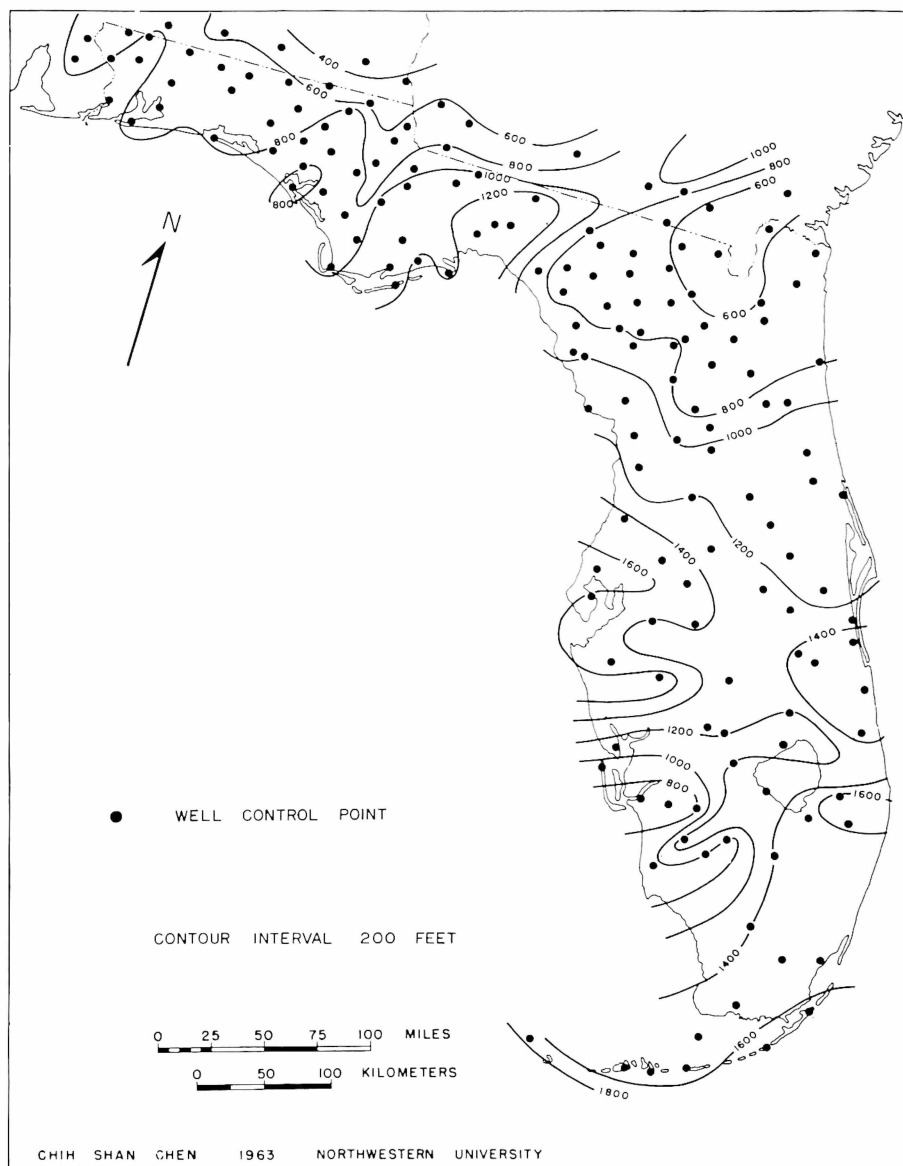


Figure 13. Isopach map of Claiborne Group (Middle Eocene).

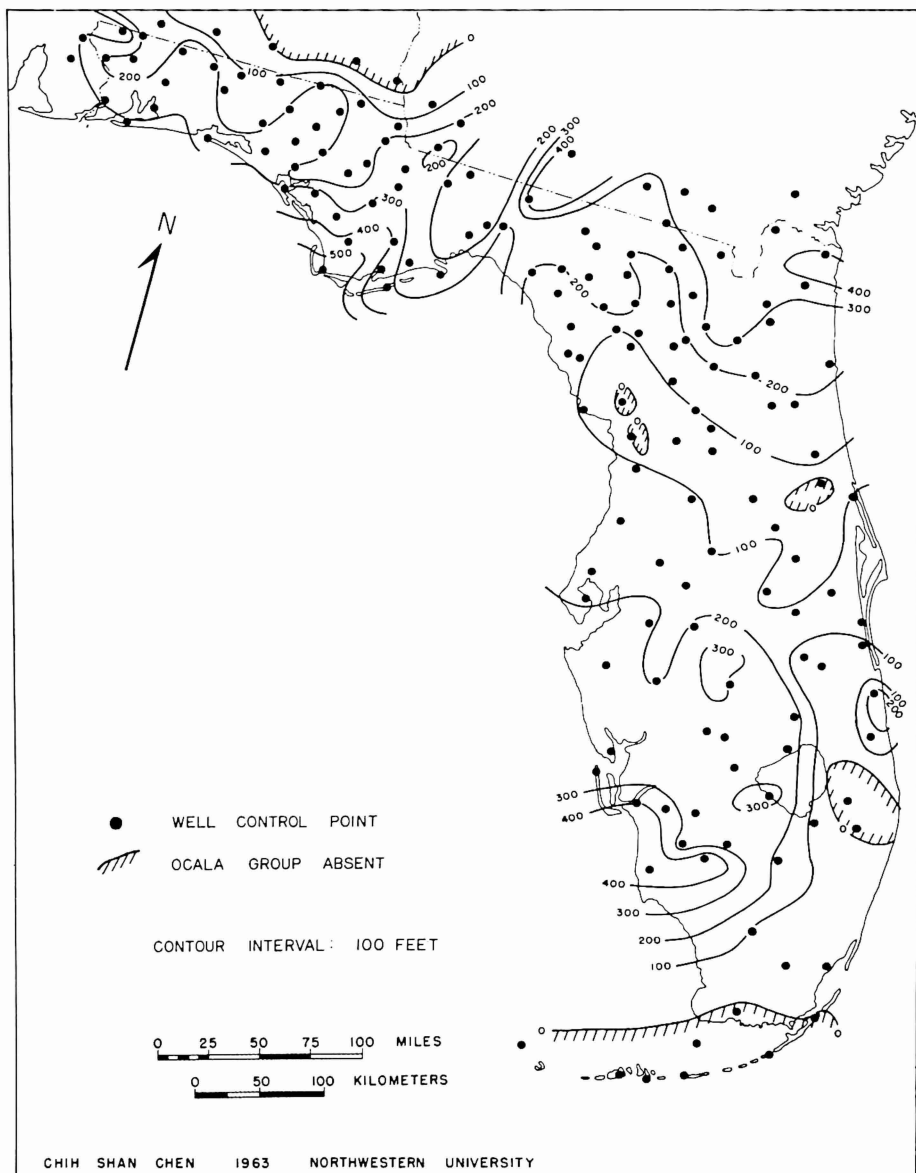


Figure 14. Isopach map of Ocala Group (Upper Eocene).

the present-day Florida Bay. However, the subsurface geological information obtained by the writer and other geologists (Puri and Vernon, 1959, 1960) reveals that the South Florida Basin plunges west toward the Gulf of Mexico with its axis passing near Sunniland and Forty Mile Bend oil fields and trending east-west (fig. 2). Thick Paleocene-Eocene sediments (exclusively carbonates and evaporites) thin both northward against the Peninsular Arch and southward toward the present-day Florida Keys (figs. 15 and 16). More than 4000 feet of nonclastic sediments were accumulated in this basin during Paleocene-Eocene time.

Basins to the northwest include the Apalachicola and Southeast Georgia embayments. These were areas of regional downwarping and were connected by the Suwannee Channel during Paleocene-Eocene time (fig. 2).

A great amount of valuable information concerning the geometry of the deposition basin and related sedimentary environments can be interpreted from a study of the relationships between the lithofacies pattern and the isopachs as represented by the combined isopach-lithofacies maps (See figs. 15-17). The results presented on these maps clearly identify the regional tectonic elements described above as the primary controls of the lithofacies pattern and the isopachs in the area. Two distinct sedimentary facies, land derived-clastic in panhandle Florida and nonclastic in peninsular Florida, are well separated by the Suwannee Channel which served as a natural facies barrier, both lithologic and biologic, throughout almost the entire Paleocene-Eocene time. The Peninsular Arch as outlined by the isopach lines is shown to be a major and prominent structural feature, and probably originated during Paleozoic time, persisting throughout the Mesozoic and Cenozoic interval. The Chattahoochee Arch, considered to be a minor structural feature, was probably a major controlling factor of the distribution of land derived-clastic sediments in panhandle Florida during Paleocene-Eocene time. The South Florida Basin and Apalachicola embayment are also well defined by the isopach lines.

The regional lithofacies patterns match well with the structural elements. No trace of the development of Ocala Uplift during Paleocene-Eocene time is indicated on any of these maps. Such evidence again strongly supports the conclusion that the Ocala Uplift is a much younger structural feature. No information is provided by the lithofacies maps regarding the regional distribution of older (probably Paleozoic) structural elements which are overlain by the thick Mesozoic and Cenozoic sediments. Nevertheless, the struc-

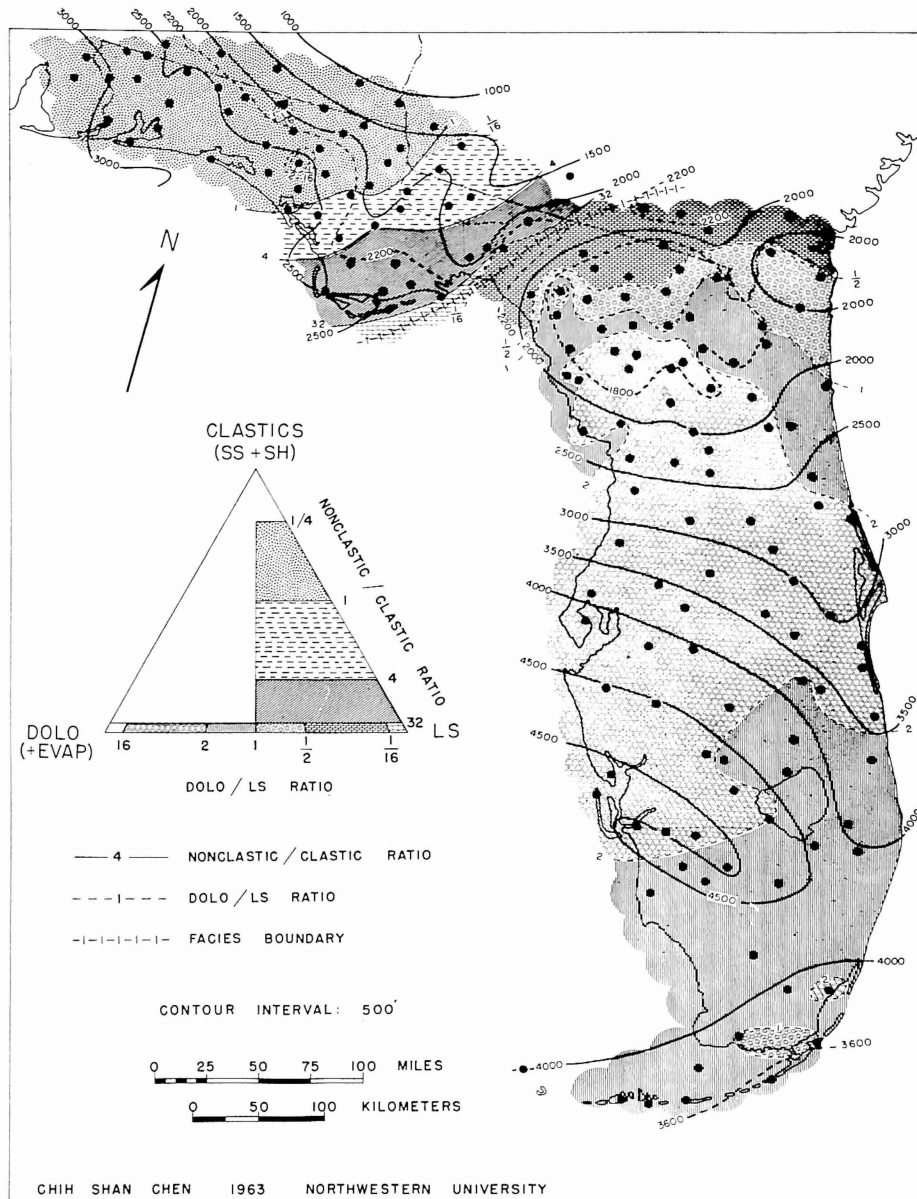


Figure 15. Isopach-lithofacies map of Paleocene-Eocene Series of Florida.

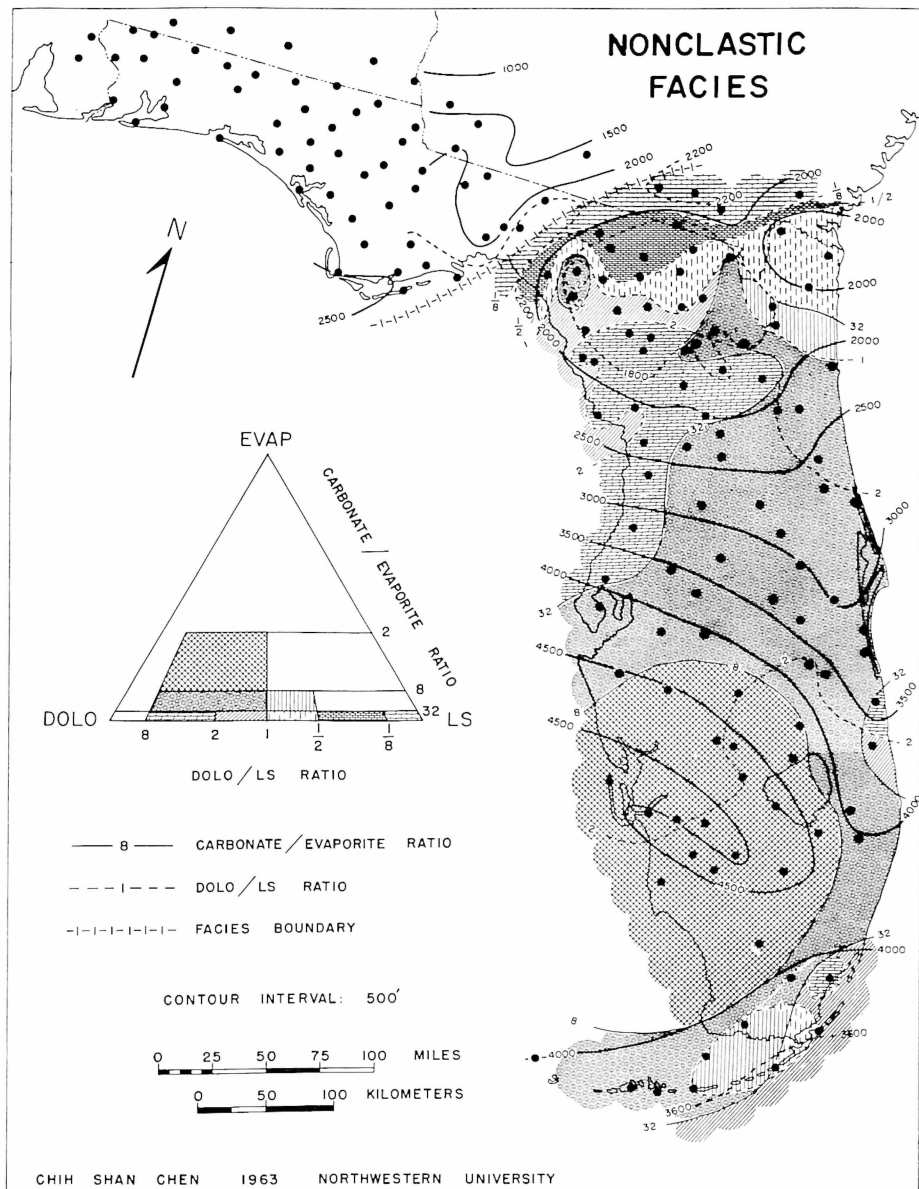


Figure 16. Isopach-lithofacies map of Paleocene-Eocene Series of panhandle Florida.

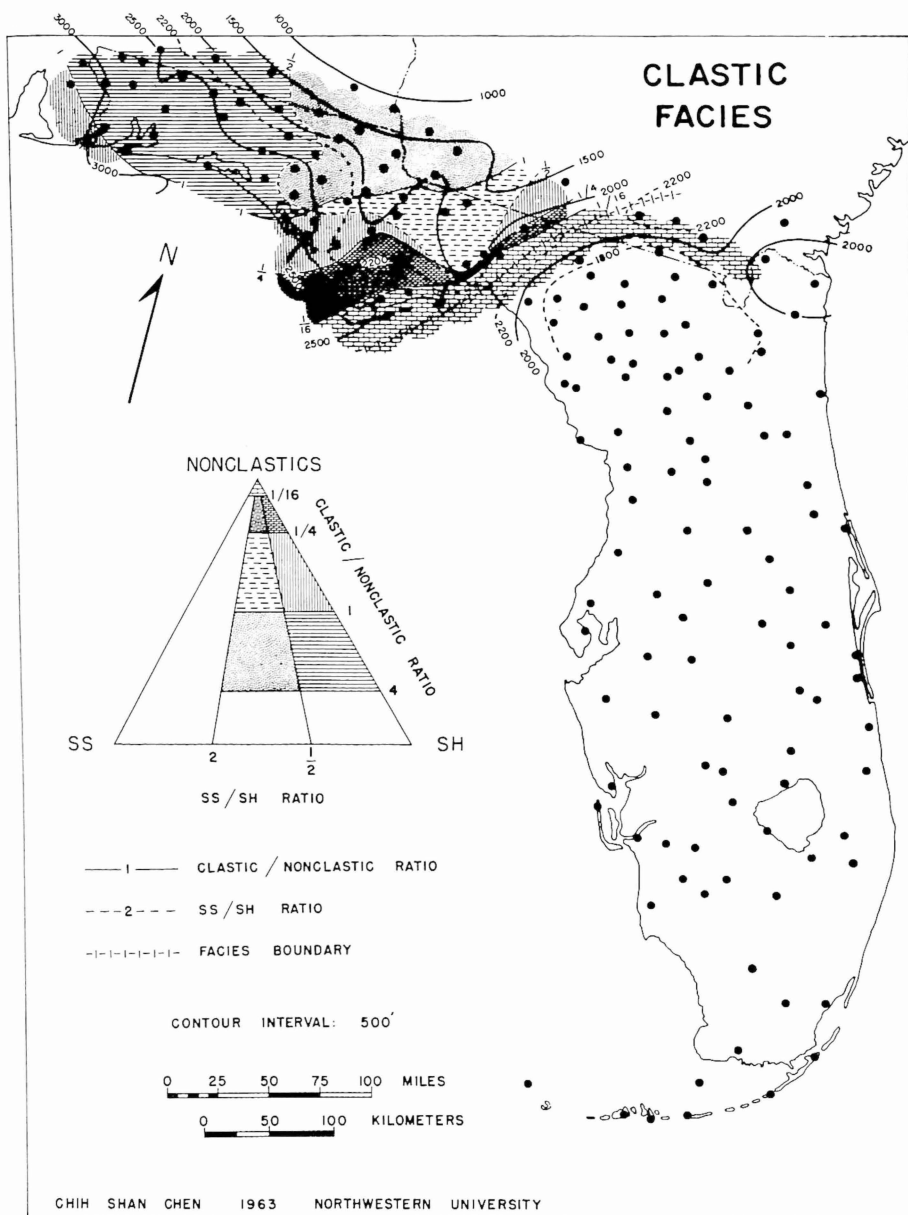


Figure 17. Isopach-lithofacies map of Paleocene-Eocene Series of panhandle Florida.



tures are considered to be the foundation of the southeastern Coastal Plain as well as the Florida Platform (fig. 2).

### ANALYTICAL PROCEDURES

A total of 164 wells were selected for the study; their locations are shown in figure 3 and listed in table 1 (see Appendix). Among these wells 143 are oil tests for which are available complete or incomplete well samples and electric logs. Generally such tests penetrate the entire Paleocene-Eocene into Mesozoic and, in some localities, into Paleozoic strata. In 43 of these wells, electric logs only were examined, since these wells occur in the vicinity of others whose lithologic and electric logs were examined in detail by the writer. The remainder are water wells that penetrate to relatively shallow depths within the Eocene section and lack electric logs.

Well samples comprise mainly cuttings or chips, with scattered cores. Only 30 wells have complete samples covering the entire Paleocene-Eocene section. For the remainder there are partial records only. Among the latter located in peninsular Florida the nature of the lithology is interpreted by integrating both the lithologic and electric log data.

Samples were obtained from the well sample library of the Florida Geological Survey and were examined under a binocular microscope. The electric log of each well was constantly checked during examination of the samples in order to obtain more reliable vertical distribution of lithologies since each sample represents an interval of rock which was generally 20 or 30 feet thick. Samples were examined in succession, from the surface down, and particular attention was paid to "first appearances" of different lithologies as well as faunal assemblages. Each sample was individually studied for major and minor lithologic constituents, crystallinity of minerals and matrix, fossil content and type of fossils, textures, and other properties.

Regionally, the lithologic changes in peninsular Florida are not great, so that missing sample intervals could be interpreted subjectively but confidently on the basis of electric logs and by comparison with adjacent wells in which well samples were complete. However, in panhandle Florida where lithologic changes are rather great, both vertically and laterally, a considerable amount of error would undoubtedly be introduced in any attempt to estimate major lithologic types based on the electric log characteristics only. There-

fore, only those wells with complete samples and electric logs were studied in the panhandle area.

Percentages of limestone and dolomite in each sample were estimated for use in the construction of lithofacies maps. These estimates were made by estimating the degree of reaction under the binocular microscope when each sample was treated with dilute HCl.

No written lithologic descriptions by earlier workers were consulted and used in this study. This procedure thus assured a uniformity in lithologic description which could not otherwise have been achieved. Such descriptions are on file at the well sample library of the Florida Geological Survey.

Thin sections were also examined, mostly from cores and only a few from cuttings. Emphasis was placed on examination of textures, mineralogic composition, relationships between mineral constituents and matrix, and diagenetic phenomena.

Clay minerals were examined by X-ray diffraction techniques. The methods described by Ostrom (1961) on separation of clay minerals from carbonate rocks were followed. The so-called slightly argillaceous dolomite and limestone in the peninsular Florida region revealed a surprisingly low clay content as well as a lack of other insoluble residues. Therefore, only calcareous shale samples obtained from wells in panhandle Florida were used in this study. Oriented slides were made from the clay fraction and were run untreated in order to obtain the characteristic lines of the clay present. No other treatments were applied in order to make more accurate determinations. Quantitative evaluation of any clay mineral is extremely difficult (Weaver, 1958a), and therefore estimates were made on the basis of the relative intensities of the basal (001) sequences of kaolinite, illite, and montmorillonite and are expressed as percentages.

Detailed paleontological work was not carried out in this study owing to the writer's inexperience in this field. However, diagnostic microfossils (foraminifera only) described by Applin and Jordan (1945) and other workers were checked during examination of the samples under the binocular microscope. Macrofossils such as echinoid shells and spines, bryozoans, algal fragments, mollusks, and other fossils were also examined and recorded, although these are rare.

Facies maps were constructed on principles summarized in Krumbein and Sloss (1951, 1963) and Sloss, Dapples, and Krumbein

(1960). Major lithologic types pertinent to the investigation were summed from each stratigraphic unit studied in each well and recorded on data sheets. Two distinct sedimentary facies exist both in the Paleocene-Eocene section and in older rocks. A nonclastic facies composed strictly of carbonate rocks and evaporites (anhydrite and gypsum) dominates the peninsular Florida region and a clastic facies consisting of sandstone, shale, and limestone dominates the panhandle Florida region. The facies boundary indicated from the limited well data is rather sharply defined. The following major lithologies were recorded:

1. Nonclastic facies

Limestone—fragmental, pseudo-oolitic, and fossiliferous, usually light brown and rather porous. A few highly fossiliferous limestones are composed almost entirely of the tests of microorganisms. Limestones are rarely dolomitic or gypsiferous.

Dolomite—microcrystalline to coarse crystalline, saccharoidal textured, brown to dark brown, usually porous and rarely dense, usually gypsiferous (especially in Paleocene section), fossiliferous dolomite also present but not common.

Anhydrite and gypsum—anhydrite is pure white to light gray or blue, occurs as beds, irregular bands, seams or veinlets, and commonly associated with microcrystalline dolomite.

No pure gypsum beds were encountered, gypsum usually forms irregular thin seams or veinlets, and/or impregnating pore spaces in the dolomite. Selenite is commonly present.

2. Clastic facies

Sandstone—usually calcareous and glauconitic, poorly consolidated, no relatively pure quartz sandstone present.

Shale—green-gray to gray-black, commonly calcareous and laminated, micaceous and glauconitic, rather soft and poorly consolidated.

Limestone—commonly fossiliferous to nonfossiliferous, arenaceous and glauconitic, and argillaceous, rarely dolomitic, cherty limestone not uncommon in certain wells.

These major lithologies were employed as end members and arranged in several different ways in order to show the regional lithofacies pattern of each stratigraphic unit studied, which may

directly relate to the major tectonic elements of the area concerned. The following are four sets of lithologic end members and ratios which were employed for the lithofacies analysis:

1. For total area (nonclastic and clastic facies)

AA: sandstone + shale

B: dolomite (+ evaporite)

C: limestone

(B+C)/AA: carbonate-clastic ratio

B/C: dolomite-limestone ratio

2. For total area (nonclastic and clastic facies)

AA: sandstone + shale

B: evaporite

C: carbonate

(B+C)/AA: nonclastic-clastic ratio

B/C: evaporite-carbonate ratio

3. For peninsular Florida region (nonclastic facies)

AA: evaporite (anhydrite + gypsum)

B: dolomite

C: limestone

(B+C)/AA: carbonate-evaporite ratio

B/C: dolomite-limestone ratio

4. For panhandle Florida region (clastic facies)

AA: dolomite (+ evaporite) + limestone

B: sandstone

C: shale

(B+C)/AA: clastic-nonclastic ratio

B/C: sand-shale ratio

Percentage values of three lithologic components of each stratigraphic unit studied and two kinds of ratio values which were generated from those percentage values were computed through the use of IBM 709 in the Northwestern University Computing Center.

Evaporite percentage maps were also constructed in order to outline areas of evaporite development. Structure maps were also made on correlative surfaces within each of the stratigraphic units studied. Distribution, thicknesses, and correlations between these units are shown in the lithologic cross sections.

## DESCRIPTIVE STRATIGRAPHY

### GENERAL STATEMENT

In Florida Paleocene-Eocene strata are covered by younger sediments, with the exception of two areas, the Chattahoochee Arch in panhandle Florida and Ocala Uplift in peninsular Florida, where Upper Eocene and Middle to Upper Eocene rocks, respectively, occur at the surface. These Paleocene-Eocene rocks can be grouped lithostratigraphically into the lower part of the Tejas Sequence which includes all cratonic sedimentary and volcanic rocks of Late Paleocene and younger age in the cratonic interior of North America (Sloss and others, 1949; Sloss, 1959, 1963).

The Paleocene-Eocene section in Florida comprises, in ascending order, the Midway Formation and its equivalent, the Cedar Keys Formation (Paleocene), the Wilcox Formation and its equivalent, the Oldsmar Limestone (Lower Eocene), the Claiborne Group and its equivalent, the Lake City and Avon Park Limestones (Middle Eocene), and the Ocala Group (Upper Eocene). A large part of the Ocala Group within this section is overlain unconformably by post-Eocene strata. Units of the entire Paleocene-Eocene section overlie unconformably the beds of Upper Cretaceous age near basin margins and up-dip toward the continental interior. However, further into the Gulf Coast basin, such beds probably are in continuous succession.

A series of four subsurface stratigraphic cross sections illustrates, both vertically and laterally, the stratigraphic relationships among units of the Paleocene-Eocene section (figs. 18-22). The datum plane of each cross section is the post-Eocene unconformity. Descriptions of the lithologic units from which these cross sections were made are presented later in this chapter. Time-stratigraphic correlations of Paleocene-Eocene strata in the area are shown in figure 23. No attempt has been made to revise correlations or to establish new names, but merely to consolidate terms most frequently used.

Two distinct sedimentary facies, clastic and nonclastic, have been recognized in each Paleocene-Eocene stratigraphic unit in the area studied. The regional facies pattern as represented by isopach-lithofacies maps (figs. 24-26, and pp. 38, 39, and 40) for each stratigraphic unit clearly demonstrate this division. However, the facies boundary of successive stratigraphic units does not persistently remain in the same position, but shifts gradually northward and northwestward through the time. As is shown in figures 4, 19, and

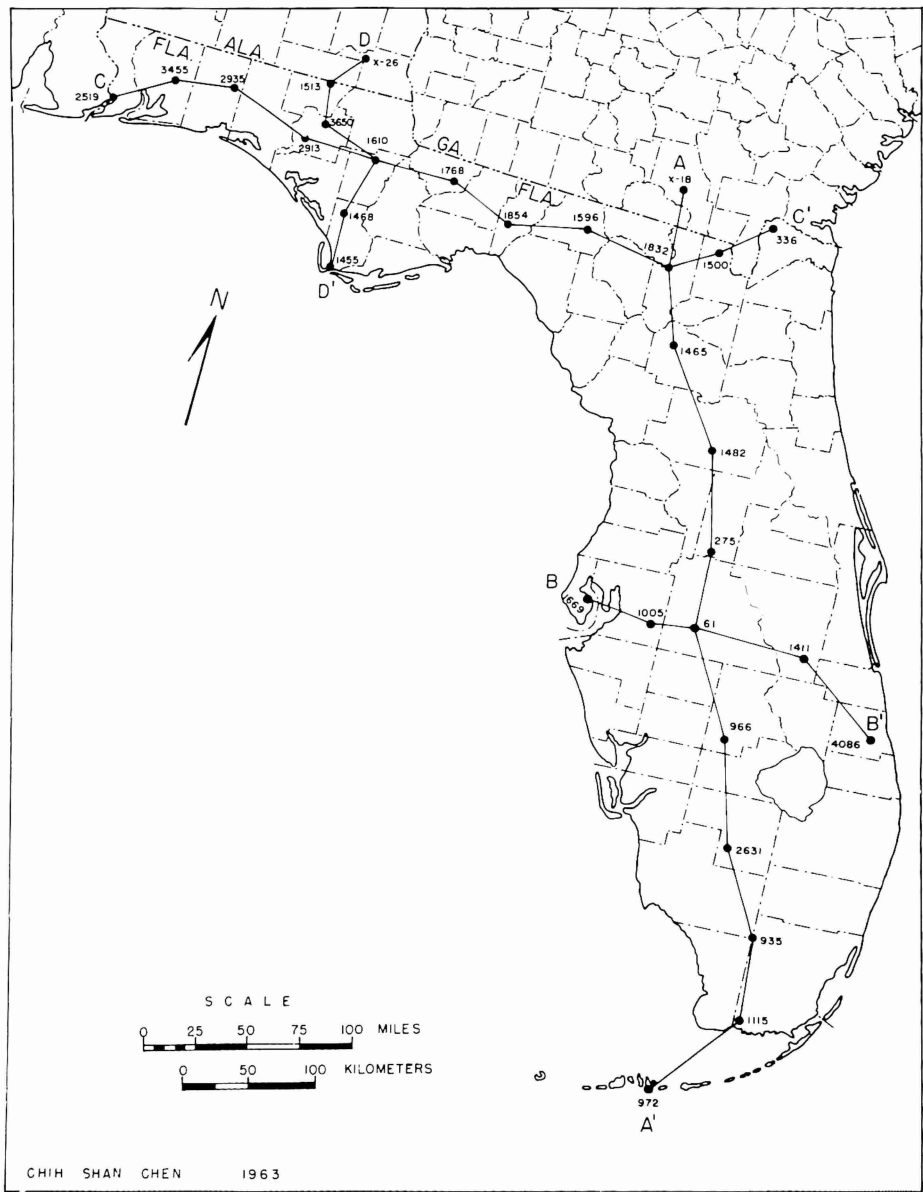


Figure 18. Index map showing location of cross sections.

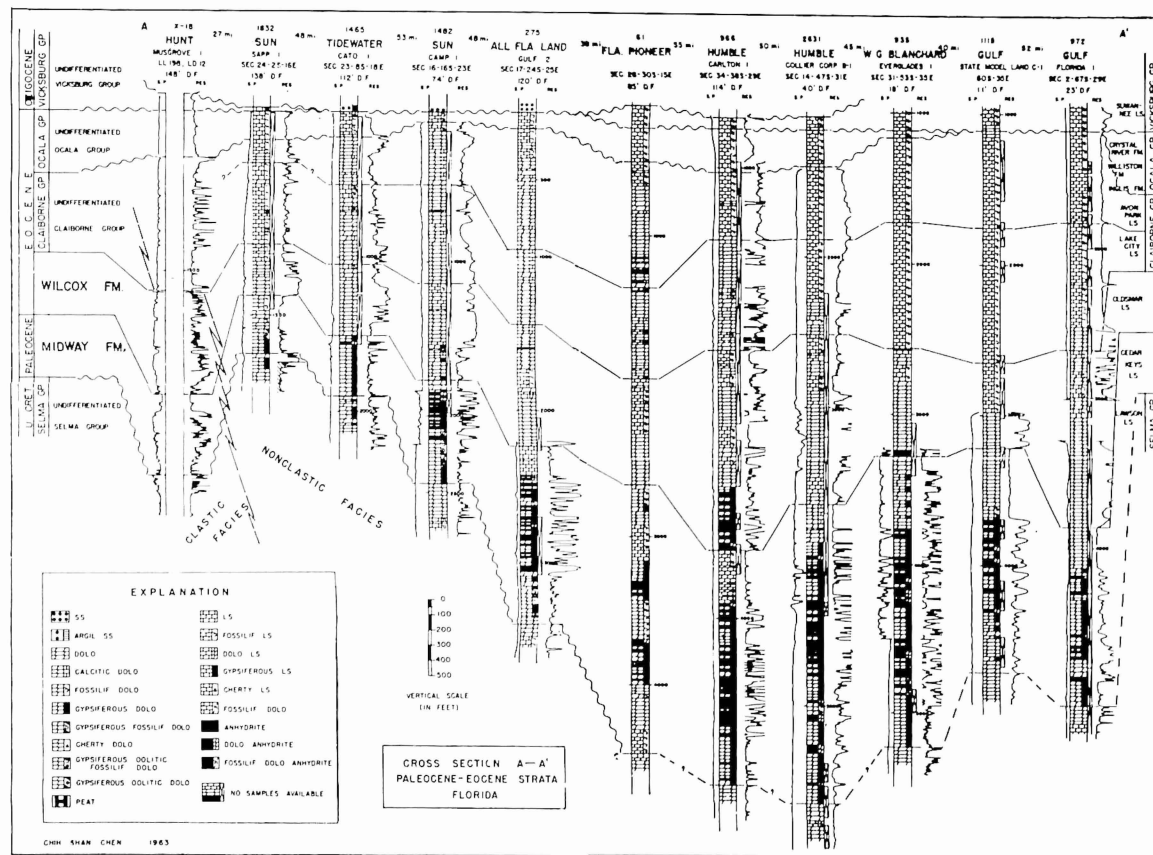


Figure 19. Stratigraphic cross section (A-A') of Paleocene-Eocene strata of Florida.

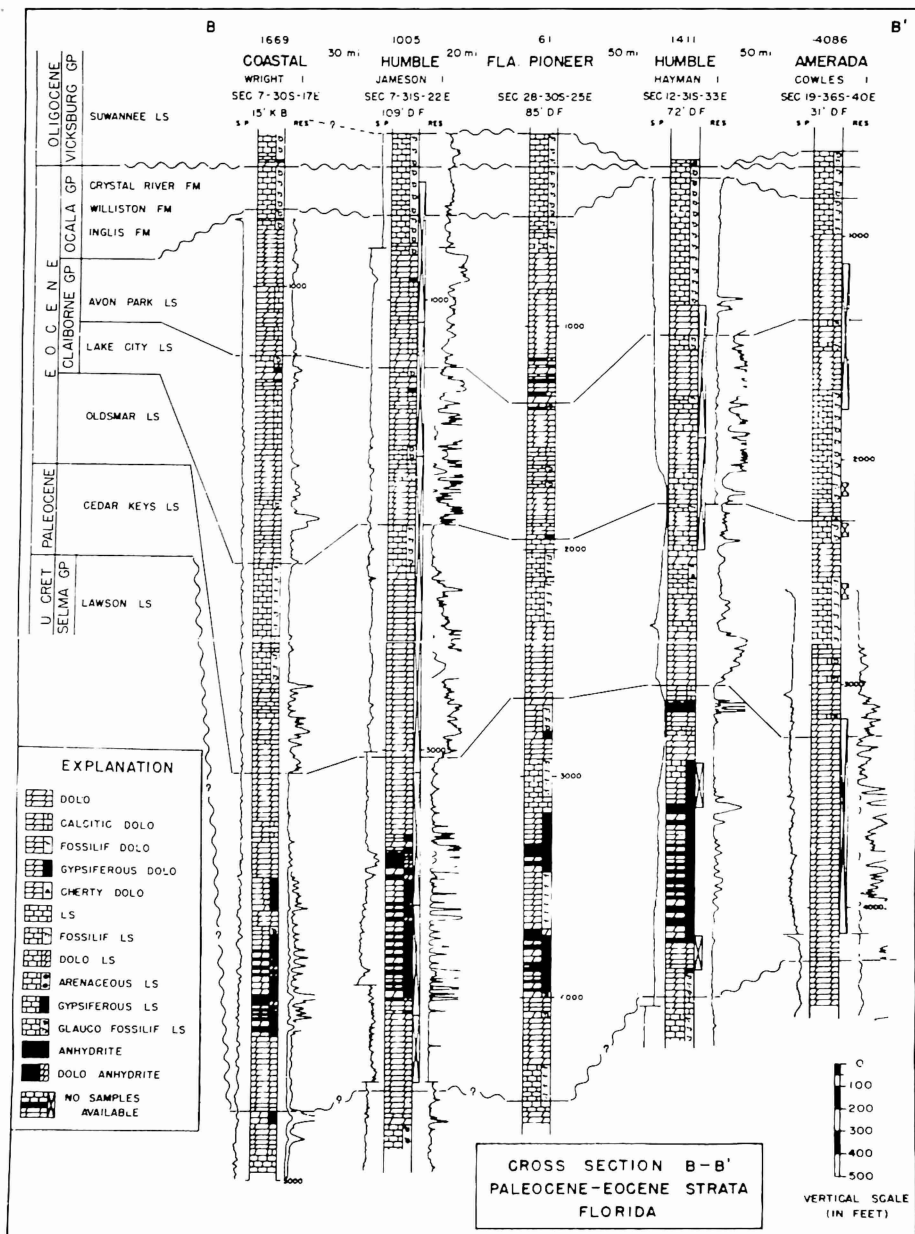
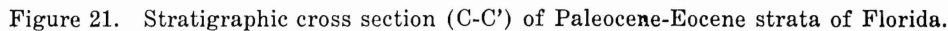


Figure 20. Stratigraphic cross section (B-B') of Paleocene-Eocene strata of Florida.





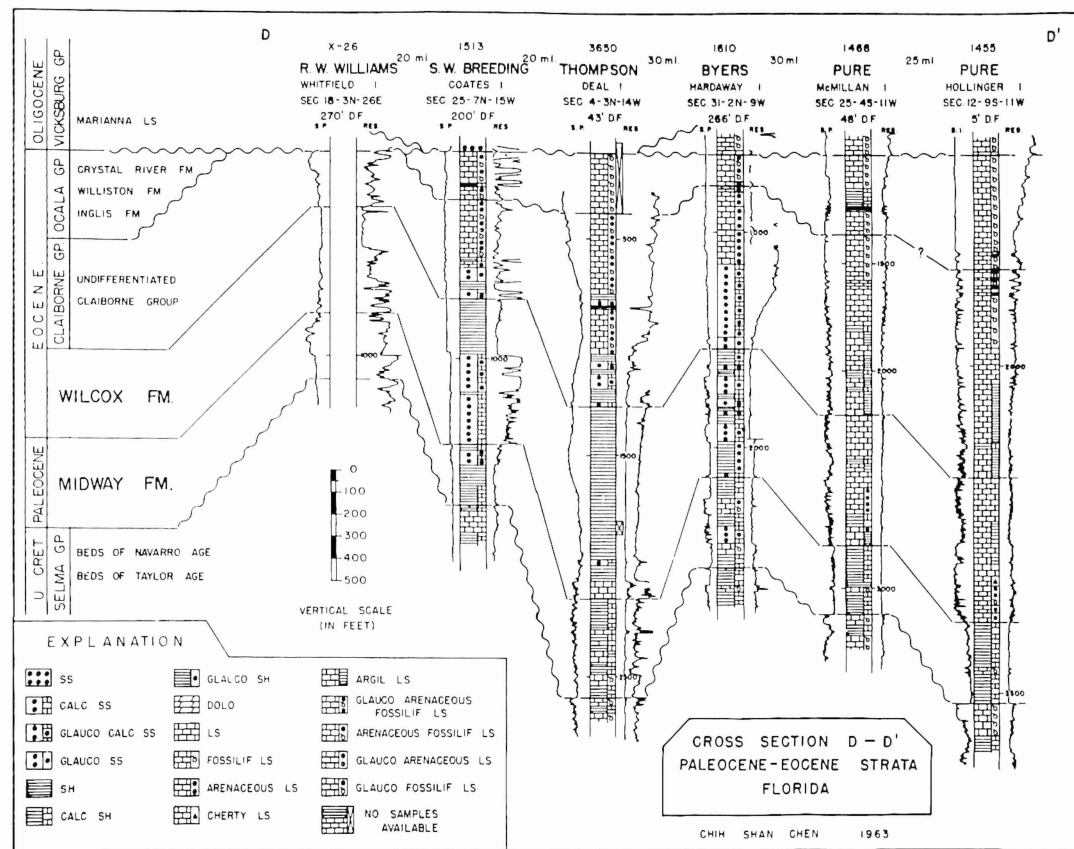


Figure 22. Stratigraphic cross section (D-D') of Paleocene-Eocene strata of Florida.

| System     | Series    | Stage     | Sequence | Alabama                                                              | Georgia<br>(southern)                              | Florida                                                         |                                     |
|------------|-----------|-----------|----------|----------------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------|-------------------------------------|
|            |           |           |          |                                                                      |                                                    | Panhandle                                                       | Peninsula                           |
| Tertiary   | Oligocene | Vicksburg | Tejas    | Byram Fm.<br>Marianna Ls.<br>Red Bluff Clay                          | Suwannee Ls.<br>Byran Fm.<br>Marianna Ls.          | Suwannee Ls.<br>Byran Fm.<br>Marianna Ls.                       | Suwannee Ls.                        |
|            |           | Jackson   |          | Yazoo Clay<br>Moody's Branch Fm.                                     | Ocala Ls.                                          | Ocala Group<br>Crystal River Fm.<br>Williston Fm.<br>Inglis Fm. |                                     |
|            | Eocene    | Claiborne |          | Gosport Fm.<br>Lisbon Fm.<br>Tallahatta Fm.                          | Gosport Fm.<br>McBean Fm.<br>Tallahatta Fm.        | Undifferentiated<br>Claiborne<br>Group                          | Avon Park Ls.<br>Lake City Ls.      |
|            |           | Sabine    |          | Hatchetigbee Fm.<br>Tuscahoma Fm.<br>Nanafalia Fm.<br>& Salt Mt. Ls. | Hatchetigbee Fm.<br>Tuscahoma Fm.<br>Nanafalia Fm. | Wilcox Fm.                                                      | Oldsmar Ls.                         |
|            | Paleocene | Midway    |          | Naheola Fm.<br>Porters Creek Fm.<br>Clayton Fm.                      | Midway Fm.                                         | Midway Fm.                                                      | Cedar Keys Fm.                      |
| Cretaceous | Gulf      | Navarro   | Zuni     | Selma Chalk &<br>Ripley Fm.                                          | Providence Fm.<br>Cusseta Fm.                      | Beds of Navarro Age<br>Beds of Taylor Age                       | Lawson Ls.<br>Beds of Taylor<br>Age |

Figure 23. Correlations of Paleocene-Eocene strata.

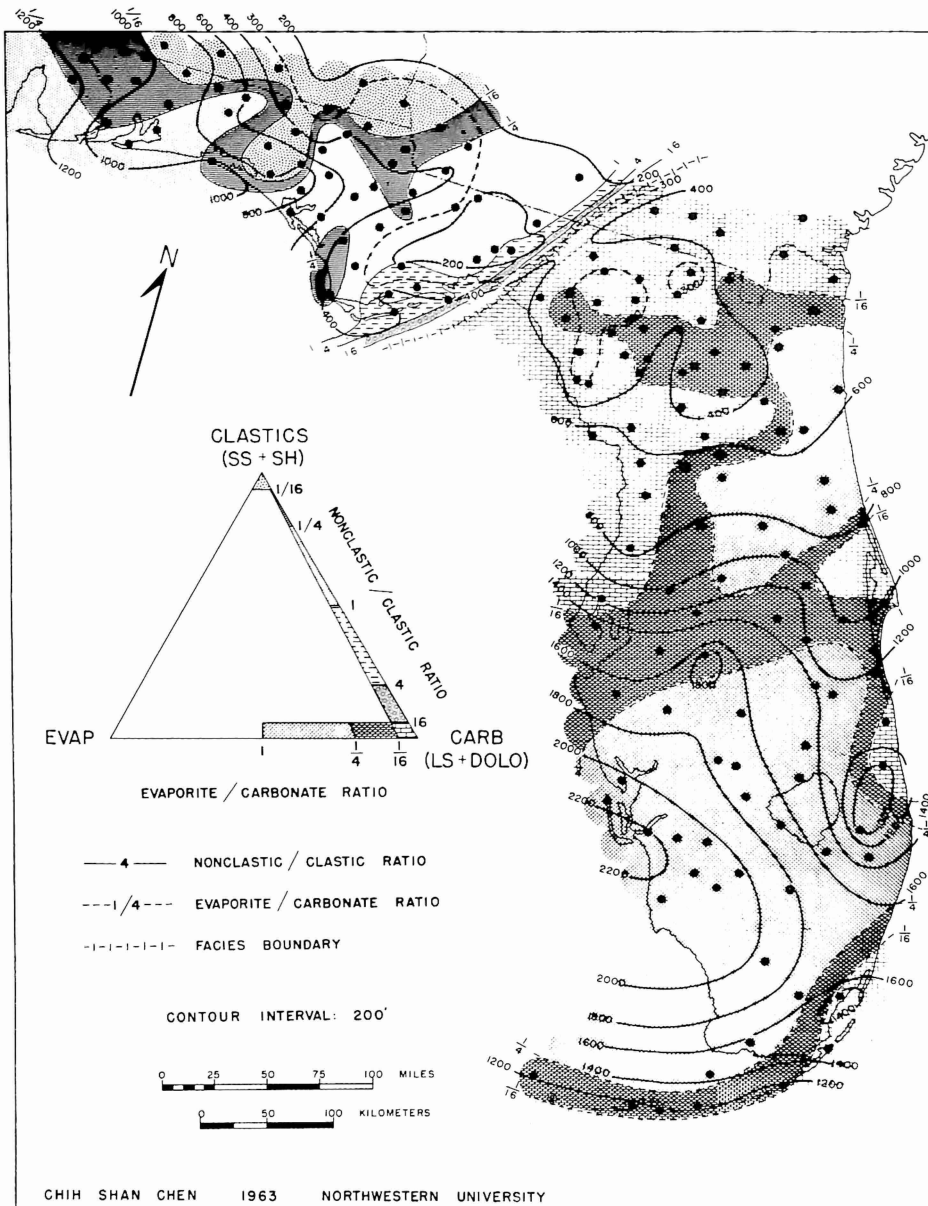


Figure 24. Isopach-lithofacies map of the Paleocene Series of Florida.

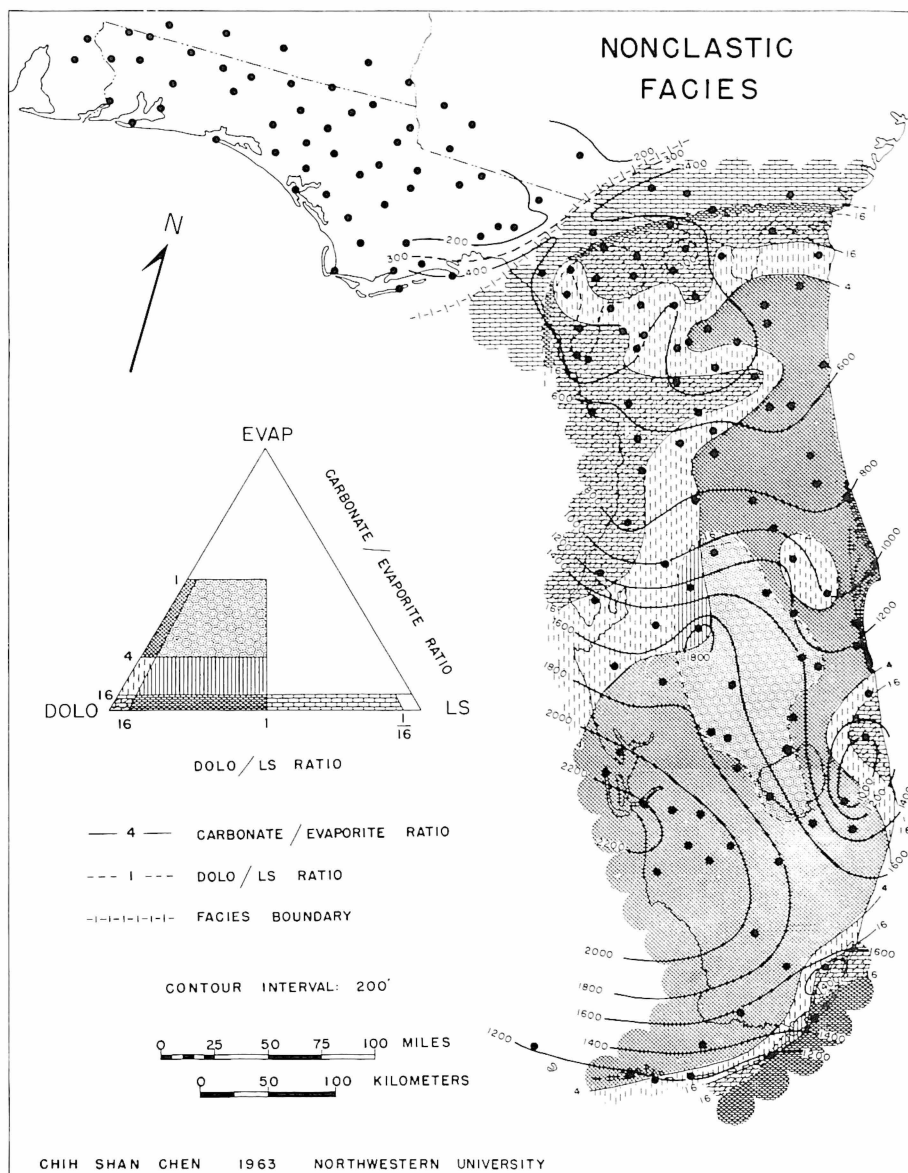


Figure 25. Isopach-lithofacies map of the Cedar Keys Formation (Paleocene Series) of peninsular Florida.

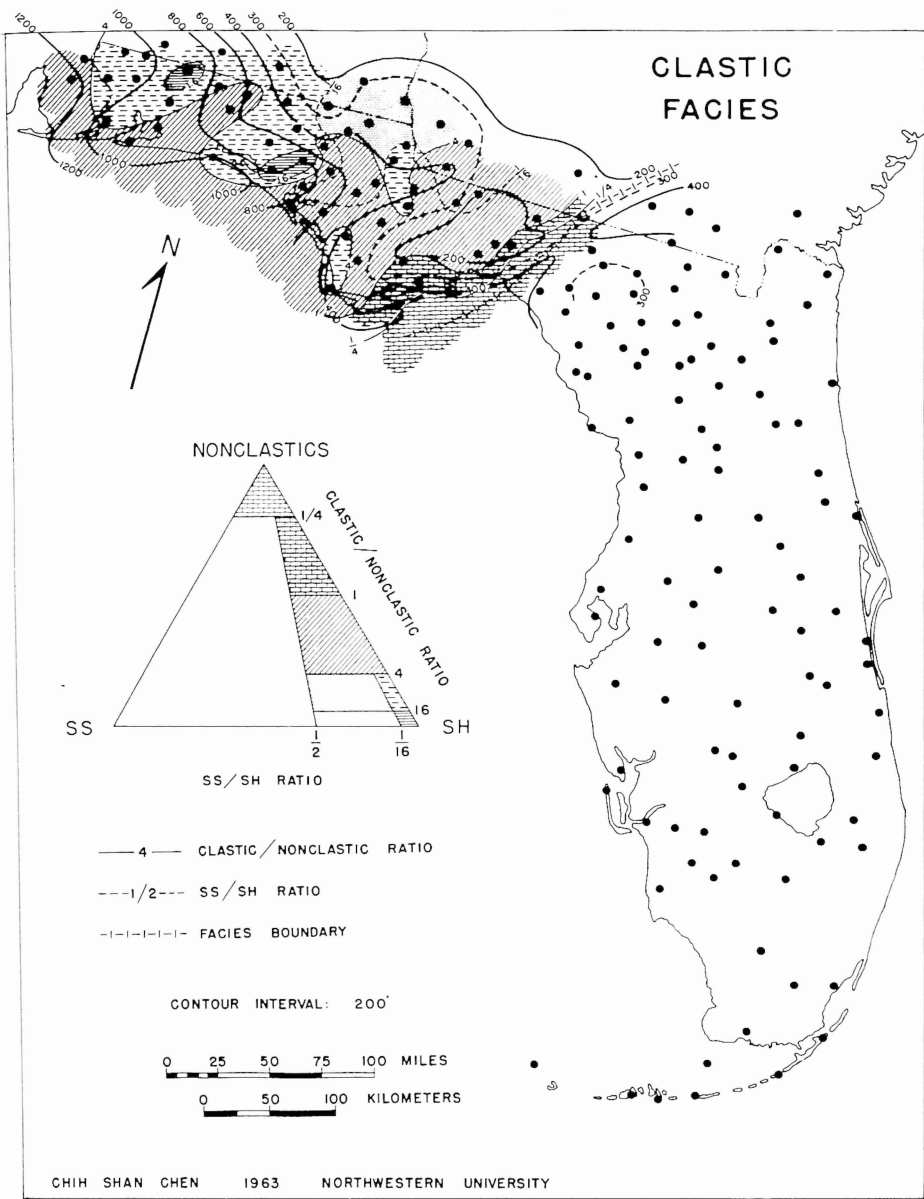


Figure 26. Isopach-lithofacies map of the Midway Formation (Paleocene Series) of panhandle Florida.

21 the nonclastic facies in peninsular Florida has encroached steadily upon the clastic facies in panhandle Florida and its adjacent areas, spreading northward and northwestward during successive stages. Near the end of Late Cretaceous time, the nonclastic facies had spread over all of the peninsular Florida region and a part of southern Georgia. The two facies tracts were separated by the so-called Suwannee Channel, a rather narrow and elongate negative structural feature which is considered to have been characterized by relatively deeper water and moderately strong currents passing through it. Such currents within the channel could prevent transport of terrigenous sediments across the channel into peninsular Florida during the time from Late Cretaceous to early Middle Eocene or Upper Eocene (figs. 4-6). Besides the major influence of the Suwannee Channel, however, some other factors may have contributed to the development of such marked facies difference. An example occurred during Paleocene-Eocene time when northwesterly prevailing long-shore currents probably existed along the coast region of the panhandle; only a small amount of clastic sediments was actually contributed from the source areas, the southern Appalachian region, to the loci of deposition; and only a few streams were available for transporting the clastic sediments.

## CEDAR KEYS AND MIDWAY FORMATIONS

### PRE-MIDWAYAN UNCONFORMITY

An important unconformity separates basal Paleocene sediments and Upper Cretaceous rocks throughout most of the Gulf Coastal Plain (Rainwater, 1960).

Applin and Applin (1944) have stated that in the vicinity of Tallahassee, Paleocene strata rest unconformably on beds of Taylor age with the Navarro equivalent and even upper beds of Taylor age being absent.

In Levy and Citrus counties of peninsular Florida, Vernon (1951) also reported an unconformity at the top of the Upper Cretaceous as evidenced by the presence of gray, chalky, limestone pebbles in the base of the Cedar Keys Formation (Paleocene). Unconformable relationships in northern and central Florida seem to be demonstrated.

In southern Florida, however, the writer sees no conclusive evidence suggesting an unconformity between the Cedar Keys Formation and Lawson Limestone (late Upper Cretaceous). Lithologic and faunal differences are quite distinct at stratigraphic positions well above and well below the formational contact, but the

contact itself is arbitrarily chosen in a transitional succession. Thus, the sub-Paleocene unconformity appears to pass into an unbroken sequence in the South Florida Basin.

#### CEDAR KEYS FORMATION

The Cedar Keys Formation was originally applied by Cole (1944) to Paleocene (his Lower Eocene) rocks of nonclastic facies in the subsurface of northern and peninsular Florida. According to Cole:

The term Cedar Keys formation is designated to cover the rocks encountered in wells in peninsular and northern Florida from the first appearance of the *Borealis* fauna to the top of the Upper Cretaceous. The Cedar Keys formation is unquestionably the stratigraphic equivalent of the Midway formation of the Gulf Coast area.

However, boundaries of the Cedar Keys Formation as currently used by the Florida Geological Survey (Vernon, 1951; Puri and Vernon, 1959) and by other southeastern Coastal Plain geologists (Applin and Applin, 1944; Toulmin, 1955) are slightly modified from those originally proposed by Cole. The top of the Cedar Keys Formation is marked by a distinct lithology consisting mainly of gray, microcrystalline, slightly gypsiferous and rarely fossiliferous dolomite that is relatively easily recognized on electric logs. This contact is generally near to but never below the top of the range zones of *Borealis gunteri* and *Borealis floridanus*. The base of the Cedar Keys is defined lithologically by the presence of the underlying Lawson Limestone (latest Upper Cretaceous) which is composed chiefly of pure, clean, very light brown and fine crystalline dolomite and/or chalky dolomitic limestone. The Cedar Keys Formation as considered here rests unconformably, at least locally if not regionally, on the Lawson Limestone and is conformable with the overlying Oldsmar Limestone (Lower Eocene).

The Cedar Keys Formation consists mostly of dolomite and evaporites (gypsum and anhydrite) with a minor amount of limestone and shows distinctive lithologic and faunal characteristics quite different from rocks above and below. The dolomite is light gray, slightly porous to porous, rather hard, microcrystalline to very fine crystalline, and nonfossiliferous to fossiliferous. Anhydrite generally forms beds, nodules, and lenses and is interbedded with dolomite. Gypsum commonly fills pore spaces within the dolomite beds and occurs as thin irregular streaks or seams in dolomite. A relatively large portion of dolomite in the formation has been impregnated, partially or completely, with gypsum. No halite or



potash minerals were found by the writer in this study and none has been reported in the literature. These evidences suggest strongly that the complete marine evaporite cycle is not represented in these strata.

The upper part of the formation is composed mainly of dolomite which is gray, more or less impure (probably contaminated by organic matter), slightly gypsiferous to gypsiferous, generally microcrystalline, rarely fossiliferous, and slightly calcitic in part; this distinctive lithologic character marks the top of the Cedar Keys Formation and shows relatively low resistivity curves on electric logs. The lower part of the formation is composed mainly of non-fossiliferous to fossiliferous and gypsiferous dolomite and anhydrite beds. Gypsiferous (or anhydritic) dolomite is commonly interbedded with dolomitic anhydrite and/or anhydrite beds. The vertical repetition of the pair of dolomite and anhydrite beds which represents each of the major but incomplete marine evaporite cycles occurring in the lower part of the formation is more common downdip toward the South Florida Basin than updip over the Peninsular Arch. Laterally, away from the basin center, these anhydrite beds are gradually replaced by the carbonates. Such vertical and lateral lithologic variations of the Cedar Keys Formation are clearly demonstrated on the lithological cross section A-A' as shown in figure 19. Faunally, the formation is characterized by the presence of the Foraminifera *Borelis gunteri* and *Borelis floridanus*.

The Cedar Keys Formation is widely developed throughout peninsular and northern Florida, and near the Georgia boundary (figs. 24-25). In the other parts of the Gulf Coast, this formation is considered by the Coastal Plain geologists to be the marine and deltaic clastic equivalent of the Midway Group.

Figure 24 is the isopach-lithofacies map of the Paleocene Series including both the Cedar Keys Formation in peninsular Florida and the Midway Formation in panhandle Florida. Figure 25 is the isopach-lithofacies map of the Cedar Keys Formation alone. Different lithologic end members are employed in constructing these two maps in order to show the most important regional lithofacies patterns. In northern Florida, near the Georgia border, and along the present-day Florida Keys, the Cedar Keys is composed mainly of fossiliferous to nonfossiliferous, very fine crystalline dolomite and calcitic dolomite with a minor amount of gypsum and anhydrite. However, slightly dolomitic, fossiliferous and nonfossiliferous limestones become dominant near or along the facies boundary lying at the northern and northwestern end of the peninsula and stretching

northeasterly as a narrow belt from southeastern Georgia to panhandle Florida and the Gulf of Mexico (fig. 25). In central and southern Florida, the formation is essentially nonfossiliferous to fossiliferous and microcrystalline dolomite, gypsum and anhydrite. The relatively high evaporite content of the formation as shown on the evaporite percentage map (fig. 27) is developed in such areas as the western part of the northern and central Florida and almost the entire southern Florida region where the South Florida Basin was located. The regional lithofacies pattern also indicates that the area with high evaporite content would undoubtedly be shown to extend farther to the continental shelf regions on both sides of the peninsula if more subsurface geological information were available for these regions.

The thickness of the Cedar Keys varies considerably, from less than 300 feet on the crest of the Peninsular Arch in northern Florida (Suwannee and Lafayette counties) to more than 2000 feet in those counties (Charlotte, Collier, Hendry, Lee, and Monroe) around the Sunniland oil field in southern Florida.

#### MIDWAY FORMATION

In western and central Alabama, the Midway (Paleocene Series) is used as a group name which, as observed at the outcrop and subsurface, can be separated into three formations; in ascending order, the Clayton, the Porters Creek, and the Neheola (Toulmin, 1955). However, in southeastern Alabama the subsurface geologic information reveals that geologists have had difficulty, both lithological and faunal, in subdividing the Midway Group and in correlating it with the rocks of the same group in western and central Alabama. Toulmin and LaMoreaux (1963), on the basis of a detailed stratigraphic study along the Chattahoochee River, state that the Tertiary formations recognized in the river section are those of the standard Alabama stratigraphic section. The Midway Group, however, is represented only by the Clayton Formation.

In panhandle Florida, the writer, as well as many other geologists who have worked in the same area, is unable to differentiate the Midway Group on the basis of well cuttings, electric logs, and fossils; and, therefore, the unit is here treated as a formation. Generally, the Midway is overlain, probably conformably, by the Wilcox Formation in the panhandle, although the regional distribution of these two units as shown at the surface (fig. 1) indicates that the Wilcox overlies the Midway unconformably in southeastern South Carolina. The Midway is underlain unconformably, at least

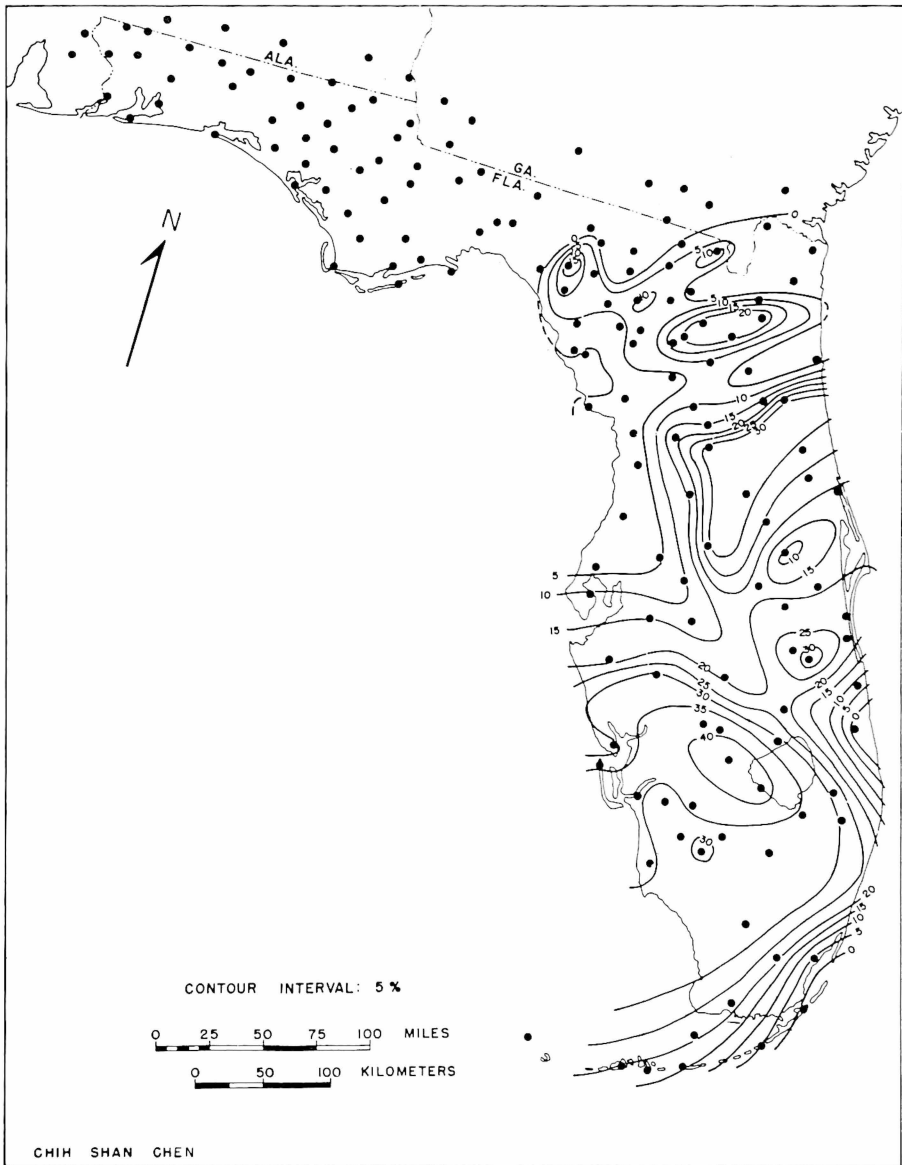


Figure 27. Evaporite percentage map of the Paleocene Series of Florida.

locally, by beds equivalent in age to Navarro and Taylor formations of the Selma Group (Upper Cretaceous).

The Midway Formation is composed mainly of dark gray to dark green-gray, micaceous and slightly glauconitic, laminated and calcareous shale with a minor amount of thin bedded argillaceous and fossiliferous limestone and glauconitic and calcareous sandstone. However, limestone becomes dominant southeastward near the facies boundary, while the sandstone exists only locally as penetrated in those wells located on the crest of the Chattahoochee Arch. Lithologically, the upper boundary of the formation has been placed at the top by the first appearance of rather compact and laminated calcareous shale, or glauconitic and calcareous shale, or argillaceous and/or cherty limestone. The base is placed at the top of a rather thick chalky fossiliferous limestone of Upper Cretaceous age that is well shown on the electric logs and can be traced laterally for a long distance (fig. 21). These lithologic boundaries have been proved applicable to study of subsurface geology in panhandle Florida where the faunal control is rather poor or not available. Faunally, a characteristic assemblage zone close to that of the type Tamesi of Mexico (Applin and Applin, 1944; Applin and Jordan, 1945) has been reported in the lower part of the Midway Formation in some wells located in Jackson, Jefferson, Wakulla, and Washington counties of Florida.

The Midway Formation underlies panhandle Florida and extends widely throughout the southeastern Coastal Plain and Gulf Coast. Regionally, the vertical and lateral changes of lithologic character and thickness of the formation are rather great as demonstrated on the isopach-lithofaces maps of figures 24 and 26. The lithofacies pattern indicates that the relatively coarser clastic sediments, such as glauconitic and arenaceous shale and glauconitic and argillaceous sandstone, are more dominant around the Chattahoochee Arch than elsewhere in the panhandle region. Further, calcareous shale is a major lithologic component over most of the panhandle region, except near the facies boundary in the southeastern panhandle area where limestone is predominant.

The Midway is relatively thin (less than 200 feet) near the facies boundary and updip toward the inner margin of the Coastal Plain. However, it thickens considerably southwestward toward the Gulf. In Escambia County, Florida the total thickness of the unit reaches more than 1000 feet.

The most important geologic information revealed from the

study of the isopach-lithofacies maps (figs. 24-26) and structure map (fig. 9) is summarized as follows:

1. The clastic-nonclastic facies boundary is rather sharply defined as far as can be determined by the limited well data.
2. Two separated evaporite basins are outlined in the peninsular Florida region, probably extending beyond the present-day land area of the peninsula to the continental shelves on both sides.
3. The amount of clastic sediments increases updip toward the inner margin of the Coastal Plain and decreases downdip toward the Gulf. However, the amount of calcareous material within the clastic facies increases steadily southeasterly toward the facies boundary, and clastic sediments are entirely absent in peninsular Florida.
4. Facies and isopach strikes are generally concordant except in northern and central peninsular Florida.
5. Regionally, the structure and isopach strikes are markedly parallel.

## OLDSMAR LIMESTONE AND WILCOX FORMATION

### OLDSMAR LIMESTONE

The Oldsmar Limestone was originally applied by Applin and Applin (1944) to the nonclastic rocks of Lower Eocene age in peninsular and northern Florida. This unit includes the interval that is marked at the top by the presence of abundant specimens of *Helicostegina gyralis*, and that rests on the Cedar Keys Limestone. Four assemblage zones were recognized in the formation by them. The formation as defined by the Applins is a biostratigraphic unit.

A lack of complete sample sets raises difficulties in selecting lithologic markers to define the upper and lower boundaries of the Oldsmar. Lithologically, however, the Oldsmar is quite different from the underlying Cedar Keys Formation, but not readily differentiated from the overlying Lake City Limestone. The top of the Oldsmar is here defined by the presence of a chalky white to light brown, rather pure, finely fragmental and fossiliferous limestone unit which is overlain by a thick dolomite section of the Lake City Limestone. The base of the Oldsmar is marked by a thick, dark brown, rather pure and clean, and fine to coarse crystalline dolomite unit which shows marked lithologic differences with the underlying Cedar Keys Formation. The writer considers that the formation has conformable relationships with the strata lying

above and below. The Oldsmar Limestone is composed essentially of dolomite and limestone with evaporites (gypsum and anhydrite) as a minor component; a minor amount of white and dark brown chert forming irregular lenses is also penetrated in certain wells scattered on the northern part of the Peninsular Arch. The limestone is usually light brown to chalky white, rather pure, porous, and fossiliferous. Reef-like limestone beds have been encountered in two wells located in those counties (W-1596, Madison County and W-2775, Suwannee County) in northern Florida. Interbedded with limestone are brown to dark brown, rather porous, fine to coarse crystalline, commonly saccharoidal textured dolomite beds. Gypsum and anhydrite are rare as regular beds but form irregular bands and veinlets or occupy pore spaces. Exceptions are noted in a few wells located in those counties (Glades, Highlands, and Okeechobee) in southern Florida where anhydrite and gypsiferous dolomite are dominant in the lower part of the formation (fig. 19). The amount of evaporite present in the formation is significantly less than in the underlying Cedar Keys Formation. Faunally, the Oldsmar is characterized by the presence of abundant foraminifers of *Helicostegina gyralis* and other recognizable guide foraminifers.

The Oldsmar Limestone is well developed and widely distributed throughout peninsular and northern Florida and a part of southeastern Georgia (figs. 28-29). The formation is considered to be the marine and deltaic clastic equivalent of the Wilcox Group in the most of the Gulf Coast region.

Figure 28 is the isopach-lithofacies map of the Sabine (or Wilcox) Stage in the entire Florida region, including the Oldsmar Limestone in the peninsula and the Wilcox Formation in the panhandle (fig. 30). Figure 29 is the isopach-lithofacies map of the Oldsmar Limestone alone. These two maps are constructed with different lithologic end members so as to show the regional relationships of pertinent facies.

The regional lithofacies pattern of the Oldsmar Limestone (figs. 28-29) indicates rather clearly the high dolomite content encountered on the crest of the Peninsular Arch, relatively high evaporite content in southern Florida, and high limestone content away from the arch and removed from those areas having high evaporite content. The areas with relatively high evaporite content as outlined by the carbonate-evaporite ratio lines (fig. 29) as well as shown on the evaporite percentage map (fig. 31) are considerably smaller and better defined than those of the Cedar Keys Formation (figs. 24, 25, and 27). In northern Florida near the facies boundary,

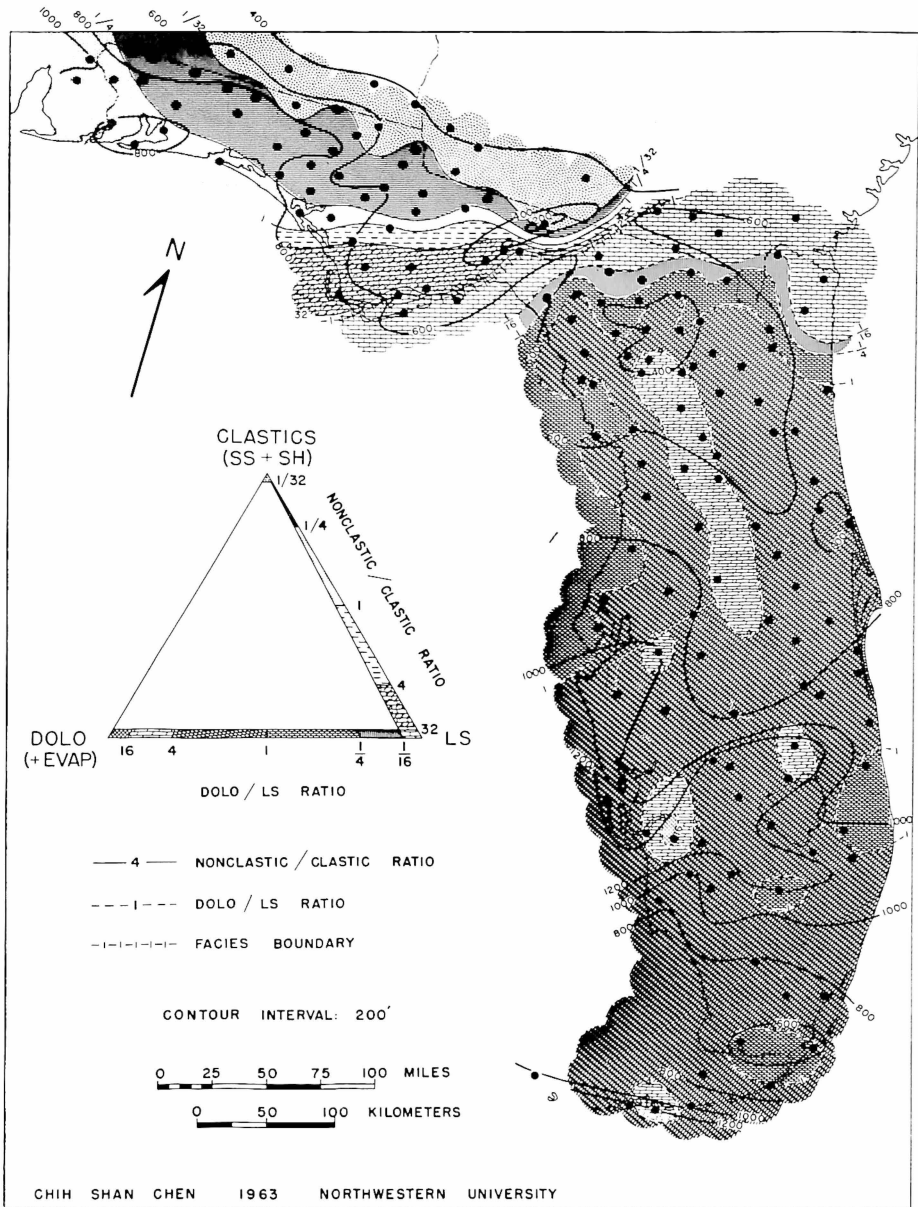


Figure 28. Isopach-lithofacies map of the Sabine (or Wilcox) Stage of Florida.

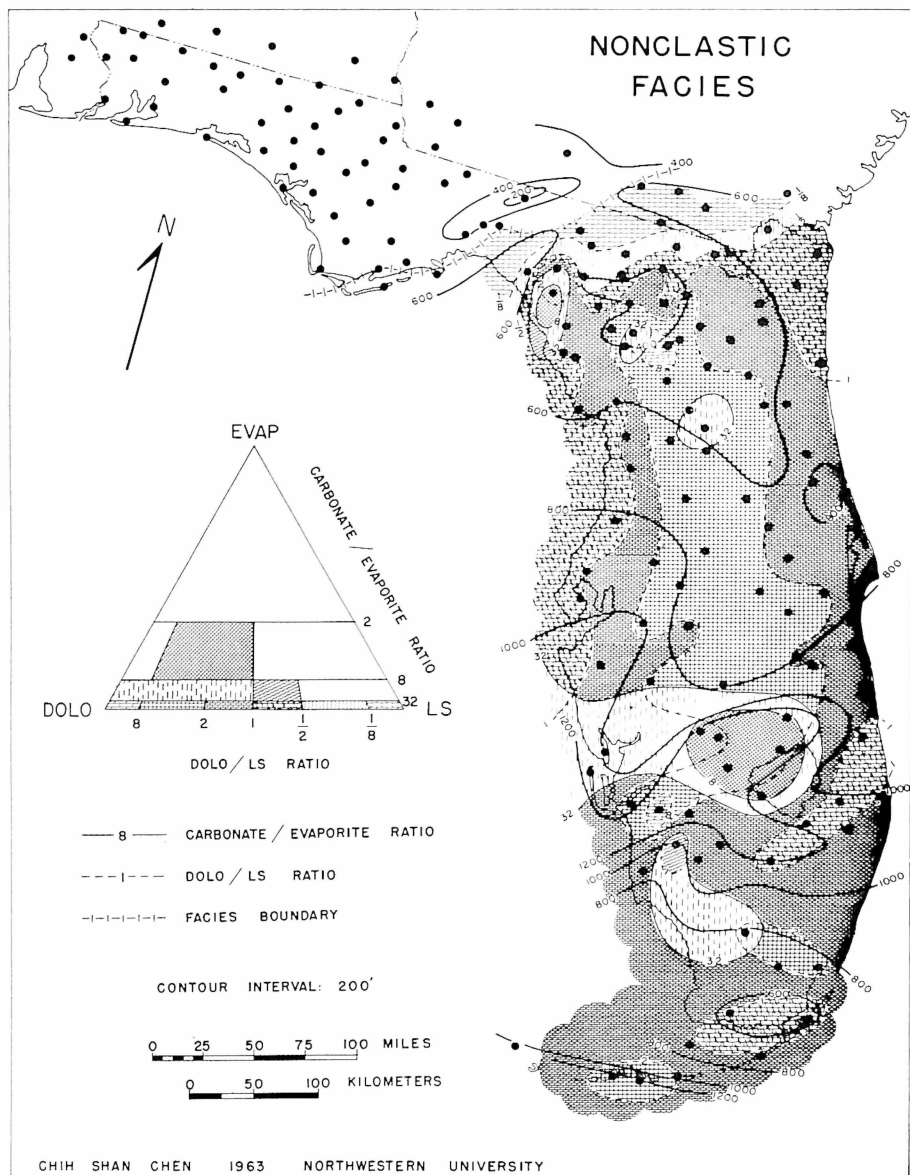


Figure 29. Isopach-lithofacies map of the Oldsmar Limestone (Sabine or Wilcox Stage) of peninsular Florida.



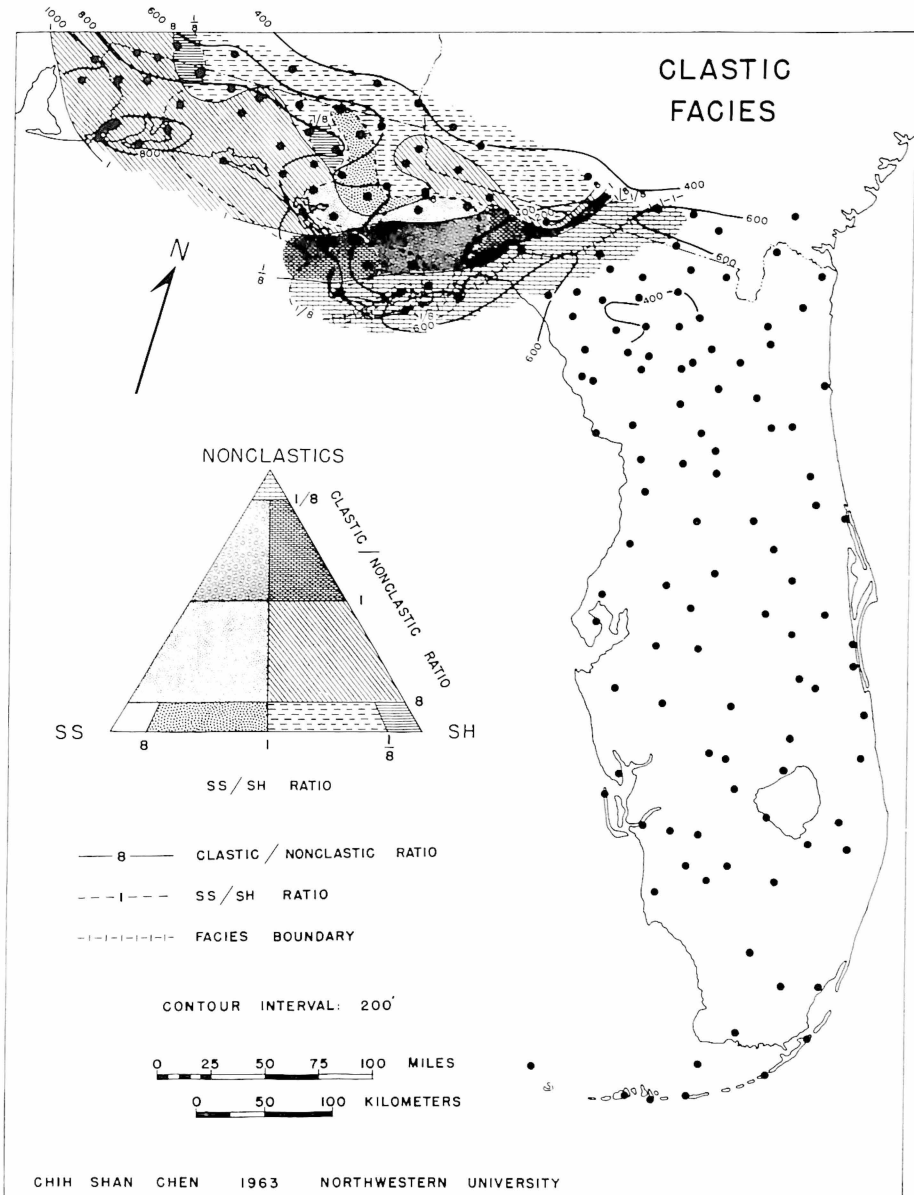


Figure 30. Isopach-lithofacies map of the Wilcox Formation (Sabine or Wilcox Stage) of panhandle Florida.

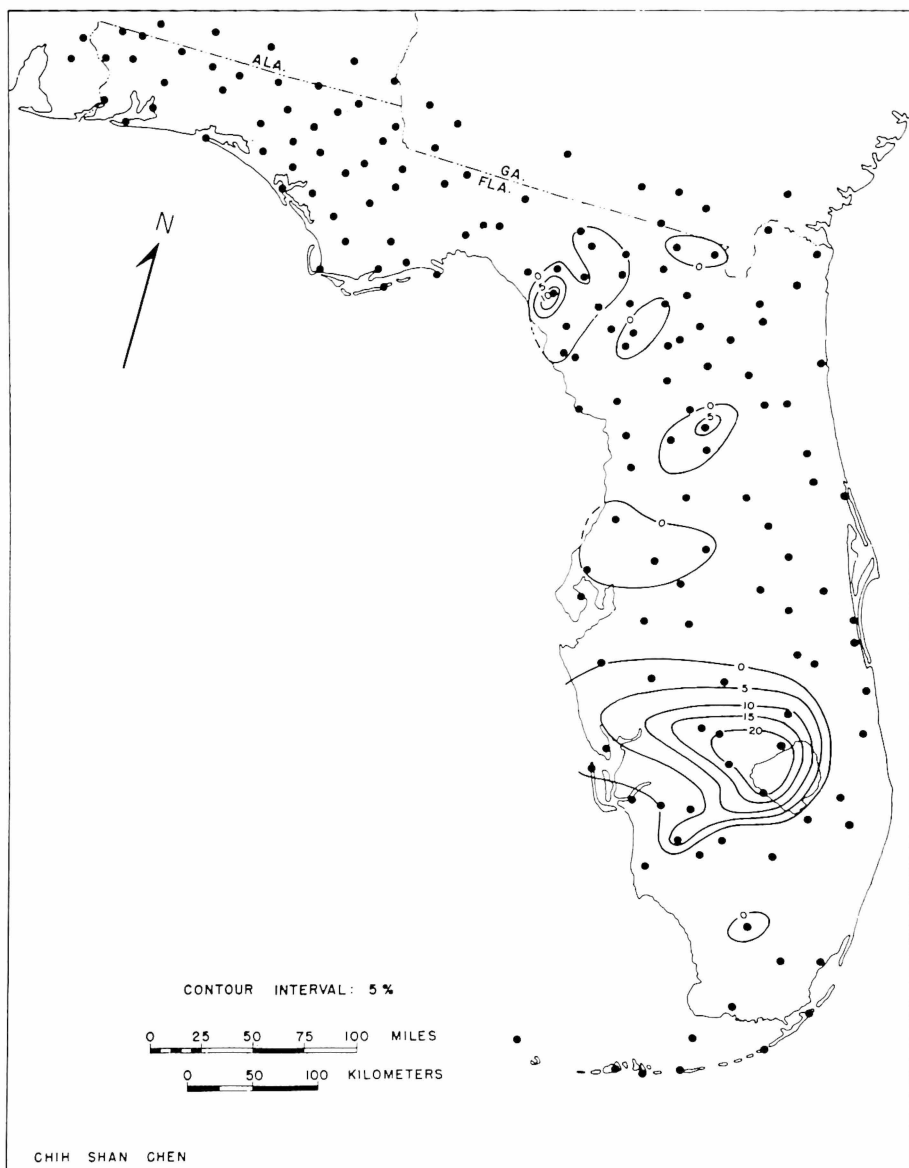


Figure 31. Evaporite percentage map of the Sabine (or Wilcox) Stage of Florida.

limestone becomes predominant and grades northwesterly and northerly into the clastic facies of panhandle Florida and southern Georgia (figs. 19, 21, and 28). As has been shown on the isopach-lithofacies maps, the writer believes that these carbonate rocks extend to the continental shelf regions on both sides of the peninsula and to the Bahamas.

The thickness of the Oldsmar Limestone varies from less than 400 feet on the crest of the Peninsular Arch to more than 1200 feet in southern Florida. The rather irregular isopach pattern shown in peninsular Florida (figs. 28-29) may be due to the intensive dolomitization which has destroyed fossils and altered the original texture of the limestone such that it is difficult to define the upper boundary of the formation (Vernon, 1951). In addition, cuttings and cores of this unit are commonly incomplete and the top of the unit is not easily recognized on electric logs.

#### WILCOX FORMATION

The simplified regional geological map of the southeastern United States as shown in figure 1 indicates that Lower Eocene strata (Wilcox Group) crop out in a narrow and convex gulfward belt extending from the east side of the Mississippi Embayment across southern Alabama into western Georgia. Farther east, these strata are overlapped by Middle Eocene and younger sediments.

Three formations of the Wilcox Group, in ascending order, the Nanafalia, the Tusahoma, and the Hatchetigbee, have been recognized in Alabama and Georgia, but these formations are undistinguishable in the subsurface of panhandle Florida and the unit is here treated as a formation. No distinctive geological evidence of unconformable relationships between the Wilcox Formation and the rocks lying above and below in panhandle Florida is recognized, although such unconformable relationships among these rocks are demonstrated in the outcrop belt to the north.

The top of the Wilcox is generally drawn on the first appearance of gray to green-gray and slightly calcareous shale; or gray, glauconitic, arenaceous and calcareous shale; or brown and essentially nonfossiliferous limestone. The base of the unit is defined by the top of the Midway.

Lithologically, the Wilcox Formation in panhandle Florida consists of glauconitic and calcareous sandstone; light brown, glauconitic and arenaceous limestone; and green-gray, micaceous and calcareous, and glauconitic and silty shale. Highly fossiliferous limestone is not common even in the dominant limestone section. Siliceous and/or cherty, argillaceous limestone is encountered in

those wells penetrating a dominantly limestone section. Sandstone and shale are dominant in northern and western panhandle Florida, while limestone is a major lithologic constituent southeastward toward the coast and the facies boundary (figs. 21, 22, and 30). Marine and deltaic clastic sediments in panhandle Florida and southern Georgia grade southeastward into nonclastic facies represented by the Oldsmar Limestone. These two distinctive sedimentary facies, though probably gradational, are rather sharply defined; they were probably originally separated by the Suwannee Channel. The faunas recognized in the panhandle region show clear relationships with Wilcox faunas described from the other parts of the Gulf Coast (Applin and Applin, 1944; Toulmin, 1955), however, they are remarkably dissimilar to those found in peninsular Florida.

The regional distribution of major lithologies of the Wilcox Formation in panhandle Florida is shown in figures 28 and 30. These maps indicate that the amounts of clastic sediments decrease rapidly southeastward toward the peninsular Florida and continental shelf region where they are almost completely absent. Sediments of the Wilcox vary in thickness from less than 200 feet near the facies boundary in the southeast margin of the panhandle to near 1000 feet southwestward toward the Gulf.

From a joint investigation of regional isopach-lithofacies maps (figs. 28-30) and the structure map (fig. 10) of the Wilcox Formation and Oldsmar Limestone in Florida, the following relationships are apparent.

1. The amounts of clastic sediments increase systematically and rapidly northward from panhandle Florida to southern Alabama and Georgia, while the amounts of nonclastic sediments increase rapidly southeastward toward the peninsula where clastic sediments are almost completely absent.
2. Dolomite is a dominant lithology for almost the entire peninsula, while limestone is more common in northern Florida and near the facies boundary.
3. The areas of the evaporite basins as well as their evaporite content are greatly reduced in comparison with those of the Paleocene section.
4. Facies and isopach strikes are almost parallel in panhandle Florida, but they are rather discordant, at least locally, in peninsular Florida.
5. Regionally, structure and isopach strikes parallel each other quite closely.

## LAKE CITY AND AVON PARK LIMESTONE AND UNDIFFERENTIATED CLAIBORNE GROUP

### GENERAL STATEMENT

The Claiborne Stage (Middle Eocene) in panhandle Florida and the northern and western Gulf Coast region is represented mainly by sandstone, shale, and limestone. However, in northern and peninsular Florida, the Claiborne is composed almost entirely of dolomite and limestone with a minor amount of evaporite and a laminae or thin beds of peat. These two sedimentary facies are quite different, both lithologically and faunally, although certain faunal assemblages common to both facies support the time-stratigraphic correlation (Applin and Applin, 1944). On the basis of lithology and faunal differences, Applin and Applin (1944) recognized three formations in the Claiborne Group in peninsular Florida; in ascending order, Lake City Limestone, the Tallahassee Limestone, and the Avon Park Limestone. The Tallahassee Limestone (and an equivalent nonfossiliferous limestone) is confined to limited areas in the vicinity of Tallahassee and in the counties of northern peninsular Florida.

The clastic sediments of the Claiborne Group crop out in western and southern Alabama and consist chiefly of glauconitic sandstone, calcareous and arenaceous shale, and fossiliferous, glauconitic and argillaceous limestone. Three formations have been recognized; in ascending order, the Tallahatta Formation, the Lisbon Formation, and the Gosport Sand. However, farther downdip toward the Gulf, the entire Claiborne Group becomes calcareous, and it is rather difficult to subdivide it into the formations of the outcrop area.

No attempt is made by the writer in this study to subdivide the rocks of clastic facies of the Claiborne Group in panhandle Florida, although, in general, the unit is divisible into lower and upper portions (figs. 21 and 22). For the purposes of the present study the unit is here treated as an undifferentiated group. However, in peninsular Florida the Claiborne Group is subdivided into two formations—the Lake City Limestone below and Avon Park Limestone above. A nonfossiliferous carbonate bed, an equivalent of the Applins' Tallahassee Limestone, is here considered as a dolomitized part of the Avon Park Limestone and/or Lake City Limestone (Vernon, 1951) in which diagnostic microfossils have been destroyed.

The Lake City Limestone as originally defined by Applin and

Applin (1944) is primarily based on faunal zones, but it is also a distinctive lithologic unit (Vernon, 1951.) Faunally, the top of the Lake City Limestone is marked by the first appearance of *Dictyoconus americanus*, and the formation is further characterized by many other diagnostic foraminifers such as *Amphistegina lopeztrigoi*, *Discocyclina* (*Asterocyclina*) *monticellensis*, *Fabularia gunteri* (Applin and Jordan, 1945). The Avon Park Limestone also has a distinctive faunal assemblage, mostly foraminifers, including *Coskinolina floridana*, *Lituonella floridana*, *Dictyoconus cookei*, and many other microfossils (Applin and Applin, 1944; Applin and Jordan, 1945; Cole, 1942, 1944; and Cooke, 1945).

The Lake City Limestone generally rests conformably upon the Oldsmar Limestone, but disconformable relationships may exist locally. The Lake City Limestone is overlain unconformably by the Avon Park Limestone according to Vernon (1951). However, the writer considers that such unconformable relationships exist only rather locally. In other words, the unconformable relationships are more apparent on tectonic shelves and positives but are less apparent toward basin centers. The unconformable relationships between the Avon Park Limestone below and the Ocala Group and the post-Eocene strata above are quite obvious. The stratigraphic relationships between the Claiborne Group and the strata lying above and below as found in panhandle Florida are about the same as in the peninsular region, although these two depositional environments are considerably different from each other in terms of the sedimentary conditions under which the clastic and nonclastic sediments were formed.

#### LAKE CITY LIMESTONE

The Lake City Limestone (early Middle Eocene) was originally named by Applin and Applin (1944) to designate a dark brown and chalky limestone facies in northern and peninsular Florida and to differentiate it from an equivalent clastic facies in panhandle Florida and the other parts of the southeastern Coastal Plain. The Applins established the top of the unit at the first appearance of *Dictyoconus americanus*. However, this unit as originally defined is a biostratigraphic unit rather than a rock unit.

Examination of well cuttings from those wells located in northern and central peninsular Florida reveals a relatively thin but rather highly carbonaceous unit consisting mainly of laminae or thin beds of peat, intercolated with dark brown to brown-black carbonaceous limestone and dolomite that usually overlies the

fossiliferous limestone in which *Dictyoconus americanus* is common. This thin and highly carbonaceous unit is quite persistent over most of northern and central peninsular Florida (fig. 32) where it provides a useful lithologic key bed at the top of the Lake City Limestone. This marker gradually thins both toward southern Florida and northerly near the facies boundary along the northern margin of the peninsula. However, near the facies boundary and in southern Florida, the key bed is replaced by a brown to dark brown, fragmental and fossiliferous limestone which contains *Dictyoconus americanus* and other foraminifers and is overlain by the basal dolomite unit of the Avon Park Limestone. This necessary modification of the top of the formation brings it into conformity with the Stratigraphic Code (1961) and has only very minor effect on the thickness of the formation as originally defined. Generally, the base of the Lake City Limestone is marked by a thick unit consisting essentially of brown to dark brown, rather porous, fine crystalline dolomite which conformably overlies the Oldsmar Limestone. This relationship is revealed in incomplete well samples obtained from widely scattered wells and prevails over most of peninsular Florida. Near the facies boundary and in the southernmost part of the peninsula a thick, brown, fragmental and fossiliferous limestone bed marks the base of the formation (figs. 19 and 20).

Lithologically, the formation is composed essentially of highly fossiliferous (mostly foraminifers) limestone and brown to dark brown dolomite with a very minor amount of evaporites and carbonaceous material (figs. 19-21). The limestone is commonly light brown to brown, fragmental, highly fossiliferous to microcoquina-like, and slightly carbonaceous and cherty. Some highly fossiliferous limestone beds consist almost entirely of foraminifers and other microfossils. Reef-like limestone beds have been encountered in the well (W-890, Nassau Co.) located in northern Florida. All stages of dolomitization, from minute dolomite crystals in the matrix to pure dolomite, can be seen. The dolomite is generally brown, rather porous, finely crystalline, and saccharoidal in texture. Unaltered microfossils and their molds are not uncommon, especially in the calcitic dolomite or dolomitic limestone. Traces of fragmental texture and microfossil relics are visible under the petrographic microscope. Gypsum is commonly present as thin seams or veinlets and fills the pore spaces within the dolomite. Selenite is quite common in cavities and vugs, but anhydrite is very rare. The amount of evaporites is almost negligible as far as the gross lithology of the formation is concerned. Thin peat and carbonaceous dolomite

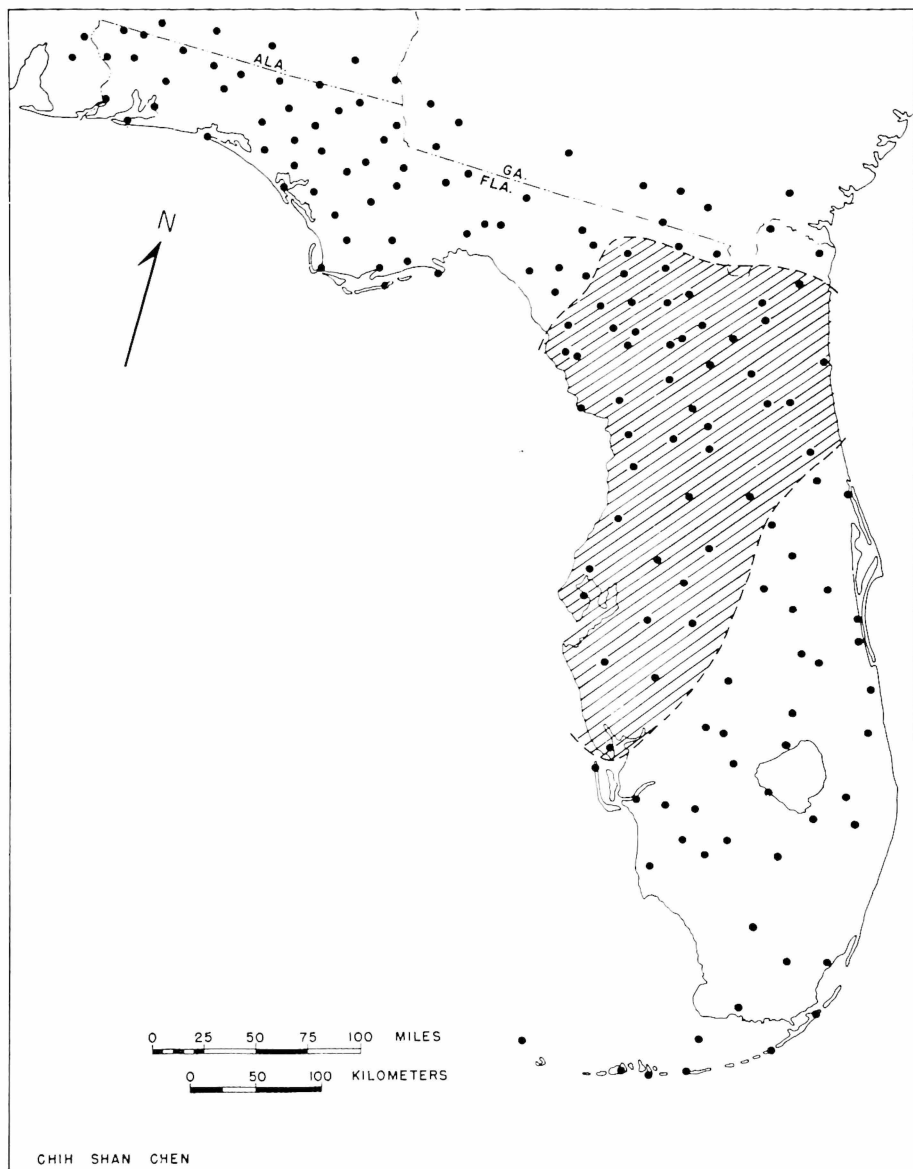


Figure 32. Regional distribution of highly carbonaceous dolomite and limestone interbedded with thin streaks or thin beds of peat in northern and central Florida near the end of early Middle Eocene time (shaded area).



and/or limestone beds are generally present in the upper part of the formation. Dark, carbonaceous dolomite and limestone are commonly associated with laminae or thin beds of peat. Dark brown chert is present in those wells located in northern Florida and near the clastic facies boundary. Milky and mammillary chalcedony and fine quartz crystals are also present in the upper part of the formation, commonly in cavities and vugs.

Thickness of the formation varies considerably from about 300 feet in northern Florida to about 900 feet in southern Florida (figs. 19-21).

#### AVON PARK LIMESTONE

Applin and Applin (1944) have named the Avon Park Limestone to include the upper part of the late Middle Eocene which exhibits its distinct faunal and lithologic characteristics in northern and peninsular Florida. The formation as originally defined is primarily a biostratigraphic unit underlying the Ocala Group (Upper Eocene) and overlying the Applins' "nonfossiliferous limestone" which they have considered to be equivalent to the Tallahassee Limestone. However, during the course of investigation of well cuttings and cores in this study, the writer recognized that there are distinct lithologic differences between the Avon Park Limestone and the strata lying above and below throughout northern and peninsular Florida.

Generally, the top of the Avon Park is marked by the presence of brown, finely fragmental and fossiliferous limestone or a brown and fine crystalline dolomite bed, either of which is quite different lithologically from the overlying strata of the Ocala Group and can be easily identified from well samples. The base of the unit is defined by the occurrence of relatively thick, nonfossiliferous, brown to dark brown, and fine to medium crystalline dolomite bed overlying the Lake City Limestone which is generally marked at the top by highly carbonaceous dolomite and limestone units (figs. 19-21). The formation is overlain unconformably by the Ocala Group and younger strata, and it rests conformably on the Lake City Limestone in northern and peninsular Florida, although local unconformities may have existed.

Lithologically, the Avon Park is composed mainly of fossiliferous limestone and dolomite with a very small amount of evaporite. The limestone is light brown to brown, finely fragmental, rather porous, and highly fossiliferous (mostly foraminifers). The dolomite is brown to dark brown, rather porous, very fine to medium crystalline, and saccharoidal in texture. Fossil remains and molds

are commonly preserved in the dolomite. Evaporites, represented essentially by gypsum, are present in small amounts, and are met with in only a few wells. Carbonaceous material is also present in both limestone and dolomite.

Faunally, the Avon Park Limestone is characterized by the presence of abundant *Coskinolina*, *Lituonella*, *Dictyoconus*, and many other diagnostic foraminifers. Other fossils such as astracodes, bryozoans, mollusks, and echinoids are also present, but are rather rare and limited in areal distribution. Plant remains are also present in the form of peat and carbonaceous material.

The Avon Park Limestone crops out on the crest of the Ocala Uplift in Levy and Citrus counties. In the subsurface, the formation extends into southern Georgia, eastern panhandle Florida, and all of northern and peninsular Florida except in Columbia, Suwannee, and Duval counties, where it is very thin or absent (figs. 19 and 21).

The thickness of the formation varies from zero to a few feet in northern Florida to more than 800 feet in southern Florida (figs. 19-21). It is demonstrable that thickness differences reflect both depositional and tectonics and post-depositional erosion.

The Lake City Limestone and the Avon Park Limestone are combined for analysis in order to use them in a joint lithofacies study in panhandle Florida where the Claiborne Group is not differentiated (figs. 33-35). Figure 33 is the isopach-lithofacies map of the Claiborne Group in the entire Florida region. The regional facies distribution of combined Lake City-Avon Park Limestone is shown in figure 34. The dolomite concentration on the Peninsular Arch and the limestone dominance in southern Florida and near the clastic facies boundary in northern Florida are clearly shown. Areas with relatively high evaporite content (fig. 36) are reduced areally and volumetrically as compared with earlier units.

#### UNDIFFERENTIATED CLAIBORNE GROUP

The exposed strata of the Claiborne Group (Middle Eocene) in western Alabama have been divided into three formations; in ascending order, the Tallahatta Formation, the Lisbon Formation, and the Gosport Sand. These formations consist chiefly of deltaic and marine clastics including green-gray shale; glauconitic sandstone; glauconitic, fossiliferous, and calcareous shale; cross-bedded, fine- to coarse-grained sandstone; and carbonaceous shale. However, in the subsurface farther downdip toward the Gulf, the sediments of the group become more calcareous and less readily differentiated into distinct formations (Toulmin, 1955).

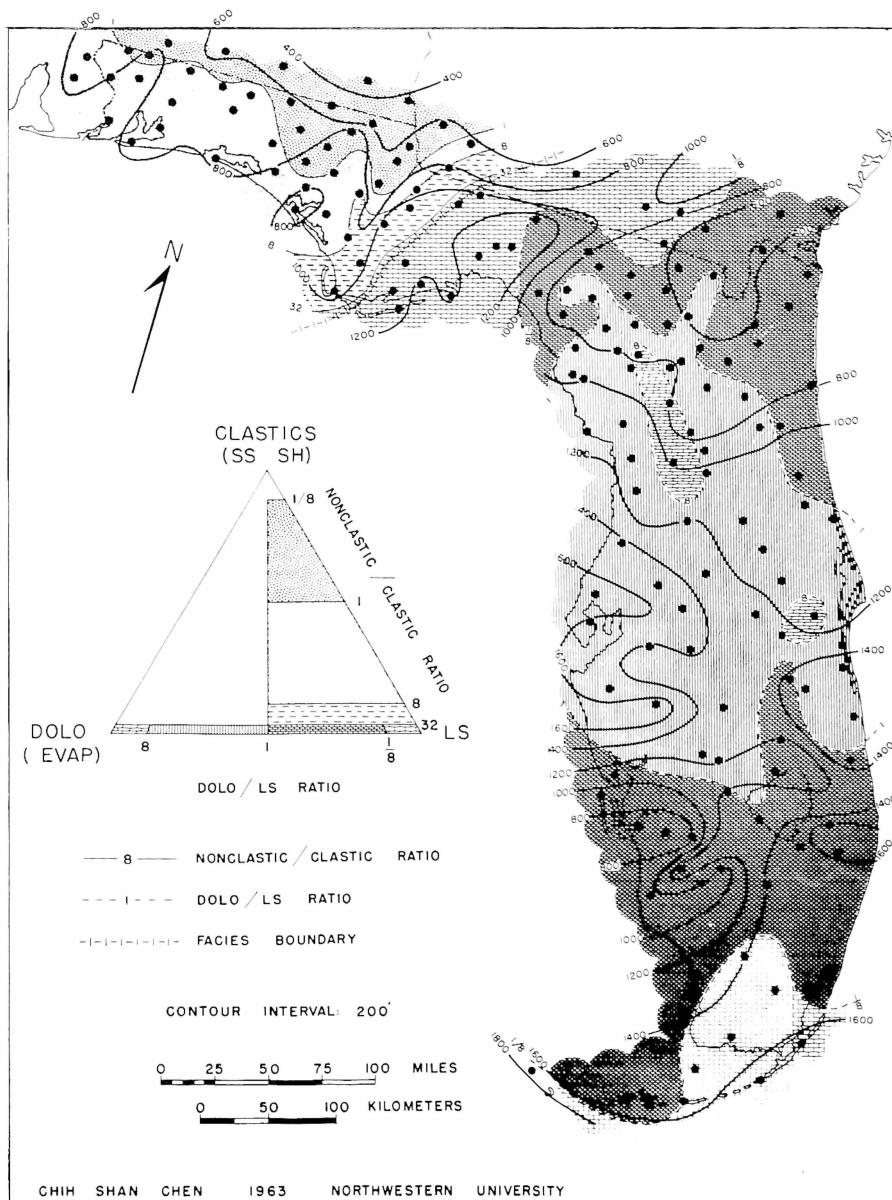


Figure 33. Isopach-lithofacies map of the Claiborne Group (Claiborne Stage) of Florida.

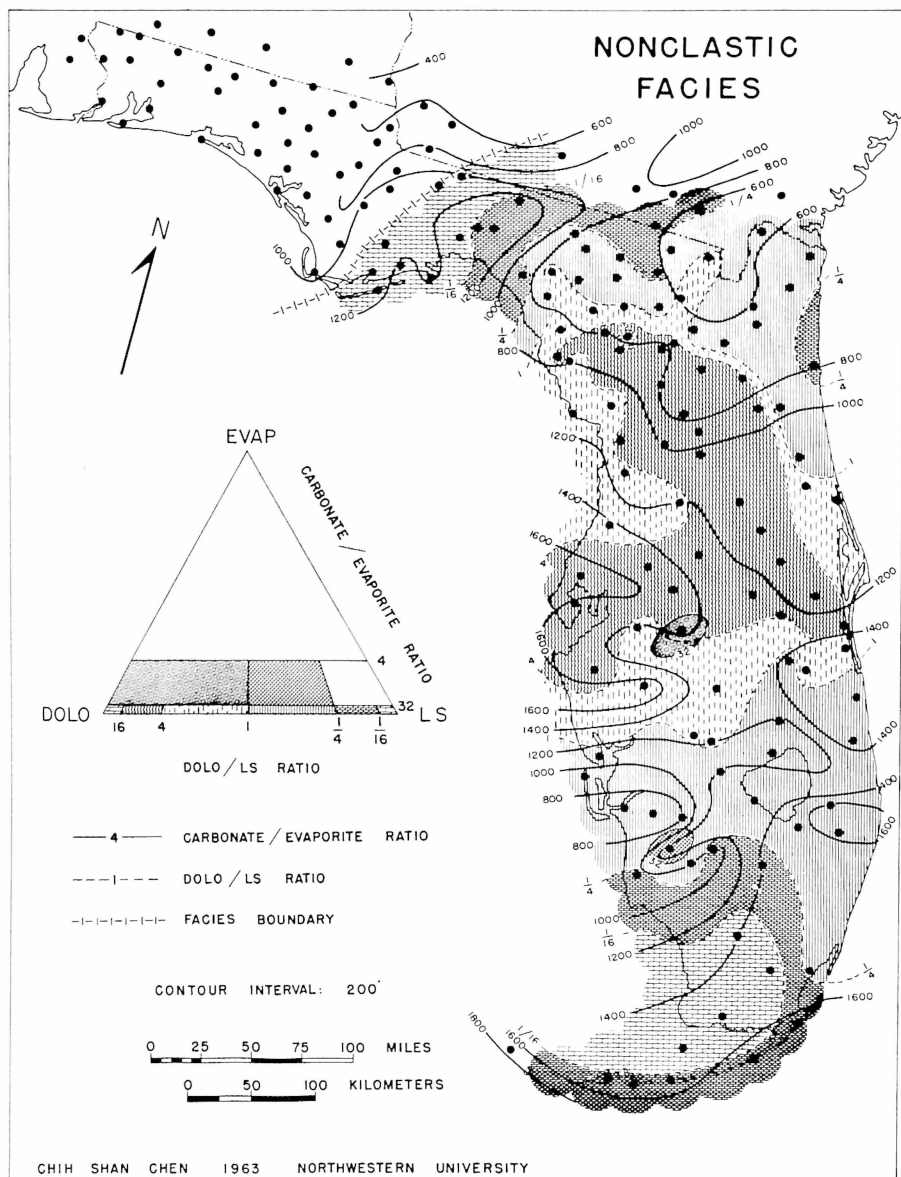


Figure 34. Isopach-lithofacies map of the Claiborne Group (Claiborne Stage) of peninsular Florida.

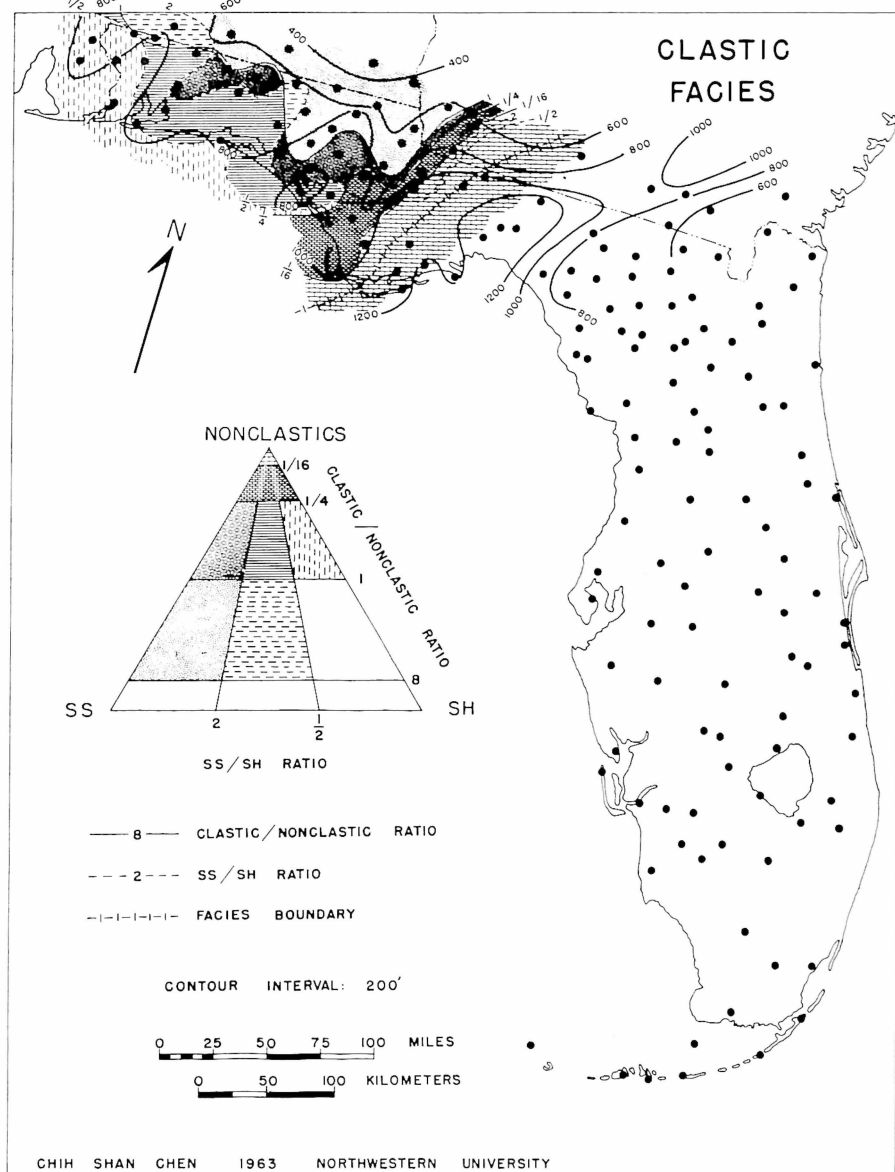


Figure 35. Isopach-lithofacies map of the Claiborne Group (Claiborne Stage) of panhandle Florida.

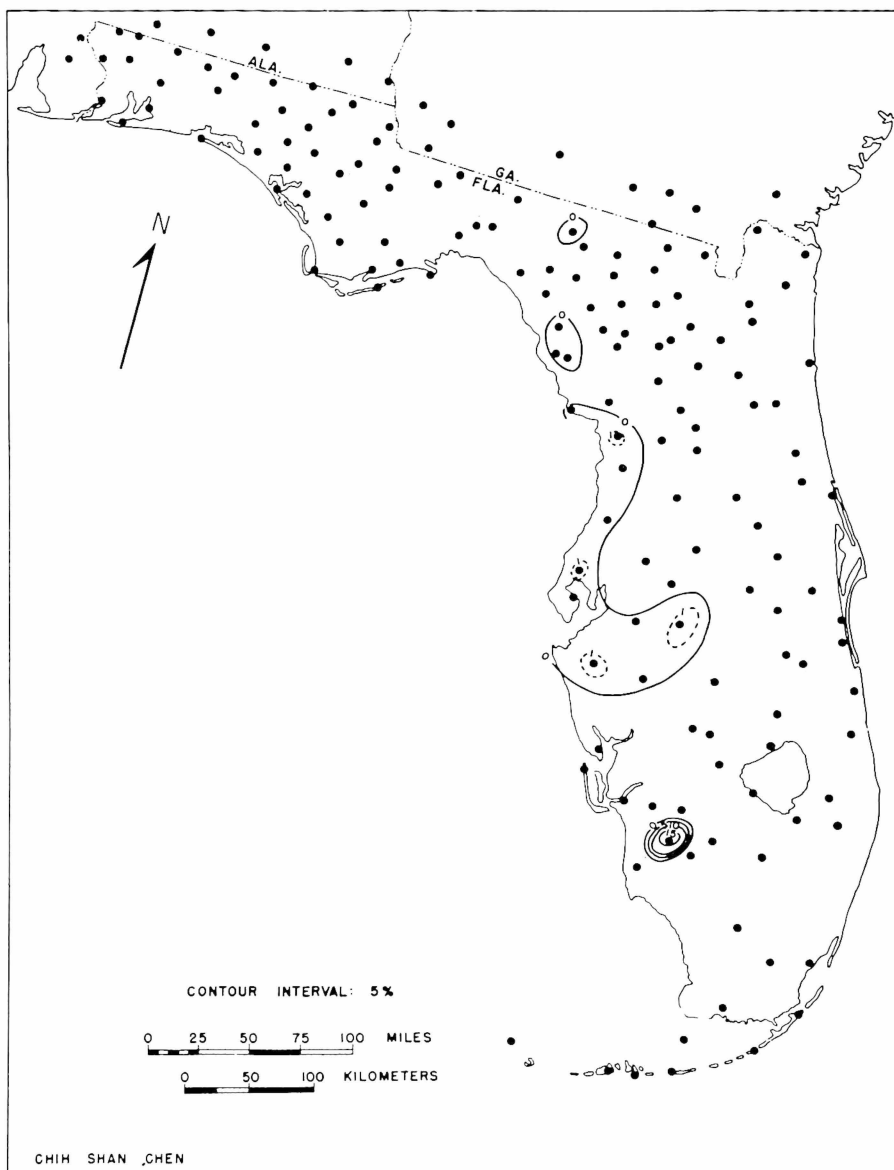


Figure 36. Evaporite percentage map of the Claiborne Stage of Florida.

In the western part of panhandle Florida, the Claiborne Group has been divided into two formations, the Lisbon Formation at the top and the Tallahatta Formation below, correlated with the Avon Park Limestone and the Lake City Limestone, respectively, of the non-clastic facies in peninsular Florida (Puri and Vernon, 1959). As has been stated previously, the writer makes no attempt to subdivide the Claiborne Group into formations in panhandle Florida, and, therefore, the group is here treated as an undifferentiated unit. The top of the undifferentiated Claiborne Group is marked by the occurrence of rather highly glauconitic, arenaceous, and fossiliferous limestone, or brown, finely fragmental, argillaceous and fossiliferous limestone, which unconformably underlies the Ocala Group (Upper Eocene). The base is defined by the presence of glauconitic and calcareous sandstone, or brown-gray and argillaceous limestone, or dark gray, glauconitic and arenaceous shale, which conformably overlies the Wilcox Formation (figs. 21 and 22).

Lithologically, the undifferentiated Claiborne Group can generally be separated into two parts. The lower part of the group is composed mainly of glauconitic and calcareous sandstone; green-gray to dark gray, glauconitic, arenaceous and calcareous shale; and glauconitic and arenaceous limestone; and brown-gray and argillaceous limestone (figs. 21-22). Minor amounts of green-gray and siliceous shale and glauconitic siliceous limestone are also encountered in certain wells. The glauconitic sandstone grades southeasterly into glauconitic and argillaceous limestone; farther southeast, across the facies boundary, it is replaced entirely by nonclastic sediments, while southwesterly toward the Gulf, the sandstone is gradually replaced by glauconitic and calcareous shale and glauconitic, argillaceous and arenaceous limestone. The upper part of the group consists essentially of glauconitic, arenaceous, and fossiliferous limestone and minor beds of glauconitic and calcareous shale.

The thickness of the undifferentiated Claiborne Group varies from less than 400 feet around the Chattahoochee Arch to more than 800 feet near the Gulf.

Both vertical and lateral lithologic changes of the undifferentiated Claiborne Group in panhandle Florida are shown on the stratigraphic cross section, C-C' and D-D' (figs. 21-22). Regionally, the major lithologic changes of the group in the panhandle are shown on the isopach-lithofacies maps (figs. 33 and 35). The maps show that sediments with a high content of coarse clastics are present around the area of the Chattahoochee Arch, and that limestone con-

tent increases toward the eastern panhandle and the peninsula. Both argillaceous and calcareous sediments become dominant southward near the Gulf.

The more important geological information which can be directly interpreted from the joint study of the isopach-lithofacies maps (figs. 33-35) and the structure map (fig. 11) of the Claiborne Group in Florida is summarized as follows:

1. Clastic sediments increase steadily northward from panhandle Florida to southern Alabama and Georgia, while the nonclastics become dominant southward near the Gulf and southeastward in the eastern panhandle and the peninsula where clastics are almost completely absent.
2. Dolomite is dominant on the Peninsular Arch region. Away from the arch, limestone becomes a principal lithology.
3. Clastic-nonclastic facies boundary is shifted farther northwest toward the panhandle as compared with older units.
4. Evaporites are greatly reduced, both volumetrically and areally, in comparison with older units.
5. Facies and isopach strikes are almost parallel to each other in the panhandle, but are rather discordant in the peninsula.
6. Regionally, structure and isopach strikes parallel each other quite closely.

## OCALA GROUP

### PRE-JACKSONIAN (SUB-OCALA) UNCONFORMITY

Late Middle Eocene strata are unconformably overlain by the Ocala Group (Upper Eocene). The unconformity is evidenced by: (1) progressive thinning of the Avon Park Limestone (Late Middle Eocene) toward the Peninsular Arch with truncation below the Ocala in certain areas on the crest of the arch; (2) superposition of Ocala on the lower part of the Avon Park Limestone and on early Middle Eocene units in certain areas in panhandle and peninsular Florida; (3) marked biostratigraphic hiatus; and (4) apparent compaction, diagenesis, and lithification of the Avon Park strata before deposition of the poorly consolidated Ocala limestones.

### JACKSON STAGE

The Jackson Stage (Upper Eocene) in western Alabama outcrops has been subdivided into two formations, the Moodys Branch Formation below and the Yazoo Clay above. These two formations are composed essentially of marine and deltaic clastic sediments.



The Moodys Branch consists chiefly of calcareous and glauconitic sandstone, and the Yazoo Clay is dominated by green-gray, calcareous and poorly consolidated shale and calcareous sandstone (Toulmin, 1955). Both formations can be traced eastward and southward in the subsurface; however, they gradually become much more calcareous and rather similar in lithology and finally grade into the Ocala Limestone in eastern and southern Alabama. The term Ocala Limestone which was originally introduced by Dall and Harris (1892) has been widely used by many Coastal Plain geologists to cover all the calcareous sediments of Upper Eocene age in southern Alabama, southern and western Georgia, and Florida. Puri (1957) has made a detailed historical review of usage of the term Ocala Limestone.

The Upper Eocene strata in Florida which were formerly included in the Ocala Limestone have been separated by Puri (1957), on the basis of a detailed biostratigraphic study, into three formations of the Ocala Group, namely, the Inglis, the Williston, and the Crystal River in ascending order.

In northern and peninsular Florida, the top of the Ocala Group is generally marked by a chalky white to very light brown, poorly consolidated, fragmental, microcoquina-like and highly fossiliferous limestone bed composed almost entirely of foraminifers and minor amounts of other fossils; however, in panhandle Florida, the top is defined by a light brown, slightly glauconitic and arenaceous, fragmental and fossiliferous limestone bed. The base of the group is commonly defined by a brown to dark brown, rather soft, saccharoidal textured, and fine crystalline dolomite, or a light brown to brown, finely fragmental and fossiliferous limestone, or a slightly arenaceous and fossiliferous limestone (figs. 19-22).

The Ocala Group is overlain unconformably by the strata of Oligocene and post-Oligocene age, and it overlies unconformably the Avon Park Limestone (Late Middle Eocene). The vertical and lateral lithologic changes as well as the regional lithofacies distribution of the group are well illustrated on the stratigraphic cross sections (figs. 19-22) and the isopach-lithofacies map (fig. 37).

Generally, in northern and peninsular Florida at least, the Ocala can be separated lithologically into an upper and a lower part. However, the writer has made no attempt to divide the group into formations for the purposes of the present study.

The Ocala Group crops out only around the Chattahoochee Arch and the Ocala Uplift and elsewhere is covered by post-Eocene sediments (fig. 1). In the northern part of western panhandle Florida,



the group is composed mainly of fossiliferous, glauconitic and arenaceous limestone with minor amount of dolomite and calcareous shale. This lithologic assemblage grades eastward in the peninsula and southward toward the Gulf into a highly fossiliferous limestone dominated by large foraminifers. In peninsular Florida, the group consists essentially of highly fossiliferous limestone with only a minor amount of dolomite at the base. The limestone is chalky white to very light brown, porous and not well consolidated, finely fragmental to microcoquinoid. Reef-like limestone beds have been encountered in the well (W-1500, Baker County) located in northern Florida. Generally, the fossils and fossil fragments are loosely cemented by a sparry calcite matrix. Faunally, the group is characterized by the presence of abundant large foraminifers such as *Lepidocyclina*, *Nummulites*, and *Operculinoides*; megafossils such as echinoids and bryozoans are relatively rare.

The Ocala Group is absent in several areas as shown in figure 37. This condition may be caused partly by post-depositional erosion and partly by nondeposition. The thickness of the group varies considerably from less than 100 feet in the northern panhandle and the central peninsula to more than 400 feet in southern Florida and near the Gulf in the panhandle. The irregularity of the isopach pattern (fig. 37) is mainly due to post-depositional erosion.

The regional distribution of the major lithologies of the Ocala Group in Florida is represented in figure 37. Although the regional facies pattern does not fully represent the original picture of the group, the writer believes that it is very helpful in making any geological interpretation in terms of the depositional environments and regional tectonics. The following geologic information can be obtained from the study of the isopach-lithofacies map (fig. 37) and the structure map (fig. 12).

1. Limestone is a dominant lithology of the Ocala Group throughout the area studied.
2. The clastic-nonclastic facies boundary is shifted even farther west toward the panhandle than is evidenced by earlier units.
3. Dolomite is a minor lithologic component in comparison with underlying units and is distributed in rather limited and isolated areas which show no connections with either the isopach pattern or the regional tectonic elements.
4. The area with relatively high content of clastic sediments is in the western panhandle, particularly on the Chattahoochee Arch.

5. Facies and isopach strikes are generally discordant, except in the western panhandle where they are more or less parallel.
6. Structure and isopach strikes approach parallelism only in the western panhandle and southern Florida.
7. The Ocala Uplift and the Peninsular Arch are obvious on the structure map, but very little evidence of the influence of these features is seen on the isopach-lithofacies map.

### SUMMARY OF EOCENE SERIES

The entire Eocene Series is also analyzed lithostratigraphically in terms of its regional lithologic distribution and the results are shown on a series of maps (figs. 38-40).

Figure 38 is the isopach-lithofacies map of Eocene Series in the Florida region. The map shows that the regional facies pattern is only slightly different from those shown in figures 39 and 40, the separate treatments of the clastic and nonclastic facies areas. Thickness of the series varies rather considerably from less than 1400 feet to more than 2800 feet in peninsular Florida and from less than 1000 feet to more than 2000 feet in panhandle Florida.

In northern and peninsular Florida, the Eocene Series is composed essentially of dolomite and limestone with a minor amount of evaporites (gypsum and anhydrite). The regional distribution of these three lithologies are shown in figure 39. Dolomite is dominant on the Peninsular Arch region, while limestone becomes a major lithology in such areas as northern and southern Florida. Evaporites are developed only in rather limited areas as outlined by the carbonate-evaporite ratio lines.

Figure 40 shows the regional lithologic distribution of the clastic facies in panhandle Florida. It indicates clearly that coarse clastic sediments are dominant around the Chattahoochee Arch, and finer clastics and more calcareous sediments become important southwesterly toward the Gulf; clastic sediments are almost completely replaced by nonclastics in the peninsula.

The regional lithofacies distribution of the series as shown on those maps (figs. 38-40) presents the following noteworthy geologic information:

1. The Peninsular Arch is well shown by the isopach pattern, while the Chattahoochee Arch is less distinct.
2. South Florida Basin is shifted slightly northeastward to the Lake Okeechobee region from its position in Paleocene time.

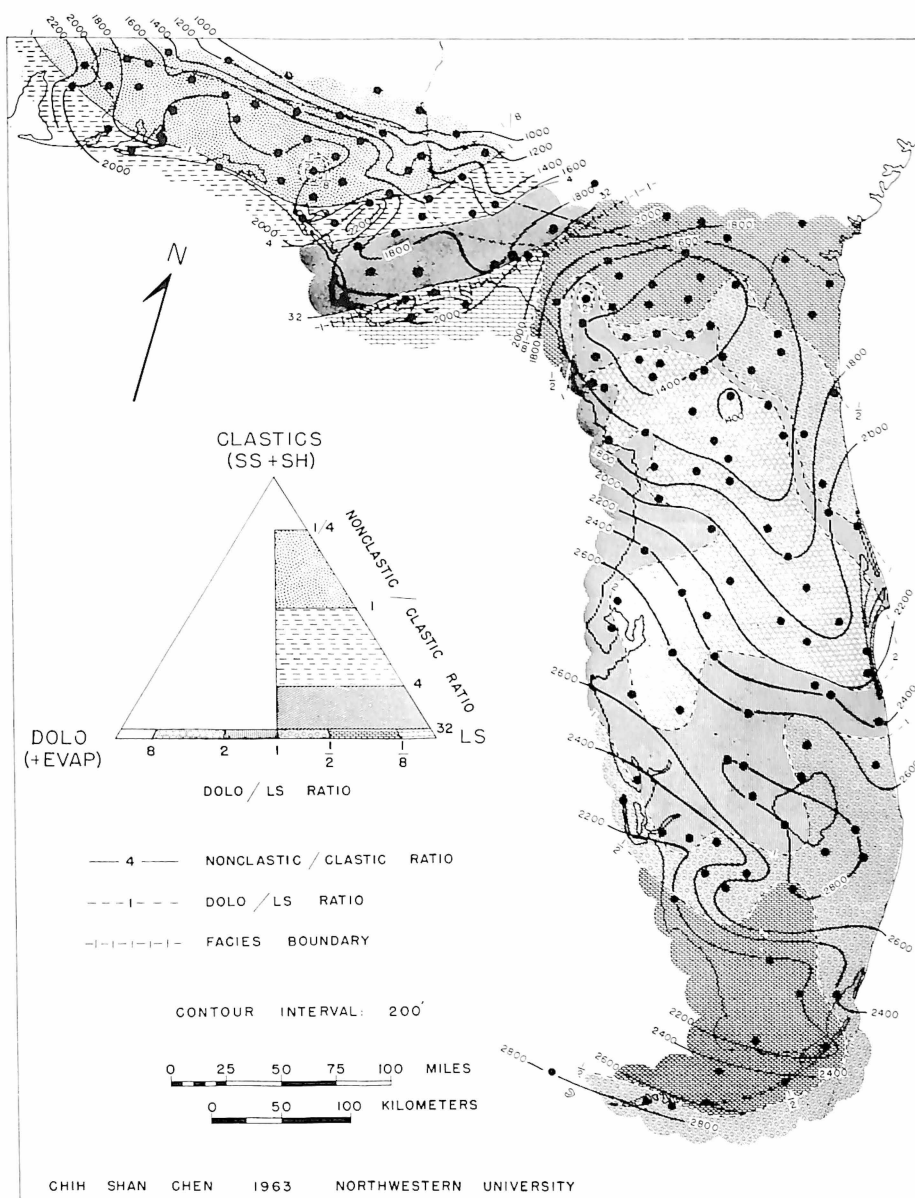


Figure 38. Isopach-lithofacies map of the Eocene Series of Florida.

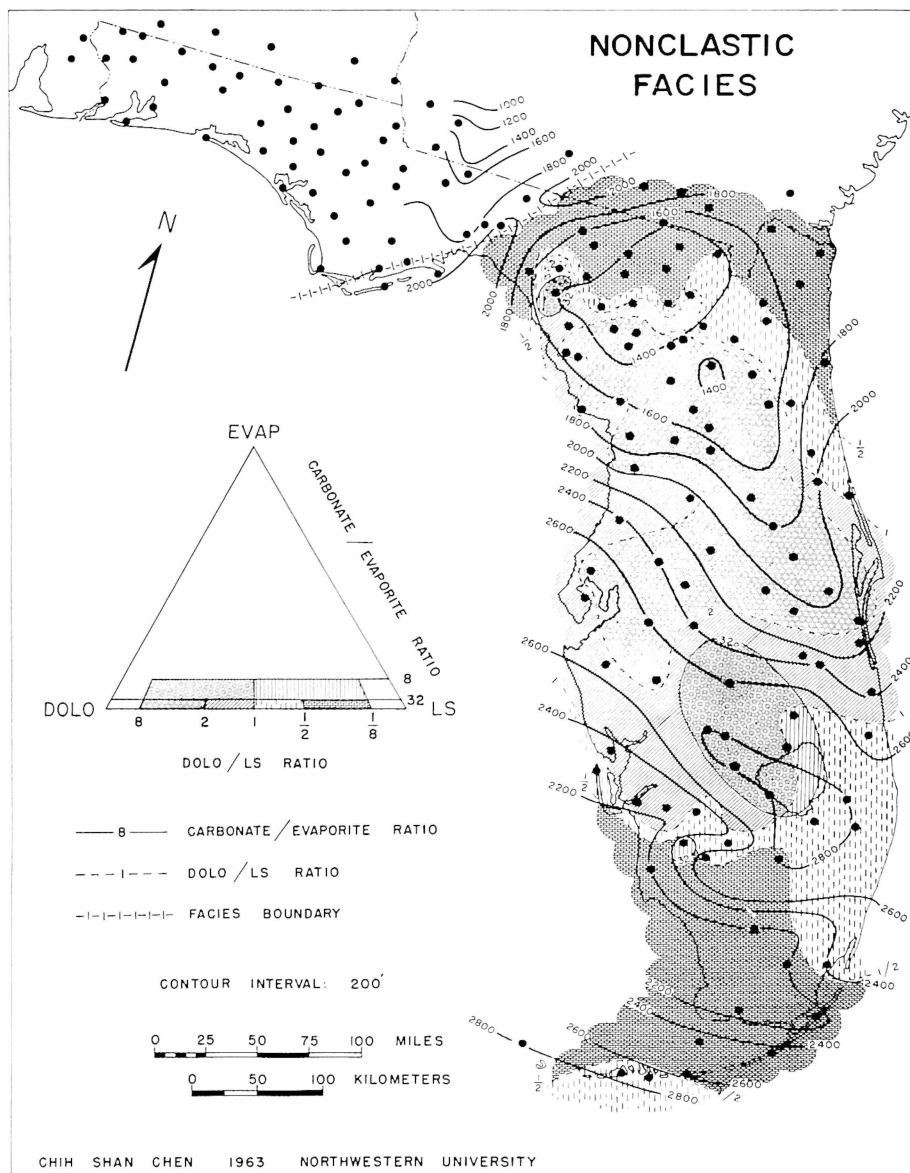


Figure 39. Isopach-lithofacies map of the Eocene Series of peninsular Florida.

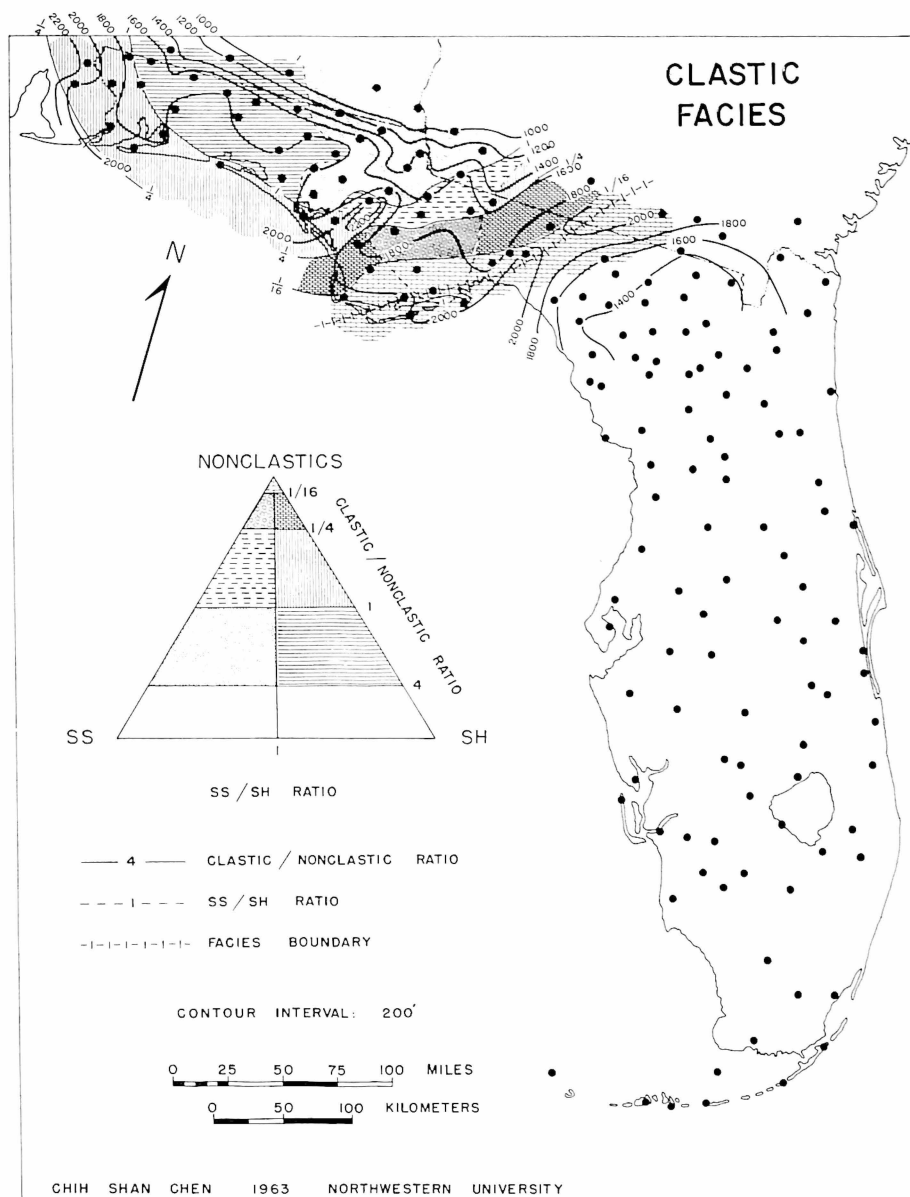


Figure 40. Isopach-lithofacies map of the Eocene Series of panhandle Florida.

3. The Suwannee Channel is probably marked by the facies boundary and the saddle-like form outlined by the 2000 foot isopach line.
4. Facies and isopach strikes are generally parallel.

## INTERPRETATIVE STRATIGRAPHY

### GENERAL CONSIDERATION

Integration of isopach-lithofacies maps and structure maps with petrographic and paleontologic data makes possible more reliable interpretations of petrogenesis (including provenance, distribution, depositional environment, and diagenesis) and of the regional tectonics of Paleocene and Eocene time in Florida. Two distinct sedimentary facies, clastic and nonclastic, have been recognized and differentiated on a series of isopach-lithofacies maps of the successive stratigraphic units. Although these two facies are closely related in space and time, they should be considered separately in terms of their sedimentary parameters.

The clastic sediments which dominate panhandle Florida and the northern and western Gulf Coast region not only bear evidences of their predepositional history, but in addition have also recorded some of the characteristic imprints of depositional and diagenetic processes. Textural and mineralogic investigations, therefore, are the major means of determining source-rock types, processes of weathering at the source area, duration of transportation, characteristics of the depositional environment, state of tectonism, and processes of diagenesis. On the other hand, the nonclastic sediments, the dominant lithologies in peninsular Florida, reveal only the characteristics of the depositional environment, the processes of diagenesis, and the influence of major tectonic elements.

Evaporites represent chemical processes alone, while carbonates are generally considered to be both chemical and biochemical products. Therefore, such information as (1) the content of major (Ca and Mg) and trace (Rb, Sr, and others) elements, (2) the abundance of stable isotopes ( $C^{12}$  and  $C^{13}$ ,  $O^{16}$  and  $O^{18}$ , and  $S^{32}$  and  $S^{34}$ ), and (3) the type and content of fossils and their regional distribution, becomes even more significant, geologically and geochemically, in respect to the interpretation of physical, chemical, and biological conditions of the depositional environment, the diagenetic processes, and the regional tectonic controls.

The writer believes that the concept of uniformitarianism is applicable to the interpretations of depositional environment of



Early Tertiary rocks in Florida in terms of physical, chemical, and biological conditions. The following reconstruction is based primarily on the major lithologic types, their regional distribution, and the paleontologic assemblages which they contain. These are evaluated in terms of local and regional depositional environments and in the light of the tectonic framework of the Paleocene and Eocene rocks in Florida.

## REGIONAL TECTONICS AND DEPOSITIONAL ENVIRONMENTS

### LITHOLOGIC CHARACTERISTICS

Nonclastic sediments—carbonates and evaporites are the major lithologies of the nonclastic facies in peninsular Florida.

Limestone and dolomite are generally pure and clean as shown by insoluble residue analysis. Only a trace amount of organic and argillaceous materials has been found in certain grayish and more or less impure limestone and dolomite.

Fossiliferous limestones are very common, and some of these are microcoquinoïd and consist almost entirely of foraminifers and other microorganisms. Macrofossils are generally rare, but they may be quite abundant in certain stratigraphic intervals encountered in some wells in northern Florida.

Reef-like limestone ranging in age from Lower Eocene to Upper Eocene have been encountered in some wells in northern Florida (W-890, Nassau; W-1500, Baker; W-1596, Madison; and W-2775, Suwannee). Major reef trends have never been recognized in well samples and electric logs of the Paleocene and Eocene sections in the area studied. However, the writer is convinced that a corollary of the distribution pattern of modern marine carbonates, such as in the Bahamas and Florida Bay and Keys could exist in the Early Tertiary of Florida. It seems possible that reef masses could be found in the Paleocene and Eocene sections of such regions as the continental shelf on the east side of peninsular Florida, the Bahamas, and the southernmost part of the Florida Platform. These are the areas facing prevailing ocean current directions.

Highly carbonaceous carbonate beds which are commonly interbedded with laminae or thin beds of peat are found in the uppermost part of the Lake City Limestone (early Middle Eocene) with a rather wide regional distribution in northern and central peninsular Florida (fig. 32). This evidence again suggests that, near the end of deposition of the Lake City, northern and central peninsular Florida was probably an area of very shallow, warm, and more or

less lagoonal environment enclosed by the broad carbonate bank occupying all of peninsular Florida. Here, seaweeds and other marine plants flourished together with other marine organisms so as to produce the highly carbonaceous carbonate and thin peat beds.

Paleocene-Eocene dolomites are brown to very dark brown, microcrystalline to coarse crystalline, and rather porous. Microcrystalline dolomite is predominant in the Paleocene strata; fine to coarse crystalline dolomite is characteristic of Lower and Middle Eocene strata; while limestone becomes a principal lithology in Upper Eocene strata. Generally, the regional lithofacies patterns illustrate that the dolomites are more common on the structural highs than on the structural lows. Except for complications introduced by dolomitization on structural highs the carbonates are quite uniform in terms of their gross lithologic characteristics on a regional scale.

Williams and Barghoorn (1963), on the basis of study of distribution of recent marine carbonates in the "American Mediterranean" region, concluded that:

In summary, it appears that biological phenomena or biological processes are the principal cause, directly or indirectly, of carbonate precipitation in the oceans and that the sites of precipitation bear recognizable, though complex, relationships to ocean currents and to physiographic features of the ocean basins.

From the study of regional distribution of recent marine carbonate sediments in the world as a whole (excluding the deep sea oozes), one finds that organic reef complexes and continental shelf carbonates are confined within a narrow belt between the latitudes of 30° north and 30° south. Biologically, the necessary conditions for the support of life in the oceans, and thus for the precipitation of marine carbonates, are (1) relatively intense illumination within the euphotic zone, (2) warm water temperature (21°-32°C or 70°-90°F), and (3) sufficient supply of inorganic nutrients. These three major requirements can only be met in such environments as warm and shallow water marine conditions on relatively flat and broad shelves, banks, and platforms. The present-day Bahamas and the Compeche Bank could be taken as models for making interpretations of the environmental conditions under which the Paleocene and Eocene carbonate rocks were formed on the Florida Platform.

Anhydrite, gypsum, and inorganically precipitated carbonates are the only evaporite minerals found in the Paleocene and Eocene strata in Florida. Vertical repetitions of cyclical deposition of carbonates and evaporites is a common phenomenon in the lower part

of the Paleocene section, particularly in the western part of central peninsular Florida and in southern Florida. Laterally, evaporite beds are replaced by carbonates.

Theoretically, in order to produce a 1-foot bed of anhydrite it is necessary to evaporate a 1400-foot column of sea water of normal composition. Therefore, it is quite clear that in order to obtain tens of hundreds of feet of evaporite beds over a large area as in the Paleocene strata in Florida, it requires a depositional environment, such as the silled reflux basin envisaged by King (1947), Scruton (1953), and Briggs (1958).

The evaporite basins are outlined on the evaporite percentage maps (figs. 27 and 31) and on the isopach-lithofacies maps (figs. 24-25, and 28-29). These evaporite basins were well developed during Early Paleocene time; however, they were greatly reduced during Late Paleocene and Lower Eocene time, and were almost completely absent during late Middle Eocene and Upper Eocene time.

As has been mentioned previously, large reef masses or reef trends have never been encountered in the Paleocene and Eocene sections in peninsular Florida. In the absence of reef trends as restricting sills, the evaporite lagoons developed in the peninsular Florida region during Paleocene and early Lower Eocene time could have been surrounded by relatively broad (probably tens of miles wide) but very shallow (water depth probably around 10 feet) carbonate banks with a few channels cutting through them. These banks could serve as sills to restrict the evaporating body of water within the shallow lagoon so that free circulation could not take place and the concentration of the brine gradually increased.

Clastic sediments.—The clastic sediments of the Paleocene and Eocene strata in panhandle Florida as well as in western and southern Alabama and southern Georgia are composed essentially of poorly consolidated, carbonaceous, calcareous, and glauconitic sandstones; green-gray to gray-black, laminated, micaceous, glauconitic, and calcareous shales; and nonfossiliferous to fossiliferous, glauconitic, arenaceous, and argillaceous limestones. Carbonaceous material and coarser clastics (sand and silt) become dominant northward toward the outcrop belt.

X-ray analyses of calcareous shales of various Paleocene and Eocene stratigraphic units in panhandle Florida indicate that montmorillonite and illite are the principal clay minerals with kaolinite in minor amounts, and that montmorillonite is more common than illite. Generally, the regional clay mineral distribution pattern as

represented by limited number of samples analyzed in this study indicates that the amount of montmorillonite increases southwestward toward the Gulf. This evidence probably suggests that these shales were deposited in shallow marine environment as they are formed today in the shelf region of northeastern Gulf Coast (Griffin, 1962).

The regional lithofacies patterns of successive stratigraphic units studied are shown on the series of maps in the preceding chapter. The patterns indicate clearly that the coarser clastics are dominant on the structural highs, such as the Chattahoochee Arch, in panhandle Florida and northward toward the Piedmont region, while finer clastics and carbonates become the major lithologic components southward toward the Gulf and southeastward toward peninsular Florida. The writer, on the basis of lithologic characteristics of these Paleocene and Eocene strata, believes that those clastic sediments found in panhandle Florida are related to the continental shelf region with marginal marine conditions, while the rocks seen at and near the outcrop belt adjacent to the Piedmont area are believed to have been deposited in environments ranging from transitional (or deltaic) to continental.

The source area of the clastic sediments in panhandle Florida and other parts of the southeastern Coastal Plain during Paleocene and Eocene time was most likely the Southern Appalachians. The fact that the amount of clastic sediments is greatly reduced near southern Georgia and northern panhandle Florida and that clastics are completely absent in peninsular Florida leads to consideration of the following interpretations: (1) the pattern could be due to the existence of a natural barrier between these two sedimentary facies, (2) no large streams were available for transporting a large amount of clastic sediments into the depositional site, and (3) only a small amount of clastics were actually contributed from the source area.

The writer believes that the presence of a natural barrier, that is, the Suwannee Channel, may be the major factor in separating these two distinct sedimentary facies. However, it remains possible that all of these three factors could well be equally important and could have operated jointly throughout the entire Paleocene and Eocene time.

#### PALEONTOLOGICAL CHARACTERISTICS

Organisms respond to and record the whole complex of environmental conditions under which they live as do the sediments with

which they are associated. Therefore, one would expect that there should be two quite different faunal assemblages representing the two distinct sedimentary environments, clastic and nonclastic, in panhandle and peninsular Florida, respectively, during Early Tertiary time.

Applin and Applin (1944), on the basis of detailed study of microfaunas, especially the foraminifers, of the Cretaceous and Tertiary strata in Florida and southern Georgia, have made the following statement:

In general also, the foraminiferal microfaunas of the clastic facies resemble those present in formations in the western Gulf Coast, whereas the microfaunas of the limestone facies in the peninsula from the top of the early Middle Eocene to the top of the beds of Taylor age resemble those of Cuba, the West Indies, Mexico, and Europe, with only few species present that are known in other places in the United States.

Cheetham (1963) has made an extensive study of the abundance and distribution of cheilostome bryozoan associations, and the nature of other fossils, and of the sediments of the Jackson Stage (Upper Eocene) in southern Alabama, southern Georgia, and panhandle and peninsular Florida. By categorizing individual cheilostome faunules as associations and considering these in terms of known ecological requirements and tolerances of living cheilostomes, he has been able to identify three different depositional environments, namely, (1) shelf phase, from the Mississippi-Alabama border to the Alabama-Georgia-Florida corner, (2) bank phase, peninsular Florida, and (3) barrier between shelf and bank, the zone of Suwannee Channel, in which different assemblages lived and different sediments accumulated during Upper Eocene time.

Nonclastic facies (peninsular Florida region).—The vast number of foraminifers presented in the carbonate rocks of Paleocene and Eocene sections in peninsular Florida are mostly referable to such families as Valvulinidae (including genera of *Lituonella*, *Coskinolina*, *Dictyoconus*, and *Gunteria*), Miliolidae, Alveolinellidae (Borelis), Amphisteginidae (*Asterigerina*, *Helicostegina*, and *Amphistegina*), Orbitoididae (*Lepidocyclina*, *Orbitoides*, *Lepidorbitoides*), and Nummulitidae (*Nummulites*, *Camerina*, and *Opericulinoidea*). Paleocologically, almost all of these foraminifers are characteristic of shallow (less than 100 feet in water depth), warm (tropic to subtropic) waters where they are commonly associated with calcareous algae of the photic zone (Cushman, 1948). According to Johnson (1961) most calcareous algae live in strong light at, or very close to, low-tide level, and at least half of them are re-

stricted to water depths of less than 60 to 75 feet. Large foraminifers common in the successive stratigraphic units studied, especially in the Ocala Group, are known to occur in a stenotopic tropical environment, living in a water depth range of 125 to 200 feet, and in calcareous mud, on biostromes and bioherms (Puri, 1957).

According to Cheetham (1963) the Jacksonian (Upper Eocene) carbonate rocks of peninsular Florida accumulated on a carbonate bank. He has suggested that the water depth probably did not exceed 150 feet over the most part of peninsular Florida at any time during the Jacksonian, and that the depositional environment seems to have been a lagoon with shoal-water, tropical climate, and exceptionally uniform hydrographical conditions.

As has been discussed previously, the lithologic evidences of the Paleocene and Eocene rocks in peninsular Florida fully support these authors' interpretations regarding the physical, chemical, and biological conditions of the depositional environment.

Clastic facies (panhandle Florida region).—According to Applin and Applin (1944) foraminifers of strata ranging in age from Paleocene to early Middle Eocene in panhandle Florida are not only strikingly different from those common throughout peninsular Florida, but also are rare. Such faunal changes are in harmony with the regional lithofacies patterns, that is, the Paleocene and Early Eocene carbonate rocks of the peninsula are clearly differentiated from the clastics of the panhandle. However, such marked faunal and lithologic differences gradually become obscure in the late Middle Eocene and Upper Eocene rocks of the same areas, reflecting the northward and northwestward spread of nonclastics over the panhandle during the time from late Middle Eocene to Upper Eocene.

Cheetham (1963) has pointed out that the Upper Eocene sediments of panhandle Florida and southern Alabama were deposited on the continental shelf in water 100-300 feet deep. In early Upper Eocene time the terrigenous sediments were abundant, and they spread southeastward nearly to the edge of the shelf. However, with the passage of time, the detrital material was gradually reduced both in its quantity and in its areal extent. Cheetham also has stated that the chief evidence of the Suwannee Channel barrier is indicated by the presence of lagenid and buliminid foraminifers and by the absence of bryozoans.

Gardner (1957) has made a paleoecologic study of the faunas (dominantly molluscan) of an Early Tertiary section cropping out on Little Stave Creek, Alabama. She concluded that the entire

sequence of Eocene and Oligocene sediments was probably laid down on a shifting continental shelf beyond the intertidal zone; that average water depth may have been about 240 feet or less; and that water temperature during the Eocene was probably as high or higher than it is in the northern Gulf of Mexico today.

### TECTONO-ENVIRONMENTAL CONDITIONS AND SEDIMENTATION

The lithologic and paleontologic interpretations of inferred ecological and environmental conditions make possible the reconstruction of the regional pattern and relationships between tectonic elements and sedimentary environments under which these Paleocene and Eocene rocks were formed.

#### NONCLASTIC FACIES (PENINSULAR FLORIDA REGION)

Two major structural elements, the Peninsular Arch and the South Florida Basin (fig. 2), played the major role in controlling the distribution of sedimentary environments which, in turn, controlled the detailed patterns of sediment distribution during Paleocene and Eocene time. As has been pointed out, the Peninsular Arch forms the backbone of the broad Florida Platform throughout the entire geological time interval from Paleozoic to Recent. The South Florida Basin was a regionally downwarped area where relatively thick accumulation of nonclastic sediments of Paleocene and Eocene age (more than 4000 feet) were deposited under slowly but steadily subsiding condition. These two structural elements are demonstrable on the series of isopach-lithofacies maps, structure maps, and evaporite percentage maps presented in the preceding chapters.

Geophysical and geologic data suggest that the tectonic belts of both the Southern Appalachian and the Ouachita systems may join together underneath the Florida Platform (Drake and others, 1963; E. R. King, 1959). However, local magnetic anomalies on the West Florida Escarpment indicate no linear belt, at least in the area surveyed, but probably represent buried volcanic cones that provided the sites upon which the calcareous banks formed (Miller and Ewing, 1956).

Petrologic and paleontologic evidences, such as (1) the exclusively nonclastic nature of the sediments, (2) generally fossiliferous to highly fossiliferous character of limestones, (3) cyclical deposition as well as vertical repetition of carbonates and evaporites, (4) high degree of purity and lithologic uniformity of car-

bonate rocks, and (5) their inferred ecologic and environmental conditions lead the writer to interpret these nonclastic sediments as deposits on a stable carbonate bank or shelf in warm, shallow water, and open marine environment. The writer believes, in general, that similar sedimentary-environmental conditions to those existing today in the Florida Bay and Keys, the Great Bahamas, and Campeche Bank could be taken as models for interpretations of the environmental conditions under which the nonclastic sediments were deposited on the Florida Platform during Paleocene and Eocene time.

In this view, at the beginning of Paleocene time, the broad region of the Florida Platform was a stable carbonate bank bounded by submarine escarpments on both the Atlantic and the Gulf of Mexico sides and separated from the continental shelf at the north by the Suwannee Channel. The platform probably included a broad bank in its northern and central portion and a broad lagoon in its southern portion, both characterized by shallow water, warm climate, relatively uniform hydrographic conditions, and open marine environment. Scattered reef masses were present on the bank, probably along its northern and eastern margins.

The entire Florida Platform was submerged during Paleocene and Eocene time, except in the late Middle Eocene and late Upper Eocene time when the greater part of the northern and central portions of the platform was emergent and subjected to nondeposition and subaerial erosion. This emergence is evidenced by the unconformable relationships between the Ocala Group (Upper Eocene) and the beds lying above and below. Sedimentation was probably continuous throughout Early Tertiary time in the southern part of the platform where evaporitic restriction of lagoonal environments was relaxed near the end of Early Eocene time as shown by the reduction of evaporites both in quantity and in areal extent.

No severe crustal movements affected the entire Florida Platform and southeastern Coastal Plain during Early Tertiary time. It is believed that the Peninsular Arch and South Florida Basin have been modified only by a series of epeirogenic movements of differential downwarping of the embayments or basins and slower subsidence of marginal areas and arches.

#### THE SUWANNEE CHANNEL

The Suwannee Channel (fig. 2) was the site of relatively thin accumulation of very fine sands, silts, clays and limestones at least



during the time from late Upper Cretaceous to Lower Eocene (figs. 5, 6, and 21). The channel was a natural barrier and facies boundary, both sedimentational and biologic, between two distinct sedimentary facies in the area throughout the entire Early Tertiary time. North and northwest of the channel is the clastic facies composed of sandstone, shale, and limestone, while just south of the channel is the nonclastic facies consisting almost exclusively of carbonates and evaporites.

As has been briefly mentioned previously, the presence of the Suwannee Channel during late Upper Cretaceous and Early Tertiary time is indicated by the following interpretations.

1. Paleocology.—According to Moore (1955) and Cheetham (1963), shallow-water types of larger foraminifers and cheilostome bryozoan assemblages are very common in Upper Eocene sediments in peninsular Florida and on the shelf region northward near the Piedmont. However, these shallow-water faunas are rare or absent in sediments of the same age at the position of the Suwannee Channel. Here, deeper-water types of lagenid and bulminid foraminifers become dominant. In addition, although no reef belt has ever been identified or reported in the literature, reef-like limestone beds ranging in age from Lower Eocene to Upper Eocene have been encountered in several wells located in those counties (Baker, Madison, Nassau, and Suwannee) near the northern edge of the Florida Platform. This may suggest that the platform could have been bounded on its northern edge by a rather abrupt escarpment.

2. Petrology.—The Paleocene and Lower Eocene strata encountered along the channel are composed mainly of calcareous shale in contrast to the coarser terrigenous clastics to the north and northwest and pure carbonates and evaporites to the southeast.

3. Tectonics.—The lesser thickness of strata ranging in age from late Upper Cretaceous to Lower Eocene within the channel (figs. 5, 6, and 21) might be interpreted as due to either erosion on a positive lineament or slower sedimentation within the channel. Cenozoic structure of the channel is synclinal, and the thickness of post-Lower Eocene rocks within the channel site is greater (1500 feet or more) than that on the Peninsular and Chattahoochee arches (1000 feet or less) giving no evidence of Cenozoic positive habit. Thus, the evidence strongly indicates slower Paleocene-Eocene accumulation within the channel rather than differential erosion.

These interpretations combine to suggest that the Suwannee Channel was a bathymetric depression and a natural barrier, both

sedimentational and ecologic, during late Cretaceous and Early Tertiary time.

By Middle or Upper Eocene time the Suwannee Channel was probably no longer an effective natural barrier in separating the clastic facies from the nonclastic facies. Disappearance of the Suwannee Channel during Middle or Upper Eocene time may be partly due to the continued transgression of the sea through Paleocene and Eocene time as is demonstrated by the steadily shifting facies boundary northward and northwestward from late Upper Cretaceous to Upper Eocene time. Or, the reduced influence of the channel may be due to great reduction of the amount of terrigenous material contributed from the Southern Appalachian region to the depositional site. Lastly, disappearance of the channel may partly reflect a dramatic change in the drainage systems with major streams flowing westward toward the Mississippi Embayment and the Gulf, and eastward toward the Atlantic Coast. These are the possibilities which must be considered in explaining the encroachment of the nonclastic facies northward and northwestward over the clastic facies.

#### CLASTIC FACIES (PANHANDLE FLORIDA AND ITS ADJACENT AREAS)

In the Coastal Plain of southern Alabama, southern Georgia, and panhandle Florida, the major pre-Cenozoic tectonic elements are: (1) the northern "root element" of the Peninsular Arch, which may better be considered as a part of the Southern Appalachian system, extended southward toward northern Florida, (2) the Chattahoochee Arch, and (3) the Southeast Georgia and Apalachicola embayments. These tectonic elements are undoubtedly to be considered as the "relics" of older structural elements, possibly Paleozoic in age. These old features are covered with a considerable thickness of Cretaceous and possibly older Mesozoic clastic sediments. It is believed that the latest Upper Cretaceous or early Lower Paleocene widespread uplift that occurred in the southeastern Coastal Plain resulted in the erosion of some Upper Cretaceous beds over a broad area in Alabama, Georgia, and Florida and in the formation of the structural sag occupied by the Suwannee Channel. Following this uplift the entire southeastern Coastal Plain slowly subsided and the sedimentation of Cenozoic sediments began.

At the beginning of Paleocene time, the southeastern Coastal Plain region was a relatively unstable continental shelf separated from the Florida Platform by the Suwannee Channel on its southeastern margin. The shelf was chiefly a deltaic or transitional and

shallow water marine environments receiving mainly sands, shales, and limestones. A degree of interfingering between the clastic and nonclastic facies must exist somewhere along the Suwannee Channel, although this can not be verified by the limited well data available in this study. Therefore, a considerable amount of subsurface geologic information needs to be obtained before any reliable interpretation can be made concerning the detailed stratigraphic relationships between these two distinct sedimentary facies.

Several minor disconformities have been recognized in the Paleocene and Eocene sections at the outcrop area, but they are generally not recognizable in the subsurface in panhandle Florida, except at the contacts of the Ocala Group (Upper Eocene) which show unconformable relationships with beds lying above and below.

Geologic and geophysical data indicate that the core of the Chattahoochee Arch as well as the entire southeastern Coastal Plain is composed of rigid rock masses of plutonic, metamorphic, and weakly metamorphosed sedimentary rocks ranging in age from Precambrian to Paleozoic. During Paleocene and Eocene time, the shelf region in panhandle Florida, although relatively unstable, was subject to a slow rate of subsidence with total accumulation of sediments ranging from less than 1500 feet on the Chattahoochee Arch to more than 3000 feet southwestward toward the Gulf. This is in contrast to the western Gulf region where the sediments of the entire Paleocene and Eocene sections reach a total thickness ranging from about 5000 feet in southeastern Louisiana to more than 20,000 feet in the Rio Grande Embayment of South Texas (Hardin, 1962; Murray, 1961).

During Early Tertiary time, the rate of sedimentation in panhandle Florida as well as other parts of the Gulf Coast region was never uniform. Murray (1951) has called loci or trends of greater accumulation of sediments "depocenters" or "depoaxes", however, neither panhandle nor peninsular Florida were significant "depocenters" or "depoaxes" in Early Tertiary time.

### PALEO GEOGRAPHY

The series of isopach-lithofacies maps, structure maps, and lithologic cross sections of the Paleocene and Eocene Series in Florida, together with lithologic and paleontologic data and ecologic and environmental conditions inferred in this study are here integrated to produce a series of paleogeographic maps of the successive stratigraphic units studied (figs. 41-44). The classification of

the sea floor into different environments is according to bathymetric zones of Hedgpeth (1957b) :

1. supralittoral (above high tide level),
2. littoral or intertidal (between tide levels),
3. inner sublittoral (low tide level to 150 feet or 50 meters),
4. outer sublittoral (between 150 and 600 feet or 50 to 180 meters),
5. bathyal (between 600 and 3300 feet or 180 and 1000 meters),
6. abyssal (below 3300 feet or 1000 meters).

The Florida Platform was separated from the continental shelf on the north by the Suwannee Channel as early as late Upper Cretaceous time. The lithologic character, as represented by the exclusive nonclastic nature of sediments, of the formations ranging in age from late Upper Cretaceous to Upper Eocene strongly suggests that the entire Florida Platform became a carbonate bank with a shallow, warm-water, marine environment during late Upper Cretaceous time. Such environmental conditions existed continuously throughout the entirety of Paleocene and Eocene time. The platform was probably not separated into the Bahamas and peninsular Florida of present-day geography until Upper Eocene time; however, much work needs to be done before such speculation can be verified.

During Early Paleocene time, an evaporitic lagoon with a considerable areal extent (fig. 41) began to develop on the carbonate bank, the Florida Platform. Lithologic character of the Cedar Keys Formation suggests that the evaporitic lagoon was occupied by a shallow and warm-water marine environment only partially restricted by very shallow but rather wide banks. This evaporitic lagoon probably disappeared during Late Paleocene time, but reappeared intermittently during early Lower Eocene and early Middle Eocene time (figs. 42-43). However, the size of the lagoon and the amount of evaporites produced during Lower and Middle Eocene time were greatly reduced in comparison with that of Lower Paleocene time. No evaporite beds have been found in those strata younger than early Middle Eocene, except for minor amounts of gypsum occurring as thin seams or veinlets in the carbonate rocks.

The Suwannee Channel acted as a natural barrier, both sedimentational and faunal, between the clastic facies (in panhandle Florida) and the nonclastic facies (in peninsular Florida) during Paleocene and Eocene time. However, the barrier nature of the

channel gradually became less effective and finally disappeared near the end of Upper Eocene time.

Generally, the environmental conditions in panhandle Florida as well as in other parts of the southeastern Coastal Plain varied from continental (supralittoral) to transitional (littoral) to shallow marine (inner and/or outer sublittoral) continuously throughout the entire Early Tertiary time, although shore lines and local environmental conditions were slightly different from one stage to the other (figs. 41-44). The fact of gradual but steady spreading of the nonclastic facies northerly and northwesterly over the clastic facies during Paleocene and Eocene time may be the result of continued marine transgression. Some sporadic regressions occurred during Early Tertiary time as manifested by the presence of local and regional unconformities.

The paleogeographic patterns of Paleocene and Eocene time were replaced in Oligocene-Miocene time by the spread of clastics across much of the Florida peninsula.



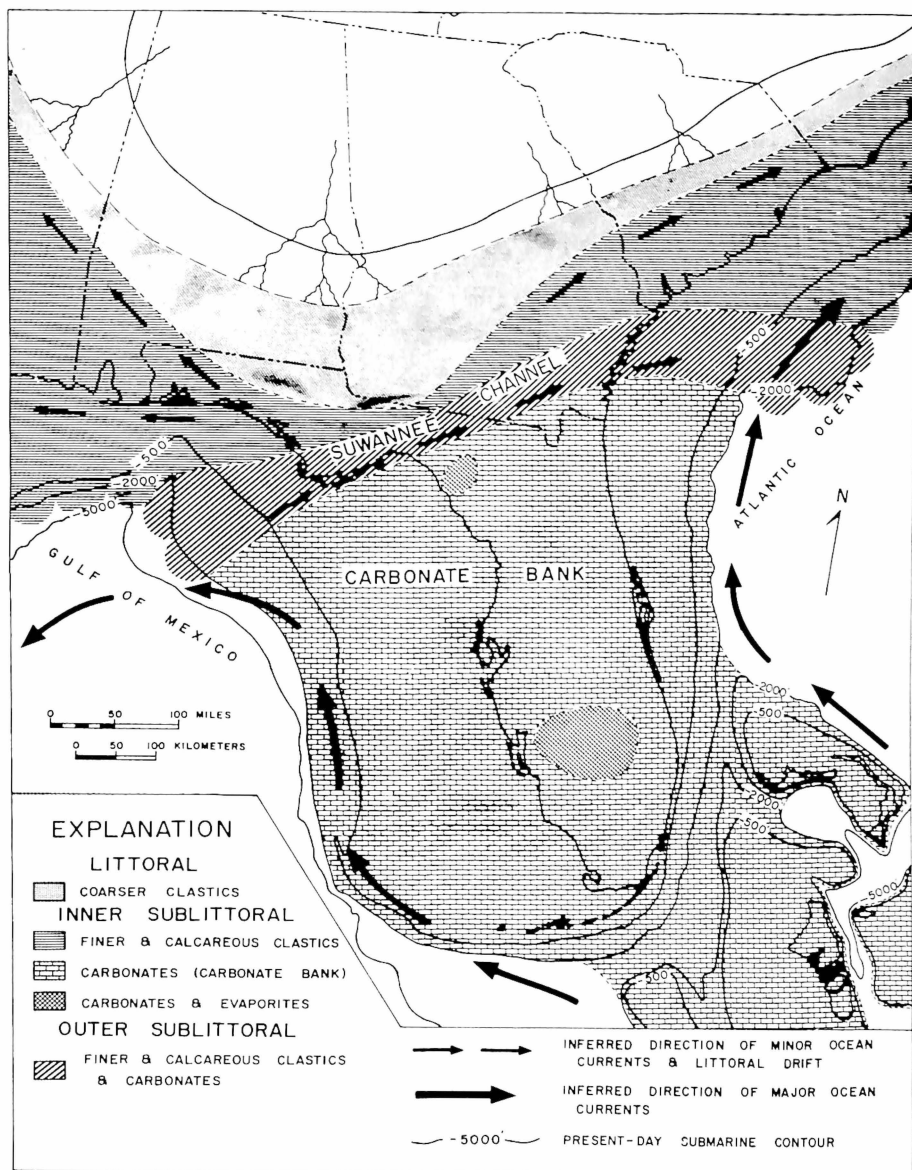


Figure 42. Paleogeographic map during Lower Eocene (Sabinian) deposition.

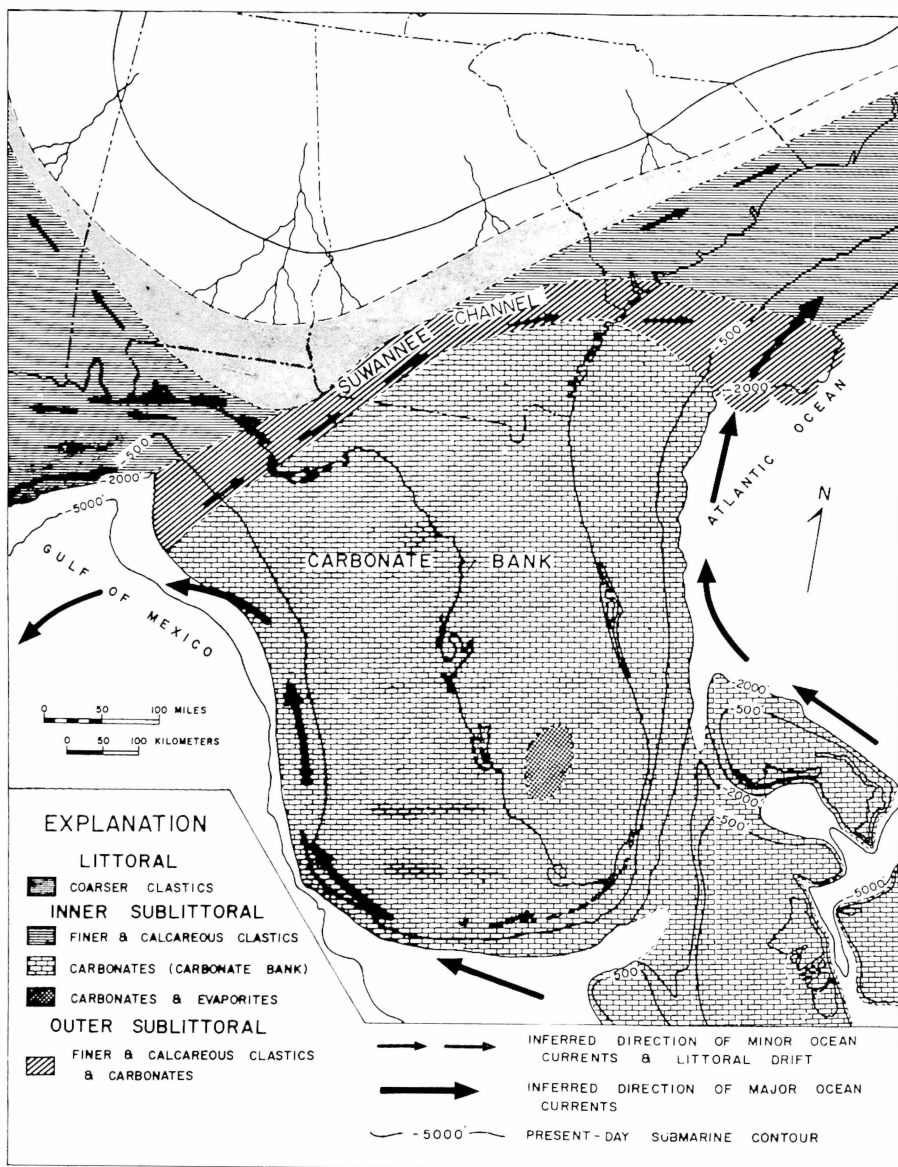


Figure 43. Paleogeographic map during Middle Eocene (Claibornian) deposition.



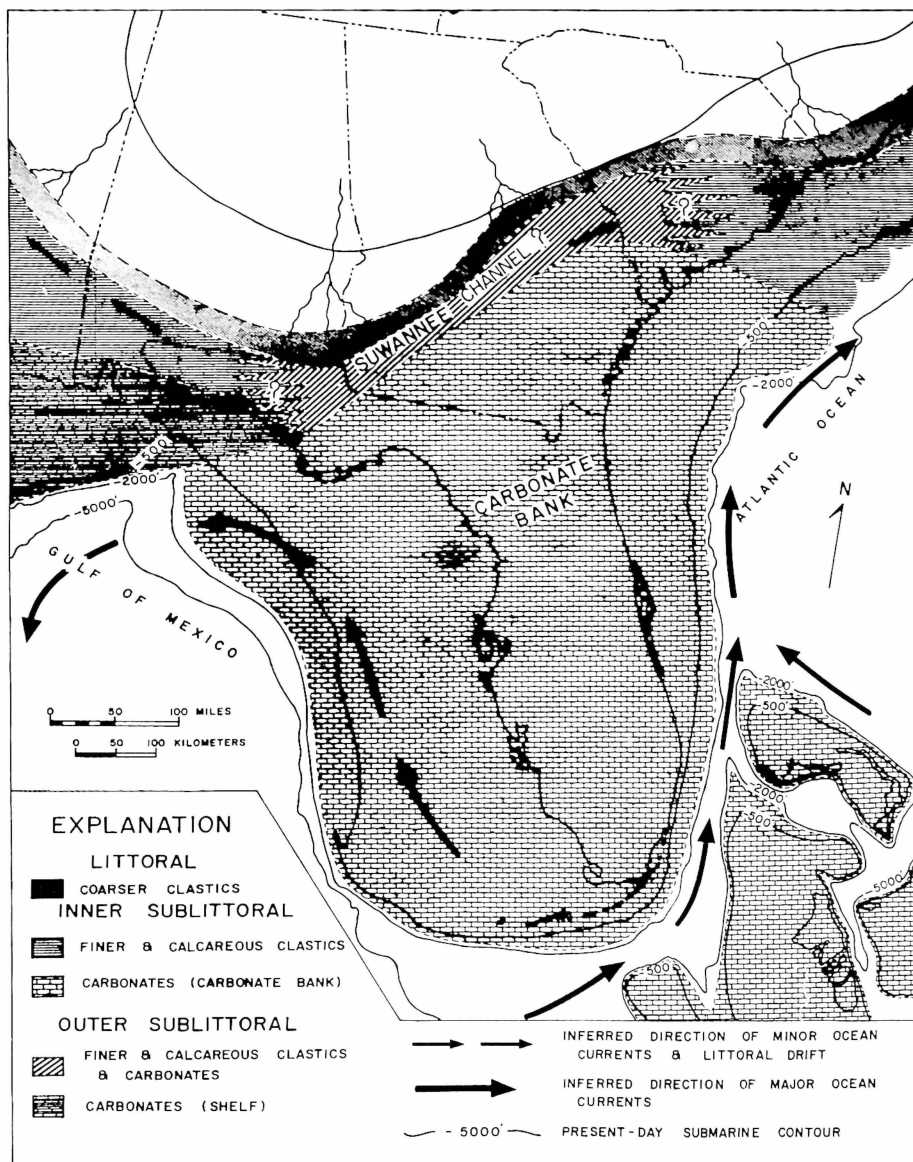


Figure 44. Paleogeographic map during Upper Eocene (Jacksonian) deposition.

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## APPENDIX

TABLE 1. Location of Wells.

| Well No. | County    | Name and Location                                                                          | Elevation (ft.) | Total Depth (ft.) |
|----------|-----------|--------------------------------------------------------------------------------------------|-----------------|-------------------|
| FLORIDA  |           |                                                                                            |                 |                   |
| 1465     | Alachua   | Tidewater Oil Co.<br>R. H. Cato No. 1<br>Sec. 23-8S-18E                                    | 112 D.F.        | 3146              |
| 1472     | Alachua   | Tidewater Oil Co.<br>J. A. Phifer No. 1<br>Sec. 24-9S-21E                                  | 132 D.F.        | 3223              |
| 1486     | Alachua   | Tidewater Oil Co.<br>Josie Parker No. 1<br>Sec. 33-7S-19E                                  | 168 D.F.        | 3218              |
| X-32     | Alachua   | The Texas Co.<br>A. M. Creighton No. 1<br>Sec. 16-11S-19E                                  | 77.26<br>D.F.   | 3524              |
| 1500     | Baker     | Hunt Oil Co.<br>Hunt Fee No. 1<br>Sec. 21-1N-20E                                           | 130 D.F.        | 3348              |
| 2187     | Baker     | National Turpentine & Pulp<br>Wood Corp.<br>Fee No. 1<br>Sec. 7-4S-19E                     | 155 D.F.        | 3043              |
| 933      | Bay       | Magnolia Petroleum Co.<br>State Block 4-B No. 1<br>Sec. 21-3S-15W                          | 7 D.F.          | 7003              |
| 2893     | Bay       | A. R. Temple, A. W. Williams<br>Inspection Co.<br>C. C. Moore No. 1<br>Sec. 27-1S-15W      | 60 D.F.         | 5021              |
| 3000     | Bay       | A. R. Temple, A. W. Williams<br>Inspection Co.<br>Gregg Lumber Co. No. 1<br>Sec. 14-3S-13W | 58 D.F.         | 5009              |
| 1466     | Bradford  | Tidewater Oil Co.<br>M. F. Wiggins No. 1<br>Sec. 15-6S-20E                                 | 132 D.F.        | 3166              |
| 9        | Brevard   | Sec. 21-27S-37E                                                                            | 17.58           | 510               |
| 4456     | Brevard   | Sec. 13-29S-37E                                                                            | 10              | 444               |
| 1610     | Calhoun   | D. E. L. Byers<br>Hardway Contrg. Co. No. 1<br>Sec. 31-2N-9W                               | 266.5<br>D.F.   | 4876              |
| 2886     | Calhoun   | Sun Oil Co.<br>E. L. Jordan No. 1<br>Sec. 36-1N-11W                                        | 160.1<br>D.F.   | 5002              |
| 3214     | Charlotte | Gulf Oil Co.<br>Vanderbilt No. 1<br>Sec. 35-41S-21E                                        | 21.45<br>D.F.   | 12685             |
| 720      | Citrus    | Sec. 6-19S-18E                                                                             | 170.04          | 300               |
| 1590     | Clay      | Humble Oil & Ref. Co.<br>Formost Properties No. 1<br>Sec. 4-6S-25E                         | 115 D.F.        | 5861              |
| 1759     | Clay      | Sec. 6-7S-23E                                                                              | 222             | 840               |
| 820      | Collier   | Humble Oil & Ref. Co.<br>Gulf Coast Realities No. 7<br>Sec. 29-48S-30E                     | 34 D.F.         | 5804              |
| 1885     | Collier   | Humble Oil & Ref. Co.<br>Gulf Coast Realities No. D-1<br>Sec. 3-48S-28E                    | 36.9<br>D.F.    | 11900             |
| X-5      | Collier   | Humble Oil & Ref. Co.<br>Collier Corp. No. 1<br>Sec. 27-50S-26E                            | 25 D.F.         | 12516             |



TABLE 1. Continued

| Well No. | County   | Name and Location                                                                    | Elevation (ft.) | Total Depth (ft.) |
|----------|----------|--------------------------------------------------------------------------------------|-----------------|-------------------|
| FLORIDA  |          |                                                                                      |                 |                   |
| 1789     | Columbia | Humble Oil & Ref. Co.<br>J. P. Cone No. 1<br>Sec. 22-1N-17E                          | 141 D.F.        | 4285              |
| 1832     | Columbia | Sun Oil Co.<br>M. W. Sapp No. 1<br>Sec. 24-2S-16E                                    | 138 D.F.        | 3011              |
| 1923     | Columbia | Sun Oil Co.<br>Clarence Loyd et al<br>Sec. 11-5S-17E                                 | 129             | 2929              |
| 215      | Dade     | Sec. 12-55S-40E                                                                      | 9.91 D.F.       | 5428              |
| 935      | Dade     | William G. Blanchard and Associates<br>Everglades No. 1<br>Sec. 31-53S-35E           | 18 D.F.         | 9725              |
| 1115     | Dade     | Gulf Oil Corp.<br>State Model Land No. C-1<br>Hy. 27-60S-35E                         | 11 D.F.         | 6024              |
| 2038     | Dade     | Coastal Petroleum Co.<br>11F State of Florida<br>#1 Lease 340A<br>Sec. 25-55S-37E    | 25.3 D.F.       | 11519             |
| 636      | Dixie    | Florida Oil Development Co.<br>Putnam Lumber Co.<br>Sec. 7-11S-12E                   | 26 D.F.         | 3853              |
| 1114     | Dixie    | Stanolind Oil and Gas Co.<br>Perpetual Forest No. 1<br>Sec. 5-11S-11E                | 33 D.F.         | 7506              |
| 1405     | Dixie    | Sun Oil Co.<br>Hazel Langston No. 1<br>Sec. 8-8S-14E                                 | 33 D.F.         | 3647              |
| 1863     | Dixie    | Sun Oil Co.<br>P. C. Crapps No. 1A<br>Sec. 36-8S-10E                                 | 41.2            | 5103              |
| 581      | Duval    | Sec. 22-3S-24E                                                                       | 75 D.F.         | 980               |
| 3869     | Duval    | Sec. 19-1S-27E                                                                       | 14 D.F.         | 1390              |
| 2236     | Escambia | John S. Neilson & W. E. Walker<br>McDavid Vaneer Inc. No. 1<br>Sec. 35-6N-30W        | 82 D.F.         | 6598              |
| 2519     | Escambia | Commonwealth Oil & Perdido Land Co.<br>Marcus Lischkoff et al No. 1<br>Sec. 8-2S-31W | 19 D.F.         | 7494              |
| 2862     | Escambia | Sunnyland G. Jeffreys & Son<br>J. A. Abbott No. 1<br>Sec. 19-3N-32W                  | 201 D.F.        | 7508              |
| 4150     | Escambia | T. E. McMillan & A. R. Temple<br>Lee Daniell No. 1<br>Sec. 1-5N-32W                  | 169 D.F.        | 6867              |
| 1473     | Flagler  | Humble Oil & Refining Co.<br>J. W. Campbell No. 1<br>Sec. 8-11S-28E                  | 31 D.F.         | 4618              |
| 1396     | Franklin | The Pure Oil Co.<br>St. Joe Paper Co. No. 2<br>Sec. 34-6S-4W                         | 7.64 D.F.       | 4787              |
| 1412     | Franklin | The Pure Oil Co.<br>Gex-Lewin No. 3<br>Sec. 3-8S-6W                                  | 15 D.F.         | 5058              |
| 5103     | Franklin | The California Co.<br>Fla. State Lse. 224 No. A-1<br>Sec. 7-9S-5W                    | 26 D.F.         | 7030              |

TABLE 1. Continued

| Well No. | County       | Name and Location                                                                            | Elevation (ft.) | Total Depth (ft.) |
|----------|--------------|----------------------------------------------------------------------------------------------|-----------------|-------------------|
| FLORIDA  |              |                                                                                              |                 |                   |
| X-8      | Franklin     | The California Co.<br>Fla. State Lse. 224-A No. 2<br>Lat. 29° 47' 03"N<br>Long. 84° 22' 51"W | 33.9<br>D.F.    | 10566             |
| 1467     | Gadsden      | Havana Syndicate Inc.<br>H. H. Swisher No. 1<br>Sec. 30-3N-1W                                | 235 (?) D.F.    | 3867              |
| 1768     | Gadsden      | Paul S. Oles & John W. Naylor<br>Florida Power Co. No. 1<br>Sec. 35-2N-3W                    | 200 D.F.        | 4238              |
| 3577     | Gadsden      | E. R. Smith<br>C. K. Wall No. 1<br>Sec. 19-2N-6W                                             | 245 D.F.        | 4022              |
| 1003     | Gilchrist    | Sun Oil Co.<br>Alto Adams No. 1<br>Sec. 15-9S-15E                                            | 93 D.F.         | 3748              |
| 1819     | Gilchrist    | Sun Oil Co.<br>Williams Bros. No. 1<br>Sec. 11-8S-15E                                        | 77 D.F.         | 3366              |
| 2396     | Glades       | Sec. 20-38S-34E                                                                              | 25 (?)          | 1215              |
| 2912     | Glades       | Coastal Petroleum Co.<br>John Tiedtka et al No. 1<br>Sec. 25-42S-33E                         | 25 (?) D.F.     | 13408             |
| 4750     | Glades       | Amerada Petroleum Corp.<br>Lykes Brother Incorporated No. 1<br>Sec. 1-41S-30E                | 54 D.F.         | 10990             |
| 1455     | Gulf         | The Pure Oil Co.<br>Pick Hollinger No. 1<br>Sec. 12-9S-11W                                   | 4.76<br>D.F.    | 5655              |
| 1468     | Gulf         | The Pure Oil Co.<br>E. L. McMillan No. 1<br>Sec. 25-4S-11W                                   | 48 D.F.         | 5069              |
| 1470     | Gulf         | The Pure Oil Co.<br>C. C. Hopkins No. 2<br>Sec. 21-6S-9W                                     | 33 D.F.         | 7258              |
| 1655     | Hardee       | Humble Oil & Refining Co.<br>B. T. Keene No. 1<br>Sec. 23-35S-23E                            | 83 D.F.         | 11934             |
| 2631     | Hendry       | Humble Oil & Refining Co.<br>Collier Corp. No. 1B<br>Sec. 14-47S-31E                         | 40 D.F.         | 11796             |
| X-6      | Hendry       | Commonwealth Oil Co.<br>Red Cattle Co. No. 1<br>Sec. 13-45S-28E                              | 40 D.F.         | 6093              |
| 994      | Hernando     | The Ohio Oil Co.<br>Hernasco Corp. No. 1<br>Sec. 19-23S-18E                                  | 47 D.F.         | 8477              |
| 996      | Highlands    | Humble Oil & Refining Co.<br>C. C. Carlton No. 1<br>Sec. 34-38S-29E                          | 114 D.F.        | 12685             |
| 2859     | Highlands    | Sec. 18-34S-29E                                                                              | 149.4 D.F.      | 1400              |
| 3578     | Highlands    | Continental Oil Co.<br>C. C. Carleton et al No. 1<br>Sec. 20-38 (?) S-28E                    | 88 D.F.         | 12602             |
| 1005     | Hillsborough | Humble Oil & Refining Co.<br>T. S. Jameson No. 1<br>Sec. 7-31S-22E                           | 109 D.F.        | 10129             |
| 1513     | Holmes       | S. W. Breding<br>N. E. Coates No. 1<br>Sec. 25-7N-15W                                        | 200 D.F.        | 4107              |

TABLE 1. Continued

| Well No. | County       | Name and Location                                                         | Elevation (ft.) | Total Depth (ft.) |
|----------|--------------|---------------------------------------------------------------------------|-----------------|-------------------|
| FLORIDA  |              |                                                                           |                 |                   |
| 1750     | Holmes       | S. P. Borden<br>Glen Moore No. 1<br>Sec. 15-5N-18W                        | 200 D.F.        | 4512              |
| X-10     | Holmes       | Cashion-Stanley-Daws<br>T. A. Yawkey No. B-1<br>Sec. 1-4N-17W             | 86 D.F.         | 4310              |
| 1908     | Indian River | Sec. 3-33S-39E                                                            | 22.2            | 671               |
| 3783     | Indian River | Amerada Petroleum Corp.<br>Fondren Mitchell No. 1<br>Sec. 28-31S-35E      | 60 D.F.         | 9488              |
| 2777     | Jackson      | I. P. & Feed Larue<br>L. A. Spencer No. 1<br>Sec. 30-4N-8W                | 132 G.L.        | 4113              |
| 3565     | Jackson      | Thompson Exploration Drilling Co.<br>J. J. Still No. 1<br>Sec. 13-5N-13W  | 135 D.F.        | 3909              |
| 3627     | Jackson      | Thompson Exploration Co.<br>D. K. Shiver No. 1<br>Sec. 11-5N-8W           | 94.95           | 3454              |
| X-9      | Jackson      | Sun Oil Co.<br>McRae Land & Timber Co. No. 2<br>Sec. 9-6N-11W             | 133.6<br>D.F.   | 3817              |
| 19       | Jefferson    | Sec. 17-2N-5E                                                             | 217.94<br>D.F.  | 3838              |
| 1854     | Jefferson    | Coastal Petroleum Co.<br>E. P. Larsh No. 1<br>Sec. 1-2S-3E                | 51 D.F.         | 7905              |
| 968      | Lafayette    | Sun Oil Co.<br>P. C. Crapps No. 1<br>Sec. 25-6S-12E                       | 70 D.F.         | 4127              |
| 1696     | Lafayette    | Humble Oil & Refining Co.<br>R. L. Henderson Est. No. 1<br>Sec. 20-4S-11E | 52 D.F.         | 4235              |
| 275      | Lake         | All Florida Land Co.<br>Gulf Exploration Co. No. 2<br>Sec. 17-24S-25E     | 120 D.F.        | 6113              |
| 2927     | Lake         | Sec. 20-19S-27E                                                           | 164 D.F.        | 750               |
| 3073     | Lee          | Humble Oil & Refining Co.<br>W. E. Kirchhoff No. 1<br>Sec. 23-45S-24E     | 22 D.F.         | 12876             |
| 4165     | Lee          | Gulf Oil Corp.<br>Consolidated Naval Stores No. 2<br>Sec. 22-45S-26E      | 45 D.F.         | 11796             |
| X-7      | Lee          | The California Co.<br>Fla. State Lse. 224B No. 1<br>Boca Grande (?)       | 39 D.F.         | 8706              |
| 936      | Leon         | Stanolind Oil & Gas Co.<br>St. Joe Paper Co. No. 1-A<br>Sec. 15-2S-2E     | 41 D.F.         | 6143              |
| 1537     | Levy         | Coastal Petroleum Co.<br>Ragland No. 1<br>Sec. 16-15S-13E                 | 14 D.F.         | 5850              |
| 2012     | Levy         | Humble Oil & Ref. Co.<br>C. E. Robinson No. 1<br>Sec. 19-16S-17E          | 56.4<br>D.F.    | 4609              |
| 3342     | Levy         | Sphinx Syndicate<br>Prudential Lumber Co. No. 1<br>Sec. 31-13S-16E        | 26 D.F.         | 3851              |

TABLE 1. Continued

| Well No. | County   | Name and Location                                                                                                | Elevation (ft.) | Total Depth (ft.) |
|----------|----------|------------------------------------------------------------------------------------------------------------------|-----------------|-------------------|
| FLORIDA  |          |                                                                                                                  |                 |                   |
| 1106     | Liberty  | Pure Oil Co.<br>Neal Lumber Co. No. 1<br>Sec. 33-2S-8W                                                           | 68 D.F.         | 4502              |
| 1385     | Liberty  | Pure Oil Co.<br>Gex and Lewin No. 1<br>Sec. 24-5S-6W                                                             | 25 D.F.         | 4745              |
| 1771     | Liberty  | R. T. Adams<br>St. Joe Paper Co. No. 1<br>Sec. 6-1S-6W                                                           | 188 D.F.        | 4266              |
| 1596     | Madison  | Hunt Oil Co.<br>J. W. Gibson No. 2<br>Sec. 6-1S-10E                                                              | 107 D.F.        | 5385              |
| 1598     | Madison  | H. L. Hunt<br>Gibson No. 4<br>Sec. 5-2S-11E                                                                      | 73 D.F.         | 4078              |
| 3612     | Manatee  | Magnolia Petroleum Co.<br>Schroeder-Manatee No. 1<br>Sec. 11-35S-19E                                             | 69 D.F.         | 11226             |
| 18       | Marion   | Sec. 10-16S-20E                                                                                                  | 75.5 D.F.       | 6020              |
| 742      | Marion   | Sec. 16-13S-21E                                                                                                  | 97.7 D.F.       | 690               |
| 1482     | Marion   | Sun Oil Co.<br>Henry N. Camp No. 1<br>Sec. 16-16S-23E                                                            | 74 D.F.         | 4635              |
| 1904     | Marion   | Sun Oil Co.<br>H. T. Parker No. 1<br>Sec. 24-14S-22E                                                             | 79 D.F.         | 3840              |
| 2        | Monroe   | Sec. 9-66S-32E                                                                                                   | 6.5 D.F.        | 2310              |
| 972      | Monroe   | Gulf Refining Co.<br>State of Florida No. 1<br>Sec. 2-67S-29E                                                    | 23 D.F.         | 15452             |
| 3011     | Monroe   | Sinclair Oil & Gas Co.<br>H. L. Williams No. 1<br>Sec. 24-59S-40E                                                | 20 D.F.         | 11962             |
| X-1      | Monroe   | Gulf Oil Corp.<br>State of Florida 374 No. 1<br>Sec. 15-67S-27E                                                  | 23 D.F.         | 6086              |
| X-2      | Monroe   | Gulf Oil Corp.<br>State of Florida No. 1<br>Lat. 25° 00'53"N<br>Long. 81° 05'54"W                                | 20 D.F.         | 12630             |
| X-3      | Monroe   | Coastal Petroleum Co.<br>State of Florida No. 1<br>Sec. 32-62S-38E                                               | 16 K.B.         | 7559              |
| X-4      | Monroe   | Gulf Oil Corp. & The California Co.<br>Marquesas Ocs Blk. 28 Well No. 1<br>Lat. 24° 27'00"N<br>Long. 82° 21'45"W | 72 K.B.         | 15290             |
| 336      | Nassau   | St. Mary's River Oil Corp.<br>Hilliard Turpentine Co. No. 1<br>Sec. 19-4N-24E                                    | 99.02 D.F.      | 4821              |
| 890      | Nassau   | Rayonier, Inc.<br>Sec. 30-3N-28E                                                                                 | 20.14<br>D.F.   | 2130              |
| 2935     | Okaloosa | Sun Oil Co.<br>B. Belcher No. 1<br>Sec. 18-3N-22W                                                                | 173 D.F.        | 6010              |
| 3225     | Okaloosa | H. L. Hawkins<br>C. L. & Mattie Kelly No. 1<br>T2S, R22W; Unsurveyed<br>Destin Peninsula                         | 27 D.F.         | 6247              |

TABLE 1. Continued

| Well No. | County     | Name and Location                                                         | Elevation (ft.) | Total Depth (ft.) |
|----------|------------|---------------------------------------------------------------------------|-----------------|-------------------|
| FLORIDA  |            |                                                                           |                 |                   |
| X-12     | Okaloosa   | The California Co.<br>Blackman Unit No. 1<br>Sec. 28-5N-24W               | 238.16<br>D.F.  | 5775              |
| 3739     | Okeechobee | Amerada Petroleum Corp.<br>Marie Swenson No. 1<br>Sec. 5-36S-34E          | 54 D.F.         | 10836             |
| 3673     | Orange     | Warren Petroleum Co.<br>G. Terry No. 1<br>Sec. 21-23S-31E                 | 100 D.F.        | 6589              |
| 1411     | Osceola    | Humble Oil & Ref. Co.<br>W. P. Hayman No. 1<br>Sec. 12-31S-33E            | 72 D.F.         | 8798              |
| 1770     | Osceola    | Hunt Oil Co.<br>Peavey Wilson Lbr. Co. No. A-2<br>Sec. 27-35S-34E         | 44 D.F.         | 5856              |
| 1833     | Osceola    | Hunt Oil Co.<br>Consolidated Naval Store No. 3<br>Sec. 4-27S-32E          | 69 D.F.         | 6510              |
| 2163     | Osceola    | Kissimmee Pennsylvania Oil Co.<br>Sec. 25-26S-29E                         | 68.26 D.F.      | 1995              |
| 20       | Palm Beach | Florida Experiment Station<br>Sec. 3-44S-37E                              | 14(D.F. ?)      | 1332              |
| 1471     | Palm Beach | Humble Oil & Refining Co.<br>Tucson Corp. No. 1<br>Sec. 35-43S-40E        | 33.5 D.F.       | 13371             |
| 3671     | Palm Beach | Amerada Petroleum Corp.<br>Southern States No. 1<br>Sec. 34-41S-39E       | 36 D.F.         | 11010             |
| 4661     | Palm Beach | Humble Oil & Refining Co.<br>State Lease 1004 No. 1<br>Sec. 2-48S-35E     | 31 D.F.         | 12810             |
| 2927     | Pasco      | Sec. 11-26S-21E                                                           | 80 (?)          | 960               |
| 1669     | Pinellas   | Coastal Petroleum Co.<br>Ed. C. Wright No. 1<br>Sec. 7-30S-17E            | 13 D.F.         | 10188             |
| 4506     | Pinellas   | R. E. Skinner<br>J. A. Boyd Estates No. 1<br>Sec. 1-28S-16E               | 22(D.F. ?)      | 4298              |
| 61       | Polk       | Florida Pioneer Oil Corp.<br>Sec. 28-30S-25E                              | 85 D.F.         | 4540              |
| 3883     | Polk       | American Syanarnid Co.<br>Sec. 22-27S-24E                                 | 136<br>(?)      | 1198              |
| 1514     | Putnam     | Sun Oil Co.<br>O. I. Roberts No. 1-A<br>Sec. 19-9S-25E                    | 206 D.F.        | 3328              |
| 1838     | Putnam     | Sun Oil Co.<br>Westbury et. al. No. 1<br>Sec. 27(?) -11S-26E              | 32              | 3889              |
| 236      | St. Johns  | The East Coast Hotel Co.<br>Sec. 18-7S-30E                                | 6.5 (?)         | 1440              |
| 4086     | St. Lucie  | Amerada Petroleum Co.<br>Cowles Magazine Inc. No. 1<br>Sec. 19-36S-40E    | 31 D.F.         | 5159              |
| 3048     | Santa Rosa | Fla. Serv. Corp.-Clinch Drlg. Co.<br>U.S.A. No. 1<br>Sec. 8-5N 26W        | 187.5 D.F.      | 6500              |
| 3455     | Santa Rosa | Mears-Hamilton-Armour Oil Co.<br>Estes Timber Co. No. 1<br>Sec. 10-2N-27W | 45 D.F.         | 6800              |

TABLE 1. Continued

| Well No. | County     | Name and Location                                                           | Elevation (ft.) | Total Depth (ft.) |
|----------|------------|-----------------------------------------------------------------------------|-----------------|-------------------|
| FLORIDA  |            |                                                                             |                 |                   |
| X-13     | Santa Rosa | Gulf Oil Corp.<br>State of Florida No. 1<br>Sec. 23-1S-28W                  | 10.1<br>D.F.    | 6063              |
| X-14     | Santa Rosa | Humble Oil & Refining Co.<br>State Lease 833 No. 1<br>Approx. Sec. 1-3S-30W | 10 D.F.<br>(?)  | 7506              |
| X-15     | Santa Rosa | A. R. Temple<br>A. M. McDavid et. al. No. 1<br>Sec. 28-4N-30W               | 68.5<br>D.F.    | 7039              |
| 1377     | Seminole   | Fosgate Growers Corp.<br>Sec. 16-21S-29E                                    | 96.6            | 1115              |
| 3        | Sumter     | Dundee Petroleum Co.<br>Sec. 24-20S-22E                                     | 76.7            | 3100              |
| 1450     | Suwannee   | Sun Oil Co.<br>Earl Odom No. 1<br>Sec. 31-5S-15E                            | 73 D.F.         | 3161              |
| 2775     | Suwannee   | Sec. 24-2S-13E                                                              | 105(?)          | 1140              |
| 2784     | Suwannee   | Humble Oil & Refining Co.<br>S. Taylor No. 1<br>Sec. 25-3S-13E              | 110.2 D.F.      | 3682              |
| 1877     | Taylor     | Humble Oil & Refining Co.<br>Hodges No. 1<br>Sec. 12-5S-6E                  | 36 D.F.         | 6253              |
| 2106     | Taylor     | Gulf Oil Corp.<br>Brooks-Scanlon Block 33 No. 1<br>Sec. 18-4S-9E            | 96 D.F.         | 5243              |
| 2161     | Taylor     | Gulf Oil Corp.<br>Brooks-Scanlon Inc. Block 37 No. 1<br>Sec. 17-6S-9E       | 67 D.F.         | 4784              |
| 1118     | Volusia    | Sun Oil Co.<br>Powell Land Co. No. 1<br>Sec. 11-17S-31E                     | 48 D.F.         | 5956              |
| 1746A    | Volusia    | Grace Drilling Co.<br>Retail Lumber Co. No. 1<br>Sec. 2-15S-30E             | 45 K.B.         | 5418              |
| 4725     | Volusia    | Sec. 32-17S-34E                                                             | 10(?)           | 1270              |
| 440      | Wakulla    | Ravlin Brothers<br>Ravlin-Brown No. 1<br>Sec. 14-3S-1E                      | 29 G.L.<br>(?)  | 5069              |
| 1591     | Walton     | D. E. L. Byers<br>E. Edward No. 1<br>Sec. 28-5N-21W                         | 212 D.F.        | 5267              |
| 1657     | Walton     | D. E. L. Byers<br>B. Sealey No. 1<br>Sec. 12-2S-18W                         | 37 D.F.         | 5477              |
| X-11     | Walton     | Arrington & Sanford<br>Walton Land & Timber Co. No. 1<br>Sec. 16-1N-18W     | 193 D.F.        | 5830<br>(?)       |
| 1758     | Washington | D. E. L. Byers<br>Alfred Brothers No. 1-A<br>Sec. 31-2N-13W                 | 125             | 4827              |
| 2913     | Washington | A. R. Temple<br>Vernon Land & Timber Co. No. 2<br>Sec. 30-2N-15W            | 148.3<br>D.F.   | 4722              |
| 3650     | Washington | Thompson Exploration Drilling Co.<br>Ross Deal No. 1<br>Sec. 4-3N-14W       | 43 D.F.         | 4170              |

TABLE 1. Continued

| Well No. | County    | Name and Location                                                       | Elevation (ft.) | Total Depth (ft.) |
|----------|-----------|-------------------------------------------------------------------------|-----------------|-------------------|
| ALABAMA  |           |                                                                         |                 |                   |
| X-30     | Baldwin   | M. S. McCurry & Oil Co.<br>Southern Kraft No. 1<br>Sec. 28-2S-4E        | 178 D.F.        | 5010              |
| X-31     | Baldwin   | Sohio Petroleum Co.<br>Tenn. Coal Iron & Rr. Co. No. 1<br>Sec. 24-4S-3E | 109 D.F.        | 8131              |
| X-28     | Covington | G. W. Strake<br>H. H. Bullard No. 1<br>Sec. 10-2N-14E                   | 230 D.F.<br>(?) | 6618              |
| X-29     | Escambia  | The Texas Co.<br>Wiggins-Cobb Unit No. 1<br>Sec. 30-2N-10E              | 215 D.F.        | 7013              |
| X-27     | Geneva    | Shell Oil Co.<br>M. C. Free No. 1<br>Sec. 5-2N-19E                      | 195 D.F.        | 4212              |
| X-25     | Houston   | J. S. Neilson<br>A. L. Sneel Est. No. 1<br>Sec. 10-2N-29E               | 150 D.F.        | 4012              |
| X-26     | Houston   | R. W. Williams<br>Whitfield No. 1<br>Sec. 18-3N-26E                     | 270 D.F.        | 6007              |
| GEORGIA  |           |                                                                         |                 |                   |
| X-21     | Brooks    | D. E. Hughes<br>Rogers Sr. No. 1-B<br>L. L. 454                         | 133 D.F.        | 3850              |
| X-16     | Camden    | The California Co.<br>J. A. Bule No. 1<br>S. of Tarbord, Ga.            | 34 D.F.<br>(?)  | 4947              |
| X-17     | Clinch    | Luke Grace Drlg. Co.<br>L. Griffis No. 1<br>LL. 36, LD. 13              | 110 G.L.        | 4588              |
| X-18     | Clinch    | Hunt Oil Co.<br>Alice Musgrove No. 1<br>LL. 198, LD. 12                 | 148 D.F.        | 4088              |
| X-22     | Decatur   | Hunt Oil Co.<br>Metcalf No. 1<br>LL. 260, LD. 21                        | 104 D.F.        | 6152              |
| X-23     | Decatur   | D. E. Hughes<br>Martin No. 1<br>LL. 189, LD. 15                         | 132 D.F.        | 3717              |
| X-19     | Echols    | Hunt Oil Co.<br>Superior Pine Prod. No. 3<br>LL. 532, LD. 13            | 144 D.F.        | 4001              |
| X-20     | Echols    | Humble Oil & Ref. Co.<br>Bennett & Langdale No. 1<br>LL. 146, LD. 12    | 181.2<br>D.F.   | 4186              |
| X-24     | Seminole  | Mont Warren<br>Emily Harlow No. (?)<br>LL. 82, LD. 27                   | 114.5<br>D.F.   | 3572              |











