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DEPARTMENT OF NATURAL RESOURCES
Tom Gardner, *Executive Director*

DIVISION OF RESOURCE MANAGEMENT
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FLORIDA GEOLOGICAL SURVEY
Walter Schmidt, *State Geologist and Chief*

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THE GEOMORPHOLOGY AND GEOLOGY OF LIBERTY COUNTY, FLORIDA

BY

Frank R. Rupert

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The geomorphology and geology of Liberty County, Florida

Frank R. Rupert, P.G. No. 149

GEOMORPHOLOGY

Liberty County is situated in the Northern Zone geomorphic province of White (1970), which includes the northern Florida peninsula and all of the panhandle. In this portion of the east-central Florida panhandle, the Northern Zone is divided into four geomorphic subzones based primarily on topographic elevations. These include the Gulf Coastal Lowlands, Beacon Slope, the Tallahassee Hills, and the River Valley Lowlands (Figure 1).

The Gulf Coastal Lowlands comprise much of southern Liberty County. This subzone is characterized by a generally flat and often swampy, seaward-sloping, sandy plain. Most of the lowlands area is ancient marine terrace, shaped by high-standing Pleistocene seas. Today, much of southern Liberty County is covered by shallow, densly-wooded swamp-like areas called "bays", and poorly-defined creeks. Elevations in the Gulf Coastal Lowlands of Liberty County range from between 20 and 25 feet above mean sea level (MSL) at the southern end of the county to approximately 100 feet above MSL where the lowlands meet the higher slopes in northern Liberty County.

An elevationally-transistional gemorphic zone

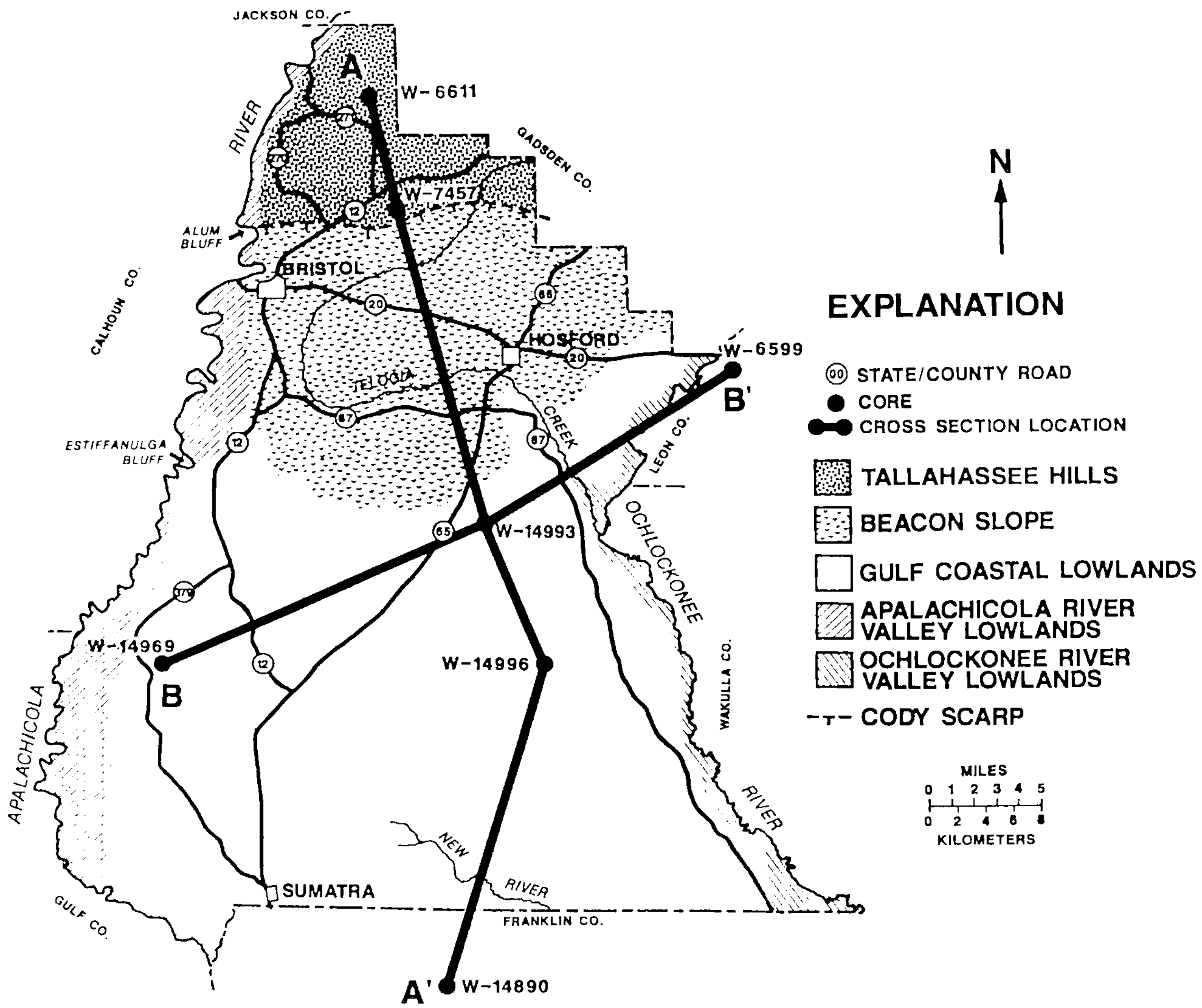

Figure 1: Geomorphic and cross section location map of Liberty County.

named the Beacon Slope (White et al., 1964) separates the Gulf Coastal Lowlands from the siliciclastic hills of northern Liberty County. The Beacon Slope is a uniformly-sloping, ramp-like feature linking the topographically higher Tallahassee Hills on the north with the Gulf Coastal Lowlands. Near-surface sediments are largely siliclastics overlying karstic limestone. Swampy depressions and cover-subsidence sinks are common throughout this terrain. In Liberty County, elevations range from about 100 feet MSL at the southern edge of the slope to approximately 200 feet MSL at the northern edge, where it adjoins the Cody Scarp. The origin of the Beacon Slope is uncertain, but it is most likely an erosional feature associated with the higher sea level stands of the Pleistocene.

A relict southward facing marine escapment named the Cody Scarp (Puri and Vernon, 1964) forms the boundary between the Beacon Slope and the topographically higher Tallahssee Hills in northernmost Liberty County. This feature spans much of northern Florida, and is one of the most persistant topographic breaks in the state. The Cody Scarp has been erosionally obscured in most of northern Liberty County. In the northeastern part of the county, the scarp rises from a toe elevation of approximately 205 feet MSL to a crest of about 220 feet MSL, marking the southern extent of the Tallahassee Hills geomorphic zone.

The Tallahassee Hills (Cooke, 1939) are a series of topographic highlands spanning the northern edge of the eastern Florida panhandle. They are part of the Northern Highlands geomorphic province, which is thought to be a stream-dissected remnant of a once continous highland plain spanning southern Georgia and northern Florida. The Tallahassee Hills are capped by deltaic to shallow marine, clayey sands, silts and clays. Elevations of the hills within Liberty County vary from approximately 220 feet MSL at the crest of the Cody Scarp to nearly 250 feet MSL at the northern county boundary. The modern hilly topography is the result of post-depositional dissection and erosion by running water. Steep bluffs occur in northwestern Liberty County, where the Tallahassee Hills end abruptly at the floodplain of the Apalachicola River. The bluffs commonly stand 150 feet or more above the floor of the floodplain, exposing Miocene to Holocene age strata. Alum Bluff, located about 2.5 miles northwest of Bristol on the Apalachicola River, is one of the best geologic exposures in Florida (Schmidt, 1983; Johnson, 1989).

The river bluffs are commonly dissected by a series of deep, east-west trending ravines containing small creeks which drain into the Apalachicola River. Many of these ravines extend several miles east of the river, ending at so-called "steepheads" (Sellards and Gunter, 1918). Steepheads form from lateral undercutting of the sandy surficial sediments by water seeping out of the surficial aquifer system. Ground water percolates downward through the surficial sediments until it encounters a clay or marl. It then travels horizontally over the less permeable strata and emerges as a small spring or seep at a bluff face. Gradually, the flowing water undermines the overburden material, which slumps off forming a semicircular, steep-walled head. As undermining and slumping continue through time, the steephead migrates laterally away from the original bluff face, cutting a ravine as it progresses. Other steepheads may branch off from the original ravine, forming a dendritic series of smaller ravines feeding the parent ravine.

The Apalachicola and Ochlockonee Rivers are the major streams flowing in Liberty County. The Apalachicola River forms the western county boundary with adjacent Calhoun County. In northwestern Liberty County, the broad valley of the Apachicola averages 50 feet MSL in elevation. The river meanders southwestward through a three-mile wide valley, which gradually descends to an elevation of about 25 feet MSL at the southern edge of Liberty County. Here, the valley coalesces into the swampy terrain of the Gulf Coastal Lowlands. The valley comprises a geomorphic subzone named the Apalachicola River Valley Lowlands.

The Ochlockonee River forms the eastern Liberty County boundary with Leon and Wakulla Counties. Originating in Georgia, the river is dammed as a hydroelectric power source just above Highway 20 in Leon County, forming Lake Talquin. South of the dam, the Ochlockonee meanders over a broad, swampy valley averaging about one mile wide. This valley comprises the Ochlockonee River Valley Lowlands geomorphic zone. In northeastern Liberty County, the river valley is approximately 40 feet above MSL. Numerous small creeks contribute to the river along its course, and oxbow lakes are common along the northern stretch of the river. In southeastern Liberty County, the valley broadens considerablly, merging with the low swampy "bays" of the Apalachicola National Forest. Elevations here average about 10 feet above MSL. The Ochlockonee empties into Apalachee Bay, southeast of Liberty County.

A number of small creeks drain the flat, swampy terrain of central Liberty County, and empty into the Apalchicola and Ochlockonee Rivers. Telogia Creek is the largest of these; it enters northeastern Liberty County from adjacent Gadsden County, arcs through the north central portion of the county, and joins the Ochlockonee River southeast of Hosford.

GEOLOGY

Liberty County is underlain by hundreds of feet of marine limestones, dolomites, sands, and clays. The oldest rocks recovered from deep oil test well drilling in this county were Paleozoic Erathem (570 to 250 million years ago) igneous rocks at depths of approximately 12,000 feet below land surface (bls) (Applegate et al., 1978)). The youngest sediments present in the county are Pleistocene and Holocene (1.8 million years old to recent) alluvium and marine terrace sands and clays.

The Mesozoic Erathem (250 to 65 million years ago) and early Cenozoic Erathem (Paleocene and Eocene Series, 65 to 38 million years ago) rocks underlying Liberty County are largely marine carbonates and interbedded siliciclastics lying at depths penetrated only by deep oil test wells. Most water wells in Liberty County draw from Oligocene and Miocene (38 to 5 million years old) strata at depths of 500 feet or less bls. One deep municipal well taps Eocene (40 to 38 million years ago) limestone. These rocks function as important freshwater aquifers for the region. For the purposes of this report, the discussion of the stratigraphy of Liberty County will be limited to these Eocene and younger sediments. Figure 1 shows the geologic cross section locations, and Figures 2 and 3 illustrate the shallow stratigraphy of Liberty County. Most of the geologic data cited in this study is taken from Schmidt (1984), Puri and Vernon,(1964), and from Florida Geological Survey well log files.

Eocene Series
Ocala Group

The Ocala Group (Puri, 1957) comprises a series of Upper Eocene (41 to 38 million years old) marine limestone units which underlie most of Florida. In Liberty County, sediments of the Ocala Group are typically white to very pale orange, slightly dolomitic, highly microfossiliferous calcarenitic limestone. It is highly porous, and an important component of the Floridan aquifer system. The Ocala Group was penetrated at a depth of 660 feet bls in one municipal water well in the city of Bristol. Because this unit lies in excess of 600 feet bls countywide, it is not used extensively as a water source in Liberty County. The Ocala Group is overlain by the Oligocene Marianna and Suwannee Limestones.

Oligocene Series
Marianna Limestone

The Marianna Limestone (Matson and Clapp, 1909) consists of gray to very light orange, chalky, fossiliferous marine limestone frequently containing large, coin-shaped *Lepidocyclina* foraminifera fossils. The Marianna Limestone is Lower Oligocene in age (38 to 33 million years old). This unit was penetrated by only one core (W-6901) in northwestern Liberty County, and the extent of its occurrence under the county is uncertain due to a general lack of well coverage. It probably underlies western Liberty County at depths in excess of 400 feet bls, but pinches out to the east. The Marianna Limestone is overlain by sediments of the Upper Oligocene Suwannee Limestone.

Suwannee Limestone

The Suwannee Limestone (Cooke and Mansfield, 1936) is an Upper Oligocene (33 to 25 million years old) light gray to yellowish-gray, well indurated, often dolomitized marine limestone. It typically contains abundant fossils including foraminifera, mollusks and echinoids. Depth to the Suwannee Limestone ranges between about 350 and 450 feet bls. Thickness of the unit is variable, and usually exceeds 100 feet. It generally dips and thickens to the southwest into the trough of the Apalachicola Embayment. The Suwannee Limestone is a component of the Floridan aquifer system. It unconformibly overlies the Oligocene Marianna Limestone, where present, or Eocene Ocala Group carbonates. The Suwannee Limestone is overlain by Miocene sediments of the Chattahoochee, St. Marks, or Chipola Formations, or by Bruce Creek Limestone.

Miocene and Pliocene Series
Chattahoochee and St. Marks Formations

The Lower Miocene (25 to 20 million years old) Chattahoochee and St. Marks Formations (Dall and Stanley-Brown, 1894; Finch, 1823) overlie the Suwannee Limestone in Liberty County. The

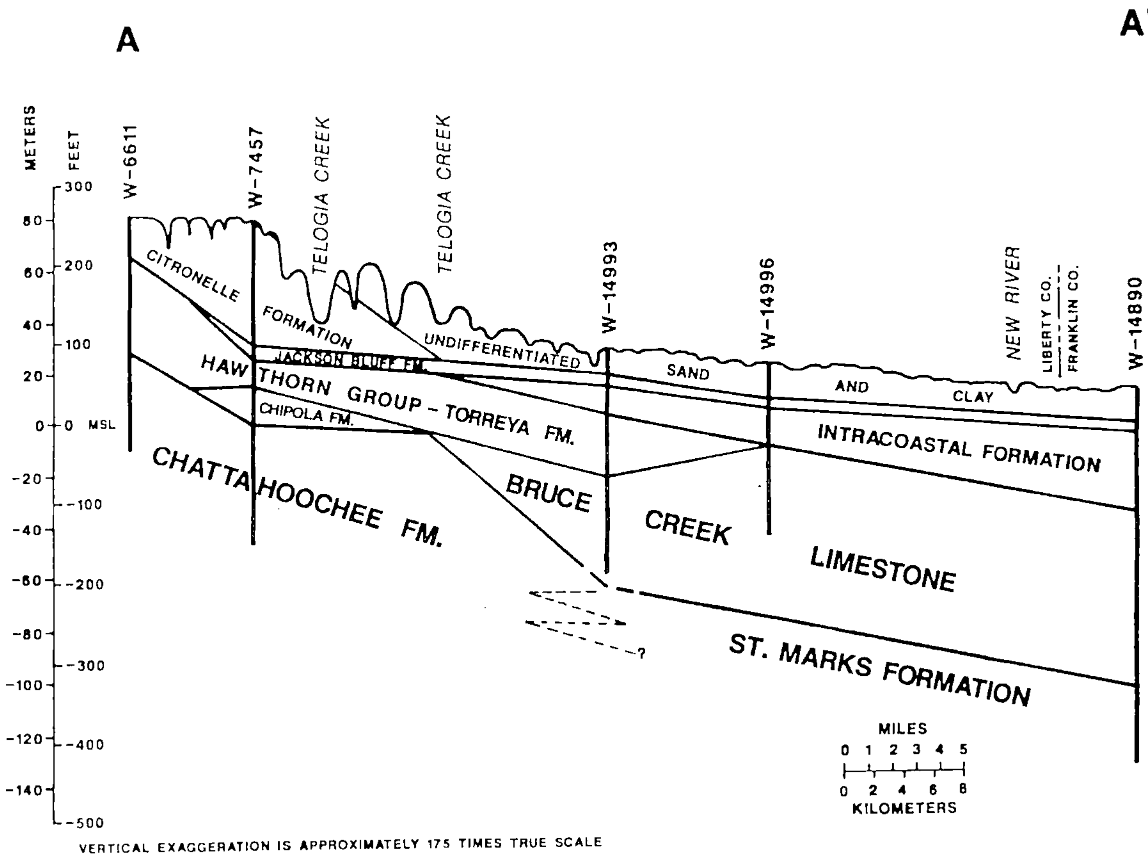

Figure 2: Geologic cross section A-A'.

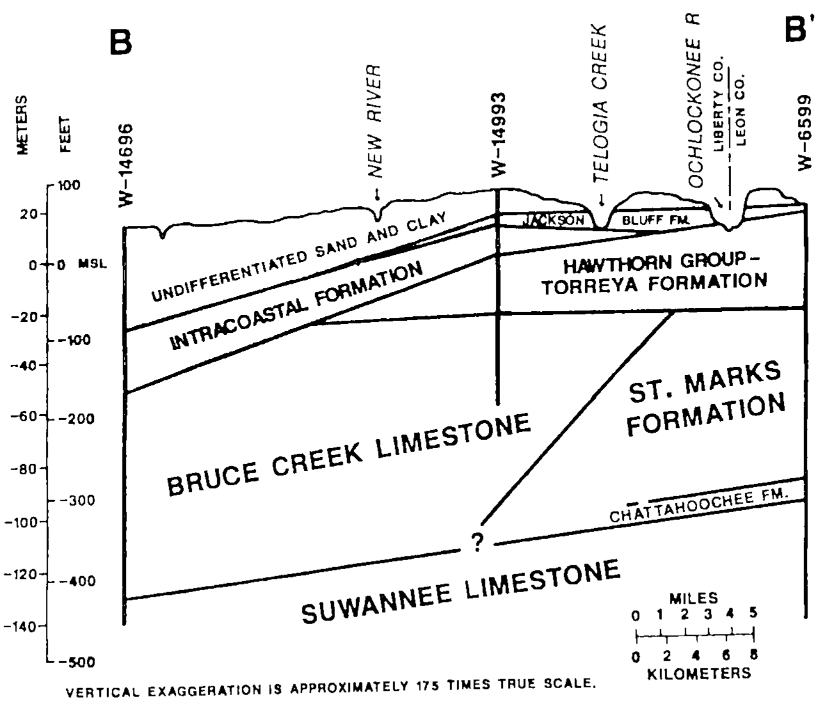

Figure 3: Geologic cross section B-B'.

Chattahoochee Formation is generally a very pale orange to white or light gray, often quartz sandy, phosphoritic, dolomitic marine limestone. It occurs under northern and western Liberty County. The age-equivalent St. Marks Formation is a white to cream, fossiliferous calcilutite limestone underlying the southern and eastern portions of the county. The two units interfinger in north-central Liberty County (Schmidt, 1984).

In some cases, post-depositional ground-water alteration of the carbonates in portions of the central and western panhandle has made differentiation of the Chattahoochee and St. Marks Formations from the underlying Suwannee Limestone and overlying Bruce Creek Limestone difficult or impossible. Where defineable in Liberty County however, the top of the Chattahoochee/St. Marks Formations varies from about 75 feet to 200 feet bls. Thickness averages about 200 feet. As with the underlying Suwannee Limestone, the Chattahoochee and St. Marks Formations dip to the west-southwest, grading into or interfingering with the Bruce Creek Limestone along the southern edge of Liberty County. The Chattahoochee and St. Marks Formations are units of the Floridan aquifer system, and many rural Liberty County wells draw from these formations. Along the southern edge of the county, the Bruce Creek Limestone overlies or grades into the Chattahoochee and St. Marks Formations. In northernmost Liberty County, the Bruce Creek Limestone is absent, and the Chattahoochee Formation is overlain by sediments of the Miocene Chipola Formation or Torreya Formation.

Chipola Formation

The Chipola Formation (Burns, 1889) is a Lower Miocene carbonate unit underlying portions of northernmost Liberty County. It is typically comprised of a yellowish-gray to light gray, moderately-to-well indurated, quartz sandy, marine limestone. It is exposed as the basal unit at Alum Bluff, north of Bristol on the Apalachicola River. Here it commonly contains abundant fossil mollusks. The Chipola Formation varies between about 60 and 200 feet bls in Liberty County, and reaches a maximum of about 50 feet thick. It is overlain by sediments of the Middle Miocene Torreya Formation or the Upper Pliocene Jackson Bluff Formation.

Hawthorn Group
Torreya Formation

The Lower Miocene Torreya Formation (Banks and Hunter, 1973; Huddlestun and Hunter, 1982; Scott, 1988) of the Hawthorn Group underlies northern Liberty County, extending from Leon County westward to Rock Bluff on the Apalachicola River. In Liberty County, the Torreya Formation is typically a siliclastic unit consisting of light gray to pale orange quartz sands and clays, commonly containing variable amounts of phosphorite. The lower portion of the unit is commonly comprised of a light olive gray, sandy, phosphoritic, and locally dolomitic limestone. Depth to the top of this formation in Liberty County varies considerably, ranging from about 10 feet to 100 feet bls. The thickness of the unit is also highly variable, reaching 100 to 200 feet thick in the northeastern portion of the county. The Torreya Formation is unconformibly overlain by sediments of the Intracoastal or Jackson Bluff Formations.

Bruce Creek Limestone

The Middle Miocene (17 to 10 million years old) Bruce Creek Limestone (Huddlestun, 1984) is a white to yellowish-gray, fossiliferous, calcarenitic, marine limestone underlying most of central and southern Liberty County. It is often highly microfossiliferous, molluskan moldic, and in some areas, dolomitic. From north-central Liberty County, this unit thickens and dips rapidly towards the south, into the trough of the Apalachicola Embayment. The Bruce Creek Limestone varies in depth from approximately 125 feet bls at its northern limit in central Liberty County to over 200 feet bls in the southern portion of the county. Its thickness increases rapidly from zero in the central part of the county southward to about 200 feet near the Liberty-Franklin county line. The Bruce Creek Limestone is the uppermost unit of the Floridan aquifer system in Liberty County. It is overlain by sediments of the Intracoastal, Chipola, or Torreya Formations.

Intracoastal Formation

The Intracoastal Formation (Huddlestun, 1984; Schmidt and Clark, 1980) is comprised of a yellowish-gray, abundantly microfossiliferous, sandy, poorly-indurated, marine limestone. It spans an age range of Middle Miocene to Late Pliocene (17 to 2 million years old), with the Late Miocene and Early Pliocene portions absent due to a hiatus. Like the underlying Bruce Creek Limestone, the updip limit of the Intracoastal Formation occurs along a west-to-east line under northern Liberty County. The formation is generally absent north of the town of Hosford. It thickens and dips to the south-southwest, approaching 100 feet in thickness in the southeastern corner of the county. Depth to the top of the unit in Liberty County is highly variable, generally ranging between 50 and 150 feet bls. The Intracoastal Formation is locally overlain by sediments of the Chipola, Torreya, or Jackson Bluff Formations.

Pliocene Series
Jackson Bluff Formation

The Upper Pliocene (3 to 1.8 million years old) Jackson Bluff Formation (Puri and Vernon, 1964) is predominantly comprised of light gray to olive gray, poorly-consolidated, clayey quartz sands and sandy shell beds. It overlies the Chipola, Torreya, and Intracoastal Formations in Liberty County. The Jackson Bluff Formation is a thin unit, attaining a maximum thickness of about 30 feet thick in western Liberty County. Depth to the top of the Jackson Bluff is variable throughout the county, ranging from 20 to 100 feet bls. It crops out locally at Alum Bluff along the Apalachicola River. In northern Liberty County, it is overlain by the Citronelle Formation and undifferentiated sediments. In the southern part of the county, it is covered by undifferentiated sands and clays.

Citronelle Formation

The reddish, clayey, coarse quartz sands and gravels of the Upper Pliocene Citronelle Formation (Matson, 1916) blanket the Tallahassee Hills in northernmost Liberty County. Believed to be of fluvial origin, the characteristic Citronelle Formation sediments are comprised of cross-bedded sands, gravels, and clays. Portions of the Liberty County surficial deposits may represent reworked and redeposited Citronelle sediments, transported from the eroding highlands to the north. Thickness generally varies between 20 and 80 feet, and the Citronelle deposits comprise the surficial sediments in their area of occurence. Within Liberty County, the Citronelle Formation sediments grade laterally southward into a series of undifferentiated quartz sands and clayey sands.

Plio-Pleistocene and Holocene Series
Undifferentiated Sand and Clays

Much of central and southern Liberty County is covered by surficial quartz sands, clays, clayey sands, and gravels. Due to the massive and discontinuous nature of many of these units, they are lumped together as undifferentiated deposits. These deposits represent a mixture of marine and fluvial siliciclastics associated with Pleistocene (1.8 million to 10,000 years old) sea level highstands and the prograding Apalachicola delta. The modern soil profiles probably evolved during the Late Pleistocene and Holocene (10,000 years ago to present). Holocene alluvium, in the form of river-borne clays and quartz sand and gravel, is deposited along the banks and bars of the Apalachicola and Ochlockonee Rivers, which border Liberty County.

GROUND WATER

Ground water is water that fills the pore spaces in subsurface rocks and sediments. This water is derived principally from precipitation within Liberty and adjacent counties. The bulk of Liberty County's consumptive water is withdrawn from ground water aquifers. Three main aquifers are present under Liberty County. In order of increasing depth, these are the surficial aquifer system, the intermediate aquifer and confining system, and the Floridan aquifer system. Data on aquifer extent and thicknesses are taken from Scott et al., 1991 (in preparation).

Surficial aquifer system

The surficial aquifer system is the uppermost freshwater aquifer in Liberty County. This non-artesian aquifer is largely contained within the undifferentiated sands and the Citronelle Formation sediments. It is present under most of Liberty County, reaching a maximum measured thickness of about 118 feet in the north-central part of the county. In central and southern Liberty County it is highly variable in thickness, ranging from about 20 to 70 feet thick. The surficial aquifer system is unconfined, and its upper surface is the water table. In general, the water-table elevation fluctuates with precipitation rate and conforms to the topography of the land surface. Recharge to the aquifer is largely through rainfall percolating through the loose surficial sediments, and to a lesser extent, by upward seepage from the underlying intermediate aquifer system. The surficial aquifer system is not used extensively as a water source in the county.

Intermediate aquifer system or confining unit

The intermediate aquifer system underlies the surficial aquifer system in Liberty County, and is largely contained within the Torreya, Intracoastal, Chipola and Jackson Bluff Formations. Permeable beds within the intermediate aquifer system vary considerably in thickness over the areal extent of the aquifer. In general, the aquifer ranges from 100 to 200 feet in thickness under Liberty County, corresponding to the variable thicknesses of the geologic formations containing it. The top of the intermediate is also highly variable, ranging from surface outcrop along rivers and creeks in northeastern and northwestern Liberty County, to 20 feet or less bls at the southern edge of the county, to as much as 100 feet bls under the Tallahassee Hills in the northernmost tip of the county. Some rural wells draw from this unit, but the intermediate aquifer system is not widely used as a potable water source in this area. Low-permeability beds in the basal intermediate aquifer system may locally function as confining units to the underlying Floridan aquifer system.

Floridan aquifer system

The Floridan aquifer system is comprised of hundreds of feet of Eocene through Miocene age marine limestones, including the Ocala Group, the Marianna and Suwannee Limestones, and where present, the Chattahoochee Formation, St. Marks Formation and Bruce Creek Limestone. Depth to the top of the Floridan aquifer system varies from about 50 feet bls at the southern edge of the county to nearly 200 feet in the west-central portion. It is the principle source of drinking water in Liberty County. The Floridan aquifer system occurs as an artesian aquifer under the entire county. Surface springs issuing from this aquifer are absent in Liberty County. Most of the regional recharge occurs further to the north in Jackson County where the strata comprising the Floridan aquifer system crop out at the surface.

MINERAL RESOURCES

The principal mineral resources occurring in Liberty County are sand and gravel, clay, limestone, peat, phosphate, heavy minerals, and petroleum. The following discussion summarizes the current mining potential of each commodity in the county.

Sand and gravel

Pleistocene marine terrace sands and alluvium and Pliocene Citronelle Formation sediments are comprised of quartz sand with varying amounts of clay matrix. These deposits blanket much of the county. A number of shallow private pits in Liberty County are worked for locally-used fill sand. In addition, the U.S. Forest Service routinely digs clayey sand for use in stabilizing forest roads in southern Liberty County (Patterson et al., 1986). None of this sand is utilized commercially.

Patterson et al. (1986) report a quartz sand and gravel stratum lying at a depth of about 15 feet below the Apalachicola National Forest in southern Liberty County. Although this deposit is of commercial quality, its remote location and the thinness of the deposit (about 13 feet thick) preclude commercial mining. In addition, sand and gravel products are produced more economically in other parts of the Florida panhandle, thus lessening the potential for large-scale mining in Liberty County.

Clay

Localized deposits of clay and sandy clay are also associated with the undifferentiated Pleistocene and Holocene marine terrace deposits, Holocene alluvium, and Citronelle Formation sediments. Most of these clays are contained in and interbedded with other sediments, and as a result are relatively impure. Miocene age palygorskite (attapulgite) fuller's earth clays are mined to the north in Gadsden County, but no commercial-grade deposits are known in Liberty County.

Flood-plain clay deposits along the Apalachicola and Ochlockonee Rivers have been utilized for brick-making in nearby Calhoun and Gadsden Counties (Bell, 1924). Bell (1924) tested clays collected at Estiffanulga Bluff, on the Apalachicola River in Liberty County, for firing and working properties. He concluded that the clay was suitable for common brick, hollow block ware, drain tile, and earthenware. Commercial exploitation never occurred.

Patterson et al. (1986) noted the presence of a sandy, shelly, plastic clay in a test boring in southern Liberty County in the Apalachicola National Forest. The sand and shell impurities, as well as the remote location of the deposit preclude economic mining.

Reserve estimates of the clay deposits in Liberty County have not been made. Future exploitation will be largely dependent upon local market demand.

Limestone

Impure Miocene limestones occur at depth under most of Liberty County. Most of the shallower units contain extensive impurities, including quartz sand. Due to the presence of these impurities, the overburden thickness (at least 50 feet), and the presence of easily-accessible limestone deposits at the surface in nearby Jackson County, it is unlikely that limestone will ever be an economical commodity in Liberty County.

Peat

Peat deposits form in a wet, reducing environment when accumulation of organic materials (vegetation) exceeds the decomposition rate of that material (Bond et al., 1986). While such conditions are common in the swampy bays covering much of the Apalachicola National Forest in southern Liberty County, only thin layers of non-commercial peaty material (organic deposits containing more than 25% ash) are present (Patterson et al., 1986).

Phosphate

Many of the Miocene and Pliocene formations underlying Liberty County contain variable percentages of phosphate sand and granules. Patterson et al. (1986) reported the phosphate content of sediments from test borings in southern Liberty County and adjacent counties to be well below the minimum commercial percentage. In addition, most phosphate-bearing strata occur at depths in excess of 50 feet. These factors preclude a high mining potential for phosphate in Calhoun County.

Heavy minerals

Heavy minerals such as rutile, ilmenite, zircon, staurolite, and others are minor components of the surficial and near-surface sediments in Liberty County. Although a county-wide study has not been conducted, Patterson et al. (1986) determined the heavy- mineral concentrations in test borings in southern Liberty County were significantly below the commercial minimum percentage. In addition, the wide range of mineral species present rather than specific concentration of the more valuable mineral types further reduces the economic potential of the deposits. Therefore, future mining potential is low.

Petroleum

Petroleum is produced from the Jurassic-age Smackover Formation and Norphlet Sandstone west of Liberty County in the Jay trend of Santa Rosa County. These formations are also present under Liberty County, but four oil wells drilled in the county to test these strata were dry holes (Applegate et al., 1978; Patterson et al., 1986). While the prospects for commercial petroleum production in Liberty County appear slim at present, only continued exploration of the Jurassic and older units will ultimately rule out the potential for the discovery of oil and gas under the county.

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