

LOWER CRETACEOUS(?)

Comanche Series

Only four wells have penetrated the Lower Cretaceous in Levy County and none in Citrus and, as typified by cuttings and cores taken from these wells, these sediments are variegated red, green, and brown clastics, largely sands and shales, that apparently are weathered rocks removed from a pre-Mesozoic near-peneplaned surface and redeposited along the flanks of the surface as it was warped throughout the Cretaceous period, or they are the residuum from the weathering of the rocks exposed at the surface of the land mass, remaining as mantle rocks, largely undisturbed.

The thickness of the Lower Cretaceous ranges from 1,435 feet in the Coastal-Ragland well in western Levy County, to 31 feet in the Humble-Robinson and 67 feet in the Sun-Goethe wells in central Levy County. The sections and distribution of the Cretaceous, see figure 16, indicate that the thickness of the Lower Cretaceous beneath Citrus County has increased slightly over the maximum of 1,435 feet as penetrated in Levy County by the Ragland well.

The sediments of the Lower Cretaceous are interbedded shales and sandstones. The shales are red, purple, green, brown and gray variegated, mottled, waxy and fissile and contain pink calcareous nodules, yellow, pink, argillaceous sand lenses and sand grains of rose quartz. The sandstone is variegated, light-greenish to yellowish-gray, brown, and white, calcareous and siliceous, and contain black siliceous nodules, rose quartz sand grains, seams of sandy shale and lenses of quartz conglomerate. The base is coarse sand and contains pebbles of Paleozoic sediments. An arkosic sandstone, believed to be a mantle developed by the weathering of Triassic diabase was penetrated by the Humble-Robinson well at depths of 4,331 to 4,344 feet.

Lower Cretaceous beds were penetrated by the following wells:

- W-355: Florida Oil Discovery Company, Sholtz (Cedar Keys) No. 2.
SE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 16, T. 15 S., R. 13 E.
Lower Cretaceous: 4,254 to 5,248 feet.
- W-1007: Sun Oil Company, J. T. Goethe No. 1.
NW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 31, T. 14 S., R. 17 E.
Lower Cretaceous: 3,893 to 3,960 feet.
- W-1537: Coastal Petroleum Company, Ragland No. 1.
SE $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 16, T. 15 S., R. 13 E.
Lower Cretaceous: 4,347 to 5,782 feet.
- W-2012: Humble Oil and Refining Company, Robinson No. 1.
NE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 19, T. 16 S., R. 17 E.
Lower Cretaceous: 4,300 to 4,331 feet.

UPPER CRETACEOUS

Gulf Series

Studies of the Cretaceous stratigraphy have been published by Applin and Applin (1944, 1947), Cole (1938, 1941, 1942, 1944, 1945), and the Southeastern Geological Society Mesozoic Committee (1949), in which correlations of the Florida Cretaceous with standard sections of Alabama and Texas have been made. The correlations apparently were based on the experience of the workers and on the lithology and paleontology of the several sections. Many early workers¹⁵ and Cole preferred to use the nomenclature of the Alabama section, whereas the Applins and the Southeastern Geological Society Mesozoic Committee have used the names applied to the Upper Cretaceous of Texas, in which many of the species of foraminifers and mollusks that occur in Florida are found. Most geologists of the oil profession of the southeastern states prefer to use a nomenclature of Beds of Navarro age (Lawson limestone), Beds of Taylor age, Beds of Austin age (which include the Selma equivalent at the top and occasional beds of the upper Eutaw sand at the base) and the Atkinson formation. Some workers prefer not to use Atkinson and divide the interval into the Eagle Ford shale and Woodbine sand. In general all workers recognize a four-fold division of the Upper Cretaceous, based on an age relationship. The Southeastern Geological Society Mesozoic Committee used Navarro equivalent, Taylor equivalent, Austin equivalent and the Atkinson formation, divided into "A" and "B" zones, and this terminology is used in this report with the exception that the Lawson limestone is used for the Navarro equivalent.

The Upper Cretaceous of the peninsular area is composed of cream-colored to brown, pasty and fragmental rarely öolitic, marine chalky limestone, dolomitized in part and with abundant fossils. Incipient dolomitization and gypsum impregnation are present rarely. The base of the section contains lenses and laminae of brown to black shale, green bentonitic shale and thin beds of glauconitic fine sand containing some gravel.

Beds of the Upper Cretaceous lie unconformably upon older beds, and in Citrus and Levy counties individual beds of the series appear to be conformable with each other. An unconformity is also indicated at the top of the Upper Cretaceous in the Humble Oil and Refining Company, C. E. Robinson well No. 1, where the overlying Paleocene Cedar Keys formation contains gray, chalky, limestone pebbles in the very base.

¹⁵Geologic logs in the files of the Florida Geological Survey.

Applin and Applin (1944, p. 1703) likewise indicate an unconformity separating Paleocene from Upper Cretaceous in the vicinity of Tallahassee where the Cedar Keys formation rests on beds of Taylor age, with the Navarro equivalent being absent.

ATKINSON FORMATION

During an investigation of the stratigraphy of Cretaceous rocks in Alabama, Georgia and north Florida, the Applins (1947, chart) determined that:

“The subsurface deposits between the base of the beds of Austin age and the top of the Lower Cretaceous should be considered as a unit in order to explain changes in depositional facies which appear in the upper part of the sequence.”

Beds occupying this horizon in the subsurface could not be correlated exactly by the Applin's with either the surface exposures of Alabama or with the subsurface classification of Mississippi, because of lithologic and faunal differences. The Atkinson formation, including three unnamed members, was proposed for the early Upper Cretaceous and was tentatively correlated with the Tuscaloosa formation and the McShane formation of Alabama. The Applins expressed the desire that the name would be sufficiently flexible to allow the extension of the surface nomenclature at a later date if desirable.

The Atkinson formation has been adequately described by the Applins and this description is not repeated here. The two basal members contain microfossils and mollusk fragments typical of the Woodbine sand of Texas, whereas the upper member contains a fauna characteristic of the Eagle Ford shale of Texas. On the basis of these faunas the Southeastern Geological Society Mesozoic Committee used a two-fold division of the Atkinson formation, an “A” and “B” zone; the “A” zone containing an Eagle Ford fauna, the “B” zone a Woodbine. This division is used in this report.

The Atkinson formation was penetrated in four wells in Levy County. Evidence presented by the Applins (1947, chart) indicates that the Atkinson is possibly absent in eastern Levy County and it is known to be absent over the crest of the Peninsular arch. However, the absence of the formation in Levy County is not substantiated by the section, figure 16, and perhaps the formation thins rapidly in Marion County and is absent over most of it.

The formation is fairly uniform in thickness ranging from 240 feet in the Sun-Goethe well, 244 feet in the Florida Oil Discovery-Sholtz well to

368 feet in the Humble-Robinson well, the thickening occurring in the upper "A" zone.

"A Zone": This zone commonly contains in marine shale beds a fauna characteristic of the Eagle Ford shale of Texas and includes *Planulina eaglefordensis*, *Valvulineria infrequens*, *Gumbelina moremani*, *G. reussi*, *Trochammina wickendeni*, *Globigerina cretacea* and numerous ostracods. In western Levy County it is composed of medium-gray to greenish-gray, calcareous, micaceous shale containing seams of argillaceous limestone and variegated, micaceous, glauconitic, pyrite and carbon flecked sandstone. Eastward the zone thickens from 190 feet to about 250 feet and is composed of interbedded, light-brownish to medium-gray, sandy, dense, hard, shaly limestone with thin seams of sandstone and flecks of lignite; greenish-gray, poorly sorted, slightly calcareous sandstone; and purple, blocky, micaceous shale. Poorly preserved mollusk shells and fish scales are fairly common in the shale beds.

"B Zone": This zone contains a microfauna characteristic of the Woodbine sand of Texas, including *Ammobaculites braunsteini*, *A. compri-matus*, *A. advenus*, *Ammobaculoides plummerae*, and *Trochammina rainwateri*, which are rare in Levy County. The zone as identified in Levy County consists of gray, micaceous, calcareous sand that overlies a dark gray, fissile, calcareous shale and shaly limestone, containing thin seams of gray to cream, shaly limestone, flecks of lignite and traces of gypsum. Medium-gray, calcareous, quartz sandstone with thin shale partings and a coarse sand and gravel conglomerate are irregularly interbedded with the shale.

The following wells¹⁶ penetrated the Atkinson formation in Levy County:

W-355: Florida Oil Discovery — Sholtz well
Atkinson formation
"A Zone" 4,010 to 4,152 feet
"B Zone" 4,152 to 4,254 feet

W-1007. Sun — Goethe well
Atkinson formation
"A Zone" 3,653 to 3,845 feet
"B Zone" 3,845 to 3,893 feet

W-1537: Coastal — Ragland well
Atkinson formation
"A Zone" 4,121 to 4,243 feet
"B Zone" 4,243 to 4,347 feet

¹⁶Locations given on page 76.

W-2012: Humble — Robinson well

Atkinson formation

“A Zone” 3,932 to 4,178 feet

“B Zone” 4,178 to 4,300 feet

BEDS OF AUSTIN AGE

Applin and Applin (1944, pp. 1715-1716) recognized three poorly defined facies in the beds of Austin age in Florida. These facies are predominately shales and sands in western and northern Florida, shale and marly limestone in central Florida and limestones in southern Florida. These writers reported that the beds of Austin age in northern and western Florida are composed of marly shales, fine-grained, argillaceous sandstone; sandy, micaceous clay; and some limestone. The limestone contains an occasional lens of black to brownish-black “speckled” shale, characteristic of the lower part of the Austin chalk of parts of Texas. In central Florida the unit is characteristically gray to greenish-gray, marly shale with streaks of limestone and a few fine-grained sand lenses, and contain lenses of the “speckled” shale. Both of these facies contain an abundant microfauna. Hard white limestone compose the beds of Austin age in the southern Peninsula.

Five wells penetrated beds of Austin age in Levy County. The top of the Austin equivalent in this report is placed at the first shaly chalk below the Taylor equivalent, and has been picked by the electric characteristics and checked by cores and cuttings in all wells except the Florida Oil Discovery and Suwannee Petroleum wells from which only irregular samples were available. The thickness ranges from 480 feet in the Humble-Robinson well, 490 feet in the Sun-Goethe well, to 527 feet in the Coastal-Ragland well.

The Austin equivalent of Citrus and Levy counties can be divided roughly into three parts. The upper 200-300 feet is light-green, cream, tan and gray, rather tight, shaly chalk that contains medium-gray marl and shale seams. The middle 100-200 feet is light-gray, speckled, fairly dense chalk. The basal 100-150 feet is a gray to cream, dense chalk with a flaky fracture and thick beds and seams of calcareous shale; gray, calcareous sand; and lignitic shale. The top of the Austin equivalent is dolomitized in the Humble-Robinson well.

The upper and middle portions are correlated with the Selma chalk and the basal section with the upper part of the restricted Eutaw sands of Alabama, by some workers. The basal beds have very definite and characteristic potentials and resistivities on electric logs.

The intervals in the following wells are assigned to the beds of Austin age:

- W-166: Suwannee Petroleum Corporation, Sholtz well No. 1
NE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 16, T. 15 S., R. 13 E.
Austin equivalent — combined with W-355 — Irregular samples
- W-355: Florida Oil Discovery — Sholtz well¹⁷
Austin equivalent: 3,690 to 4,010 feet
- W-1007: Sun — Goethe well
Austin equivalent: 3,163 to 3,653 feet
- W-1537: Coastal — Ragland well
Austin equivalent: 3,594 to 4,121 feet
- W-2012: Humble — Robinson well
Austin equivalent: 3,452 to 3,932 feet

BEDS OF TAYLOR AGE

The Taylor equivalent in Citrus and Levy counties is a fairly thick and consistent section composed of white to cream chalk separated by thin beds and seams of tan, crystalline dolomite and characterized by fragments of *Inoceramus* sp. and *Torreina* sp.

Three thin beds in the base of these deposits make a very distinctive pattern on the electric logs, the resistivity and potential both being low. These patterns are particularly well-developed at depths of 3,338 feet, 3,348 feet, and 3,357 feet in the Coastal-Ragland well. Because the potential is flat throughout most of the Upper Cretaceous of peninsular Florida, these strong depressions are very prominent in the potential. These beds are widely developed although only 1 to 2 feet thick, and are believed to be a series of clay beds, probably ash falls. The beds are present in almost all of the wells that penetrate the basal Taylor beds in peninsular Florida and make a very good correlation point between these wells and provide a very suitable contouring horizon for the Upper Cretaceous, see the structural map of figure 16. Because the clay beds are so thin, the sediments are rarely recovered in rock cuttings, but occasional fragments of greenish-gray to light-gray, fissile, waxy shale and of brown calcareous clay in the cuttings at depths corresponding to these electric patterns are believed to represent the beds.

In the thick section of chalk of the lower Lawson limestone and Taylor equivalents, and the gradual change in faunal content of the two sections, the top of the Taylor is placed by some workers at the first occurrence of abundant fragments of *Inoceramus* sp. This top has proved to be highly variable, even in closely spaced wells, and the Taylor equiva-

¹⁷Locations of wells given on page 76.

lent has been identified in this report through its rather distinctive electric log characteristics. The top is indicated by a series of strong and evenly spaced resistivities separated by chalk line resistance as observed on the electric logs as follows: 2,892 feet in the Coastal-Ragland, 2,780 feet in the Humble-Robinson, and 2,535 feet in the Sun-Goethe. These distinctive features are referred to rather generally by geologists as "Taylor kicks".

The Taylor equivalent is present from depths of 2,892 to 3,594 feet in the Coastal-Ragland well, a thickness of 702 feet; from depths of 3,092 to 3,690 feet in the Florida Oil Discovery-Sholtz well and the Suwannee-Sholtz well, a thickness of 598 feet; from depths of 2,780 to 3,452 feet in the Humble-Robinson well, a thickness of 672 feet; from depths of 2,535 to 3,163 feet in the Sun-Goethe well, a thickness of 628 feet.

LAWSON LIMESTONE (NAVARRO EQUIVALENT)

The Lawson limestone was described and named by the Applins (1944, p. 1708) for the late Upper Cretaceous beds and the name is taken from the J. S. Cosden-Lawson well No. 1, Marion County, Section 25, Township 13 South, Range 20 East. The formation includes two members, an upper and lower. The name was proposed for:

"A limestone facies of the late Upper Cretaceous occurring in northeast Florida and the peninsula . . . below the Cedar Keys limestone and above beds of Taylor age."

In Levy County the Lawson limestone is also separable into an upper and a lower member, each with a distinctive fauna. The upper member is a cream-colored, fragmental, marine limestone with gypsum lenses and porosity impregnation. The lower member is commonly cream to white, pasty, marine chalk and fragmental limestone. The Applins (1944, pp. 1708-1709) recorded that an undescribed *Rotalid* sp., *Vaughanina* sp., *Orbitoides* sp. and *Pseudorbitoides?* sp., are present in the upper member, and that the lower member is characterized by *Lepidorbitoides* sp., *L. (Asterorbis) aquayoi* D. K. Palmer, *L. (Asterorbis) rooki* Vaughan and Cole, and *Sulcoperculina lawsoni* Applin and Jordan.

The term Lawson limestone has been accepted by most southeastern geologists. The lower member is clearly Cretaceous in age and correlates with the Cretaceous of Cuba, Mexico and Europe, and occupies the same stratigraphic horizon as clastic beds of Navarro age of western Florida, Alabama and Mississippi.

The upper member was defined as late Upper Cretaceous, but in recent oil tests, particularly, the Humble-Hodges well No. 1, in Taylor

County, the fauna characterizing the member occurs very high in the section in an interval normally considered to be Cedar Keys formation, of Paleocene age. This additional information indicates that the upper Lawson is a transitional bed including fossils characterizing both Paleocene and Cretaceous, but since characteristic Cretaceous fossils, particularly species of *Pseudorbitoides* sp., *Torreina* sp., *Orbitoides* sp., and *Vaughanina* sp., are present in the bed it is considered to represent the top of the Cretaceous in peninsular Florida by most writers.

The Lawson limestone was identified from rock cuttings from seven wells in Levy County. The top of the upper Lawson is marked by a very definite and characteristic cream-colored, porous, granular, sub-öolitic, marine, fragmental dolomite. The upper few feet is extremely fossiliferous being a coquina of Applin's *Rotalid* sp., *Pseudocyclammia* sp., and *Pseudorbitoides* sp., loosely cemented together and greatly altered by dolomitization. This extremely fossiliferous zone is thin and the lower part of the upper Lawson is similar to the upper part lithologically but is less fossiliferous.

The lower Lawson is a pasty to fragmental, marine, chalky limestone, frequently dolomitized. *Torreina* sp., *Sulcoperculina cosdeni* Applin and Jordan, several species of *Lepidorbitoides* and *Cibicides harperi* (Sandridge) characterize the bed. Specimens of *Lepidorbitoides* are quite common.

Gypsum is rare to common throughout the upper Lawson, occurring as impregnations of the porosity, but is rare in the lower Lawson. Some carbonaceous partings are present in the lower Lawson, but these are absent in the upper.

The Applins (1944, p. 1739) assigned only 42 feet of the section in the Florida Oil Discovery-Sholtz well to the upper Lawson limestone. This appears thin for the formation because 173 feet of this member was cut by the Coastal-Ragland well, located about a mile south of the Sholtz. The top of the Cretaceous is believed to be obscured in dolomite in the Sholtz well. The formation thins from west to east in Levy County, being 612 feet thick in the Coastal-Ragland well and only 345 feet in the Sun-Goethe well, see figure 16.

The Lawson limestone was penetrated by the Suwannee Petroleum-Sholtz well and the Florida Oil Discovery-Sholtz well but poor sampling prevents exact identification. The formation is present in the following wells as tabulated:

W-1007: Sun — Goethe well

Lawson limestone

Upper: 2,190 to 2,280 feet

Lower: 2,280 to 2,535 feet

W-1537: Coastal — Ragland well

Lawson limestone

Upper: 2,280 to 2,453 feet

Lower: 2,453 to 2,892 feet

W-2010: C. M. Brukenfeld, Assoc.,

Levy-Lennon Syndicate, Inc., well No. 1

NE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 5, T. 14 S., R. 16 E.

Lawson limestone

Upper: 2,010 to 2,120 feet (T. D.)

W-2012: Humble — Robinson well

Lawson limestone

Upper: 2,290 to 2,420 feet

Lower: 2,420 to 2,780 feet

W-2166: J. A. Abbott, Prudential Lumber Company well No. 1

NW $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 34, T. 13 S., R. 16 E.

Lawson limestone

Upper: 1,935 to 1,945 (T. D.)

CENOZOIC ERA TERTIARY SYSTEM

PALEOCENE SERIES

CEDAR KEYS FORMATION

Terminology: The Cedar Keys formation was proposed by Cole (1944, pp. 27-28) for tan-colored, hard limestones which contain *Borelis gunteri* Cole and *Borelis floridanus* Cole in their upper portion, and being sparingly fossiliferous or unfossiliferous in the lower. As used by Cole, the formation extended from the uppermost occurrence of the *Borelis* fauna to the top of the Upper Cretaceous, as identified by him, and included a thin transition zone at the base which is considered by most southeastern geologists to represent the top of the Upper Cretaceous, being the upper member of the Lawson limestone.

The Cedar Keys formation, as used in this report, covers the interval extending from the top of the *Borelis* fauna, the first occurrence of small foraminifers associated with *Borelis*, or the top of a characteristic lithology to the top of the Cretaceous, which in Levy County is the upper Lawson limestone. Cole's Cedar Keys formation is thus expanded by the inclusion of an indefinite thickness of beds at the top and contracted by the exclusions of the upper Lawson limestone. The Applins (1944, p. 1704) applied the name Cedar Keys limestone to a similar interval, and

with this usage the formation is much more uniform in its occurrence and thickness, than as formerly defined. The Florida Geological Survey has accepted the new definition but retains the original name for this formation.

The bed is characterized by the two species of *Borelis*, *Cribrospira? bushnellensis* Applin and Jordan, *Planispirina? kissengenensis* Applin and Jordan, *Valvulammina nassauensis* Applin and Jordan, and by two ostracods, *Cytherella symmetrica* Alexander and *Cythereis* sp. aff. *C. sculptilis* Alexander which according to the Applins (1944, p. 1704-05) suggest a slight relationship to the Midway beds of the western Gulf Coast.

The formation is widely developed throughout most of peninsular Florida and is considered the marine equivalent of the clastic facies of the southeastern states to which the term Midway group has been applied. It lies below a definite Salt Mountain fauna of lower Eocene, Wilcox age and conformably upon transitional Upper Cretaceous beds. It thus occupies the interval represented elsewhere by the beds of Midway age.

Lithology: The Paleocene of peninsular Florida is white, cream and gray, pasty to fragmental limestones, which have rare lenses of oölitic limestone. The porosity of the rock is impregnated by gypsum, giving it a speckled appearance.

The top of the Cedar Keys formation is commonly dolomitized and unfossiliferous. The chalky appearance of this dolomite, however, contrasts strongly with the crystalline, flaky dolomite of the basal Oldsmar limestone. Placing this dolomite in the Cedar Keys formation is substantiated by rare molds of *Borelis* sp. found in this interval in at least one well, the Abbott-Prudential well. Thin clay lenses and pyrite concentrations occur at the top rarely and almost complete porosity filling by gypsum sometimes marks the top of the formation.

The Cedar Keys formation of Levy County is composed of interbedded tan to gray, finely granular, fragmental, often very fossiliferous limestone and tan to brown, finely crystalline to chalky textured dolomite. Gypsum has completely impregnated the porosity of large sections and occurs irregularly as thin lenses. The limestone is rarely fossiliferous near the top and is dolomitized. The lower portion is more fossiliferous and some beds are essentially composed of specimens of microfaunas held in a pasty limestone matrix. Fossils characterizing the bed elsewhere in peninsular Florida are present and are abundant in these unaltered limestones.

Thickness: The Cedar Keys formation is only slightly thinner in eastern-central than in western Levy County but it can be presumed to thin toward the Peninsular arch in northern and eastern Florida, that part of the State having been structurally high during the Paleocene. The formation is 600 feet thick in the Coastal-Ragland well, in western Levy County, and 540 feet in the Humble-Robinson well, 713 feet in the Sun-Goethe well, 550 feet in the Brukenfeld-Levy-Lennon well, and 445 feet in the Abbott-Prudential Timber well in eastern central Levy County.

The Cedar Keys formation was identified at the depths tabulated under the following wells:

W-166 and W-355: Florida Oil Discovery-Sholtz and Suwannee Petroleum-Sholtz wells — samples combined.

Cedar Keys formation: 1,636? to ? feet

W-1007: Sun-Goethe well

Cedar Keys formation: 1,658 to 2,190 feet

W-1537: Coastal-Ragland well

Cedar Keys formation: 1,680 to 2,280 feet

W-2010: Brukenfeld-Levy-Lennon well

Cedar Keys formation: 1,460 to 2,010 feet

W-2012: Humble-Robinson well

Cedar Keys formation: 1,750 to 2,290 feet

W-2166: Abbott-Prudential well

Cedar Keys formation: 1,335 to 1,935 feet

EOCENE SERIES

Lower Eocene

OLDSMAR LIMESTONE

The Oldsmar limestone was used by the Applins (1944, p. 1699) to, "include the interval that is marked at the top by the presence of abundant specimens of *Helicostegina gyralis* Barker and Grimsdale, and that rests on the Cedar Keys limestone."

The formation was separated into four faunal zones, which in descending order were as follows:

Zone 1: *Helicostegina gyralis*

Zone 2: Salt Mountain faunal unit, characterized in the Peninsula by *Pseudophragmina cedarkeysensis* Cole.

Zone 3: *Coskinolina elongata* Cole

Zone 4: Unnamed, characterized over the northern Peninsula by *Miscellanea nassauensis* Applin and Jordan and

over the central and southern Peninsula by *Lockhartia cushmani* Applin and Jordan.

The Oldsmar limestone as erected by the Applins is predominately a series of faunal zones and is not different lithologically from the overlying and underlying formations. It is composed essentially of fragmental marine limestones, partially to completely dolomitized and containing irregular and rare lenses of chert, impregnations of gypsum and thin shale beds. Fossils are common but sometimes dolomitized and poorly preserved.

The limestone and dolomite of lower Eocene age of peninsular Florida, the Oldsmar limestone, grades westerly and northerly into a clastic facies, greenish-gray clay and variegated, micaceous, glauconitic, sandy, carbonaceous clays containing several highly fossiliferous zones, the faunas having been identified as those of Wilcox age. A few species occurring in the Salt Mountain reef limestone of Wilcox age in Clarke County, Alabama, occur in the limestone of the Peninsula, and the correlation is made more exact.

Thickness: The thickness of the Oldsmar limestone is variable, the top of the formation being identified by the first occurrence of *Helicostegina gyralis*. In a thick section of limestone of fairly uniform lithologic characteristics in which the original texture of the rock and the fauna have been destroyed or altered by partial or complete dolomitization, an irregular thickness is to be expected. This dolomitization, combined with the irregularities of fossil occurrences, introduce additional variations in thickness. The formation, or rather faunal zone, is 380 feet thick in the Coastal-Ragland well, in western Levy County and 500 feet thick in the Humble-Robinson well, 568 feet in the Sun-Goethe well, 550 feet thick in the Brukenfeld-Levy-Lennon well, and 445 feet in the Abbott-Prudential well of central Levy County. No wells penetrated the Oldsmar in Citrus County.

Lithology: The Oldsmar was penetrated by seven oil tests in Levy County, but no wells have been drilled in Citrus County that penetrated sufficiently deep to encounter the formation.

The Oldsmar limestone is marked by the presence of *Helicostegina gyralis* in brown, very porous, friable, granular limestone composed of calcite grains loosely imbedded in limestone paste. This limestone is interbedded with brown, coarsely crystalline, sugary, porous dolomite containing seams of white chert and anhydrite; thick beds of coffee-colored, dense chert; and finely crystalline, tan to brown dolomite. The

base of the formation is commonly brown, granular, porous, soft limestone, a coquina of small foraminifers in a soft limestone paste. The faunal zones recognized by the Applins (1944) are present in the formation but these are not tabulated in the following record of wells that penetrate the Oldsmar limestone in Levy County.

- W-166: Florida Oil Discovery-Sholtz and
- W-355: Suwannee Petroleum-Sholtz wells
Oldsmar limestone: 1,340? to 1,636? feet
- W-1007: Sun-Goethe well
Oldsmar limestone: 945 to 1,658 feet
- W-1537: Coastal-Ragland well
Oldsmar limestone: 1,300 to 1,680 feet
- W-2010: Brukenfeld-Levy-Lennon well
Oldsmar limestone: 910 to 1,460 feet
- W-2012: Humble-Robinson well
Oldsmar limestone: 1,250 to 1,750 feet
- W-2166: Abbott-Prudential well
Oldsmar limestone: 890 to 1,335 feet

Middle Eocene

Claiborne Group

GENERAL NOMENCLATURE

The rocks assigned to the Claiborne group of peninsular Florida differ both in faunal content and lithology from those recognized throughout the Gulf Coast elsewhere. In general, the Claiborne group of northern and peninsular Florida is composed of carbonates and evaporites and that of the western Gulf Coast is composed of clastics, largely sands and clays. An occasional fossil common to both sections support stage-age assignments, but these are insufficient to allow the extension of the Gulf Coast formational nomenclature to the carbonate rocks of Florida. Because of these differences between the geology of the two areas, the Applins (1944) felt justified in erecting three formations in the Claiborne group. Beds of early middle Eocene were named the Lake City limestone and those of late middle Eocene were divided into a lower formation, the Tallahassee limestone, and an upper formation, the Avon Park limestone. The Tallahassee limestone and an equivalent non-fossiliferous limestone is restricted in its occurrence to the vicinity of Tallahassee and counties lying to the east in northern peninsular Florida.

The Applins (1944, p. 1739) assigned 411 feet of dolomite in the Florida Oil Discovery-Sholtz well, Levy County, to the non-fossiliferous

limestone, but the writer believes this interval represents a dolomitized Lake City limestone and includes these beds in that formation. No other beds in Levy County could be definitely assigned to the Tallahassee limestone and equivalent.

REGIONAL CORRELATION

The Claiborne group, a three-fold division in peninsular Florida, is likewise represented in Alabama by three formations, the Gosport sand at the top, the Lisbon formation, and the Tallahatta formation at the base. Further west in Mississippi the Claiborne group is subdivided into the Cockfield formation at the top, the Cook Mountain formation (Wautubbee formation of the Mississippi Geological Survey), Sparta sand (Kosciusko formation of the Mississippi Geological Survey), Zilpha clay, Winona formation and Tallahatta formation at the base. It is generally accepted that the Cook Mountain, Sparta, Zilpha and Winona formations are equivalent to the Lisbon formation of Alabama.

Cooke (1939a) believed the Gosport to be a facies of the Moodys Branch formation and included it in the Jackson group, but the larger number of Gulf Coast stratigraphers disagree with this conclusion. The Gosport sand has been traced by MacNeil (1947) from Alabama into Mississippi where it passes into the Cockfield formation.

In western Florida the Claiborne group is not present at the surface, but a two-fold division of the group can be recognized in the subsurface, the Gosport sand at the top and the Lisbon formation at the base. The Lisbon can be divided in some areas into an upper calcareous part believed by Rainwater and others (1945) to be equivalent to the Cook Mountain formation of Louisiana and the Wautubbee of Mississippi and a lower glauconitic phase, equivalent to the Winona greensand of Mississippi, the Tallahatta formation of Alabama in part and the upper part of the Cane River formation of Louisiana.

The Applins (1944) in their discussion of the Claiborne group did not include a correlation with the Tallahatta formation, nor with the Lisbon formation. The clastic sediments of early middle Eocene age of western Florida were believed by them to be "Beds of Cook Mountain age" and to be equivalent with the Lake City limestone. Clastic beds of late middle Eocene age were not recognized by the Applins (1944) and an unconformity was presumed to separate the Ocala limestone from the "Beds of Cook Mountain age", the Tallahassee limestone and the Avon Park limestone or equivalents being absent.

Cooke (1945) considered the Claiborne group of western Florida to be equivalent to both the Tallahatta and Lisbon formations. Rainwater and others (1947, p. 51) correlated the Lake City limestone with the Lisbon formation and divided the Lisbon into an upper calcareous and a lower glauconitic phase, correlating the lower phase with the Tallahatta formation, at least in part.

From this review of correlation and considering the Claiborne faunas, lithology, and stratigraphy, the Claiborne group of peninsular Florida can be at least tentatively correlated as follows: The Avon Park limestone, having many mollusks in common with those of the Gosport sand of Alabama and occupying the same stratigraphic interval, is possibly the equivalent of the Gosport sand. The Tallahassee limestone and equivalent non-fossiliferous limestone are believed to be equivalent to the lower part of the Cockfield formation by the Applins (MacNeil, 1947). The bed is very limited in its distribution and where present lies on early middle Eocene beds and thus occupies the same stratigraphic horizon as basal Cockfield beds. This correlation thus appears to be logical, but this section was not recognized in Levy and Citrus counties. The Lake City limestone, represented by an upper calcareous and a lower glauconitic phase in western Florida is probably equivalent, at least in part, with both the Lisbon formation and the Tallahatta formation of Alabama and the entire section of Mississippi except for the Cockfield formation.

Early Middle Eocene

LAKE CITY LIMESTONE

Lithology: The Applins (1944) erected the Lake City limestone to differentiate a chalky limestone facies of the early middle Eocene in northern and peninsular Florida from a chalky, glauconitic, sandy, clastic facies in western Florida that contains a fauna related to the Cook Mountain formation of Claiborne age, into which it grades. The type section and fauna are contained in samples from a well at Lake City, Columbia County, filed in the rock cuttings library of the Florida Geological Survey as number W-299.

As used by the Applins the Lake City limestone is predominantly chalky to granular limestone, containing chert and gypsum in some areas. The limestone grades laterally into the clastic facies in a series of wells extending from Wakulla County westward to Walton County.

In practice the Lake City is commonly identified from its fauna, the top being marked by the first appearance of *Dictyoconus americanus*

(Cushman) and as thus used it was a faunal zone. In recent months, however, the writer has found, particularly in Citrus and Levy counties, that the formation was a lithologic unit having diagnostic lithologic characteristics as well as a distinct fauna. In fact, the formation in Levy and Citrus counties is one of the most distinctive of the Eocene beds.

The formation is characterized by several lithologies which probably occur as thin beds in a thick carbonate section. The formation is composed of a matrix of tan to cream, fragmental, often peat-flecked, granular and pasty limestone in which are embedded quantities of foraminifers, crystals of calcite and echinoid plates. The limestone is irregularly dolomitized and dolomitization is present in all stages from incipient dolomite crystals in the matrix to complete dolomite. The change is usually accompanied by decalcification of the fauna to a degree comparable to the amount of dolomitization. Such decalcification is present in stages from unaltered fossils, calcite dust retaining some of the fossil forms to molds surrounded by crystalline dolomite. The complete removal of fossils sometimes results in a dolomite that retains the texture of a former granular limestone, in which the matrix and interiors of the faunas have been filled by dolomite and the calcite shells removed, to form a very porous scab and skeletal spongy texture. Sometimes the limestone is essentially a coquina of specimens of *Dictyoconus*, *Coskinolina*, *Lockhartia* and associated foraminifers, and rarely this coquina may be so impregnated with gypsum that the fossils appear to be embedded in gypsum.

Gypsum has impregnated much of the Lake City limestone and commonly the rock is completely impregnated with anhydrite and gypsum, all porosity being filled, this resulting in rare gypsum casts of the fossils. Thin beds and seams of anhydrite and selenite are also present and these may represent cavity fills, since the impregnation appears in most samples to have occurred after dolomitization.

The general lithology is emphasized by beds which apparently characterize the Lake City limestone. These beds occur throughout the formation but many are concentrated at the top and serve with the diagnostic foraminifers to mark the top of the formation.

These beds include a pseudo-oolite, a brown to coffee-colored chert, a bentonitic (?) clay, and a brownish-gray, laminated, finely crystalline dolomite containing seams of black carbon and flattened decalcified specimens of *Fabularia vaughani*, *Coskinolina* sp., *Archaias columbiensis*, and larger *Valvulinidae* giving it a mottled and laminated (molasses and butter) appearance. Occasionally, the last mentioned rock is

seamed with peat and is not fossiliferous. The finely crystalline dolomite matrix grades vertically in some wells to a granular fragmental matrix containing many small calcareous foraminifers, making a white and brown speckled limestone with a dolomite matrix.

At the top of the formation, and sometimes also in samples below, a cream, yellowish- and brownish-gray, very fissile, waxy, highly absorptive, possible bentonitic clay was encountered in a number of wells that penetrated the Lake City limestone. Silica is commonly associated with the clay and occurs at the top of the formation in great abundance. The silica is dense, mammillary, hard, brown- to tan-colored chalcedony which is transparent on thin edges. The chert is frequently peat-flecked and rarely contains specimens of *Archaias columbiaensis*, *Lockhartia cushmani* and *Dictyoconus* sp. The brown chert is frequently associated with a white chalcedony and milky quartz and rarely all the silica is white and milky. The clay and silica usually occur with the laminated and speckled dolomite described above.

Lower in the formation and rarely near the top the chert occurs with an exceedingly finely crystalline dolomite that is composed of loosely cemented dolomite crystals rounded on the edges to give the external appearance of fine öolites. No öolitic structure was detected, however. The chert occurs commonly as impregnations of porosity in this dolomite.

Stratigraphic Relations: In Citrus and Levy counties the Lake City limestone overlies the Oldsmar limestone, lower Eocene and underlies the Avon Park limestone, upper middle Eocene. The formational contacts are known only from rock cuttings taken from oil and water wells, and the upper contact is penetrated by more wells than the lower. The Lake City may rest unconformably upon the Oldsmar, but this cannot be proved with the limited information available. In general, the peat content increases toward the top of the Oldsmar, indicating progressive near shore facies. Little else can be cited in support of an unconformable contact.

The upper contact of the Avon Park limestone upon the Lake City limestone is undoubtedly non-conformable. The development of peat and lignite beds, clay and sand stringers, and phosphorite and limonite nodules along the contact are evidences of an unconformity. In some well penetrations the rock cuttings show signs of oxidation and weathering of the Lake City limestone at the contact and locally the formation appears to have been thinned. An insufficient number of wells that penetrate through the Lake City limestone, however, prevent an accurate isopach evaluation of the formation.

Fauna: Almost nothing is known of the large fossils of the Lake City limestone. Where present the echinoids and mollusks are fragmented or occur as broken molds. Some rock cuttings contain fragments of an echinoid, which in its internal structure and general shape has characteristics of *Periarchus* sp. No specimen sufficiently well-preserved to allow complete identification was observed in this study.

Cole (1938, 1941, 1942, 1944), Applin and Applin (1944) and Applin and Jordan (1945) have identified many species of foraminifers from the interval assigned to the Lake City limestone. *Dictyoconus americanus* (Cushman) was selected by the Applins as a guide fossil and the bed is also characterized, according to Applin and Jordan, by *Amphistegina lopezstrigoi* D. K. Palmer, *A. nassauensis* Applin and Jordan, *Archaias columbiaensis* Applin and Jordan, *Asterigerina cedarkeysensis* Cole, *Discocyclina* (*Asterocyclina*) *monticellensis* Cole and Ponton, *Discorbis inornatus* Cole, *Epistomaria semimarginata* (d'Orbigny), *Eponides gunteri* Cole, *Fabiana cubensis* (Cushman and Bermudez), *Fabularia gunteri* Applin and Jordan, *F. vauhani* Cole and Ponton, *Gunteria floridana* Cushman and Ponton, *Lepidocyclina* (*Pliolepidina*) *cedarkeysensis* Cole, *Linderina floridensis* Cole, *Lockhartia cushmani* Applin and Jordan and *Operculinoides jennyi* Barker. In general, *Dictyoconus americanus* and *Gunteria floridana* mark the base of the Lake City limestone, abundant *Lockhartia cushmani* and *Fabiana cubensis* the middle, and rare *Archaias columbiaensis* and abundant specimens of *D. americanus* and both species of *Fabularia* the top.

In addition to these a large *Valvulinidae*, flattened, cone-shaped and up to one centimeter in diameter which is tentatively identified as *Dictyoconus?* *gunteri* (Moberg), also makes a satisfactory guide fossil. This fossil occurs along with *Dictyoconus americanus* and may represent an extreme form of the species. In some specimens the sub-chambers number only two to three as compared to five in *D. americanus*, and two species are probably represented. Specimens of a similar form, with two to three sub-chambers occur in at least one zone in the younger Avon Park limestone, Zone "B" of this report.

Thickness: The formation was identified from 17 wells in Levy and two in Citrus County, see Table 8. The thickness recorded by these wells ranges from 575 to 923 feet. This variable thickness may be caused by erosion of the top of the formation, by poor sampling, or by placing the top of the Oldsmar low, the top being picked on the first abundant occurrence of *Helicostegina gyralis* Barker and Grimsdale.

TABLE 8.—Wells that Penetrate the Lake City Limestone.

<i>Well Library No.</i>	<i>Location</i>	<i>Depth, below ground</i>	<i>Ground elevation</i>	<i>Sub-sea elevation of the top of Lake City</i>	<i>Sub-sea elevation of the top of Oldsmar</i>
		<i>feet</i>	<i>feet</i>	<i>feet</i>	<i>feet</i>
W-166..	NW ¼ Sec. 16, T 15 S, R 13 E	4010	+17.8	—399	—1322
W-501..	SW ¼ Sec. 20, T 14 S, R 16 E	373	+17.5	—311	.....
W-511..	NE ¼ Sec. 15, T 14 S, R 17 E	1310	+65.7	—194	— 971
W-871..	SW ¼ Sec. 15, T 13 S, R 16 E	679	+34.1	—196	.....
W-1007.	SW ¼ Sec. 31, T 14 S, R 17 E	3997	+28.8	—256	— 910
W-1449.	SE ¼ Sec. 16, T 13 S, R 16 E	380	+34.1	—196	.....
W-1537.	SW ¼ Sec. 16, T 15 S, R 13 E	5850	+ 5.0	—475	—1295
W-1564.	SW ¼ Sec. 28, T 11 S, R 14 E	1006	+30.1	—253	.....
W-1841.	SW ¼ Sec. 25, T 15 S, R 17 E	600	+81.0	—329	.....
W-1843.	SE ¼ Sec. 24, T 13 S, R 15 E	680	+25.2	—235	.....
W-1844.	SE ¼ Sec. 24, T 12 S, R 14 E	440	+31.47	—259	.....
W-1845.	SW ¼ Sec. 22, T 13 S, R 13 E	361	+10.0	—320	.....
W-1847*	SW ¼ Sec. 1, T 17 S, R 17 E	1198	+29.6	—360	—1000
W-1848*	SW ¼ Sec. 11, T 17 S, R 17 E	1105	+41.65	—389	.....
W-1849.	NW ¼ Sec. 4, T 14 S, R 15 E	670	+20.38	—290	.....
W-1850.	NE ¼ Sec. 34, T 13 S, R 15 E	680	+25.06	—274	.....
W-2010.	NW ¼ Sec. 5, T 14 S, R 16 E	2173	+17.0	—213	— 893
W-2012.	NE ¼ Sec. 19, T 16 S, R 17 E	4309	+46.0	—362	—1192
W-2166.	SE ¼ Sec. 34, T 13 S, R 16 E	1945	+18.0	—297	— 872

* Located in Citrus County.

Structure and Cross Sections: The distinct lithology of the Lake City limestone can be visualized clearly if the individual beds are plotted on sections. The three sections of figure 17 demonstrate the change in lithology and fauna at the contact of the Avon Park limestone with the Lake City limestone. Section A-A' extends along the center of Levy County to the eastern edge of Citrus County, B-B' crosses Levy at the center, and C-C' runs along the northern edge of Citrus County.

No faults are shown in the sections because the wells were so scattered that the small displacements recorded in younger beds are not as obvious in these sections as in those drawn through surface outcrops and core holes along the proposed ship canal (figure 14, section E-E'). However, certain changes in dip, as between wells W-1843 and W-871, figure 17, occur where faults are known to be present in younger beds and are possibly extensions of these. Faults also have been disregarded in contouring the top of the Lake City limestone. The crest of the Ocala uplift is clearly demonstrated in the structure map of figure 17, and the trend and map location of the crest correspond to that drawn on the Inglis member of the Moodys Branch formation, figure 11 and Plate 2.