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Open File Report - 51

Geomorphology, Geology, and Hydrogeology of the Savannas State Reserve, Martin and St. Lucie Counties, Florida

by

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Tallahassee, Florida
1992

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INTRODUCTION

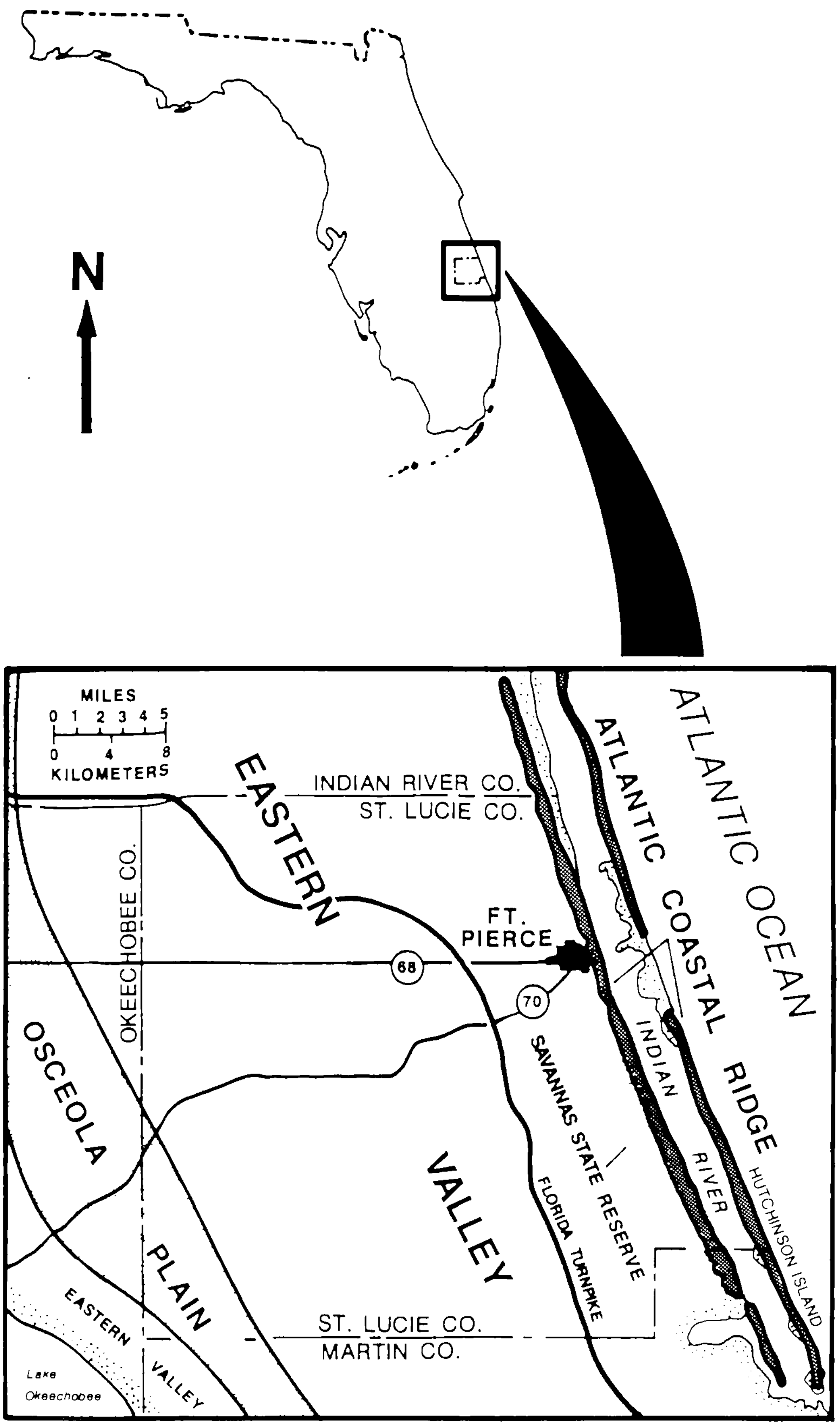
Many of Florida's natural ecosystems are rapidly disappearing as the state's burgeoning population expands. To protect these unique natural features for the enjoyment of future generations, the Florida Legislature mandated the purchase of lands, both submerged and dry, exhibiting exceptional biological and aesthetic value. As a result of the mandates, a number of areas best representing natural Florida ecosystems were acquired by the State for permanent protection. These lands are divided into two broad categories: aquatic preserves, which consist of submerged lands and the overlying waters, and the generally dry land State Reserves, which may contain associated wetlands. The Savannas State Reserve is one of a series of reserves and preserves statewide which will be maintained in their natural or existing conditions. The Florida Department of Natural Resources (FDNR) is charged with ensuring the quality and preservation of these exceptional areas. This is accomplished through the implementation of standardized management plans, law enforcement, and public education programs.

Geological processes have played the dominant role in the evolution of natural Florida. Many of the unique ecosystems now protected in preserves and reserves exist as a result of the particular bedrock geology, the hydrogeology, the local geomorphology, or some unique combination of these factors. Therefore, an understanding of the geology is integral to formulating effective land and resource management policy for these natural areas. To this end, the Florida Geological Survey prepares, upon request, reports on the local geology for the aquatic preserves and State reserve areas. The following text was prepared at the request of the FDNR Office of Land Use Planning and Biological Services.

GEOMORPHOLOGY

The Savannas State Reserve is situated on the eastern edge of the Eastern Valley geomorphic province of the Atlantic Coastal Lowlands of White (1970). This province extends eastward from the topographically higher Osceola Plain province of the central Florida peninsula to the Atlantic Ocean, and spans the eastern peninsula from Jacksonville southward to southern Palm Beach County. The Eastern Valley is characteristically flat and elevationally low, with land surface elevations varying between 0 and 35 feet above mean sea level (MSL). Surficial sediments are predominantly marine terrace sands and shelly sands, deposited during the Pleistocene age Pamlico sea level highstand. Relict beach ridges, paralleling the modern east coast, are common features throughout the Eastern Valley.

Bordering the eastern edge of the Eastern Valley province, between the Savannas and the Indian River, is a narrow coast-parallel sand ridge named the Atlantic Coastal Ridge (White, 1970). This ridge system extends intermittently along Florida's east coast from Jacksonville Beach to just south of Miami. Elevations along that portion of the ridge near the Savannas Reserve average about 30 to 35 feet above MSL, and isolated sand hills on the ridge may attain elevations of 50 feet above MSL. These higher elevations appear to represent now quiescent aeolian dunes built up on the ridge core, and vegetated with bunchgrass, low shrubs, pine, and palmetto (Bearden, 1972).



GEOMORPHIC MAP OF THE REGION ADJACENT
TO THE SAVANNAS STATE RESERVE

Near the reserve, the ridge varies between about 1/8 and 1/4 mile wide. A separate, similar ridge, considered by White (1970) to be part of the Atlantic Coastal Ridge system, extends along Hutchinson Island east of the mainland.

The Atlantic Coastal Ridge has a foundation composed of calcareous sandstone and sandy coquina of the Pleistocene Anastasia Formation (Bearden, 1972). The mainland portion of the ridge, and topographically lower Hutchinson Island, a barrier island lying across the Indian River to the east, are believed to be developed on former offshore bars of the Pamlico (Pleistocene) sea (Cooke, 1939).

Savannas State Reserve occupies most of a north-south trending, 13 mile long by 3/4 mile wide marshy swale, situated along the western side of the Atlantic Coastal Ridge. The savanna terrain extends from approximately St.Lucie Inlet northward to Ft. Pierce. Land elevation within the swale is approximately 14 feet above MSL. Historically, the Savannas have been a freshwater marsh. At one time, the portion of the Savannas north of the present Reserve was partitioned with a levee and served as a main water supply reservoir for the city of Ft. Pierce (Parker et al., 1955; Bearden, 1972).

Cooke (1939) and MacNeil (1950) believe that the topographically low, trough-like area occupied by the Savannas is a portion of a relict Pleistocene waterway, analogous to the modern Indian River. The Atlantic Coastal Ridge may have functioned as a barrier island during higher sea level in the late Pleistocene, with a shallow, coast parallel lagoon behind it to the west. Sand and silt infilling of this Pleistocene lagoon, in conjunction with a late Pleistocene sea level drop, produced the modern Savanna topography.

GEOLOGY

Savannas State Reserve is underlain by over 12,000 feet of Mesozoic and Cenozoic sedimentary rocks, resting on Mesozoic volcanic basement rock. Most of the younger overlying rocks are Cretaceous and Cenozoic age marine carbonates and siliciclastics, which dip and thicken to the southeast. The Cenozoic rocks which comprise the upper 3,000 feet of the sediment column are Paleocene, Eocene and Oligocene carbonates, which function as primary freshwater aquifers. These are overlain by Miocene to Recent age siliclastics. Most water wells penetrate Eocene and younger sediments. For the purposes of this summary, the discussion of the geology underlying Savannas Reserve will be limited to the Eocene and younger strata.

Eocene Series
Avon Park Formation

The Avon Park Formation (Applin and Applin, 1944; Miller, 1986) is a cream to tan colored, highly recrystallized biogenic marine limestone or dolostone. It generally lies at depths in excess of 800 feet below land surface (bls) under St. Lucie and Martin Counties, and attains a thickness of over 1,000 feet (Chen, 1965; Wedderburn and Knapp, 1983; FGS well data). The Avon Park Formation is unconformably overlain by the Upper Eocene Ocala Limestone.

Ocala Limestone

The Ocala Limestone (Dall and Harris, 1892) is an Upper Eocene, white to pinkish-white colored marine calcarenitic limestone. Two units within the Ocala are often recognizable: an upper, more coquinoid unit comprised of large foraminifera, such as *Nummulites* and *Lepidocyclina*, and other skeletal fragments in a calcilutite matrix, and a lower, medium to coarse-grained biocalcarenitic limestone unit. In St. Lucie County, the Ocala Limestone generally occurs at depths of 500 feet or more bls, and is between 50 and 150 feet thick (Chen, 1965; Mooney, 1979; Wedderburn and Knapp, 1983; Armstrong, 1980).

Statewide, the Ocala Limestone is an important unit of the Florida aquifer system.

It is unconformibly overlain locally by either an Oligocene age unnamed carbonate unit, where present, or Miocene Hawthorn Group sediments.

Oligocene Series
Unnamed carbonate unit

An unnamed, white, microfossiliferous, calcilutite unit, dated by microfossils as Late Oligocene unconformably overlies the Ocala Limestone in eastern St. Lucie and Martin Counties (Mooney, 1979; Armstrong, 1980). Some workers (Lichtler, 1960; Stodghill and Stewart, 1984) have assigned this unit to the Suwannee Limestone, while others such as Wedderburn and Knapp (1983) consider it equivalent to the Hawthorn Group; its stratigraphic affinity is uncertain. The top of the unnamed calcilutite ranges between about 392 and 602 feet bls, with a highly variable thickness between 0 and 168 feet under St. Lucie County (Mooney, 1979). Most workers have included this unit in the Floridan aquifer system. The unnamed calcilutite is unconformibly overlain by the Miocene Hawthorn Group.

Miocene Series
Hawthorn Group

The Miocene Epoch marked the beginning of a significant change in the depositional regime of the Floridan Platform. Sediments deposited prior to Miocene time were largely pure carbonates. In the early Miocene, siliciclastic sediments from the continental mainland to the north were carried onto the platform and reworked and deposited by marine and fluvial processes. The rocks deposited since the beginning of the Miocene therefore contain a significant siliciclastic component. This is typified by the sediments of the Hawthorn Group.

The Hawthorn Group (Scott, 1988) in St. Lucie County is comprised of two units: a lower carbonate unit, largely quartz sandy, phosphatic, limestone and dolostone with interbedded clays, named the Arcadia Formation by Scott (1988); and an upper unit composed of gray to olive gray to white interbedded clayey, phosphatic, and calcareous quartz sands, clays, and limestones and dolostones, named the Peace River Formation by Scott (1988). In St. Lucie County and northeastern Martin County, the top of the Hawthorn Group varies, on average, between 100 and 200 feet bls, and the unit ranges from 300 to 600 feet thick, dipping and thickening to the southeast (Mooney, 1979; Wedderburn and Knapp, 1983; Scott, 1988). It is unconformibly overlain by the Pliocene Tamiami Formation.

Pliocene Series
Tamiami Formation

The Upper Pliocene Tamiami Formation (Mansfield, 1939) in the vicinity of Savannas Reserve consists of a white to greenish-gray quartz-sandy, very fine grained biogenic limestone, commonly containing phosphate sand and fossil shells. It occurs at a depth of approximately 100 feet bls, and is about 30 feet thick (Wedderburn and Knapp, 1983). The Tamiami formation is overlain by the Pleistocene Anastasia formation.

Pleistocene Series

The Pleistocene sediments underlying eastern St. Lucie and Martin Counties range from clean quartz sands to shellbeds to sandy limestones and calcareous sandstones. Some of the units may be locally discontinuous, and are often difficult to differentiate lithologically, particularly in well cuttings.

Caloosahatchee Formation

The Caloosahatchee Formation (Dall and Harris, 1892) is principally composed of shelly sands and occasional fossiliferous, slightly phosphatic, light gray to yellowish-gray limestones. Due to the difficulty in locally differentiating Pleistocene units and the sparse well data, the areas of occurrence, depth, and thickness of the Caloosahatchee Formation under St. Lucie County is uncertain. Two wells in eastern St. Lucie County penetrated gray limestones thought to be Caloosahatchee Formation in the depth intervals 63 to 125 feet bls and 60 to 105 feet bls respectively (FGS unpublished well data). It probably extends eastward and possibly offshore from its mapped occurrence in the central peninsula. It overlies the Tamiami Formation, and is overlain by the Ft. Thompson Formation, where present, or by Anastasia Formation sediments.

Ft. Thompson Formation

In its type area in Lee County, the Ft. Thompson Formation (Sellards, 1919) consists of discontinuous, alternating beds of fresh, brackish, and marine marls and limestones. This unit probably extends under eastern St. Lucie County, possibly with sporadic occurrence. One well, near the Savannas Reserve in eastern St. Lucie County, penetrated a gray fossiliferous limestone between 22 and 65 feet bls which may belong to the Ft. Thompson Formation. Delineation of the unit in well cuttings, especially in the absence of definitive freshwater mollusks, is difficult. Therefore its extent and depth are uncertain.

Anastasia Formation

The Upper Pleistocene Anastasia Formation (Sellards, 1912) varies from unconsolidated quartz sand and shell to calcareous sandstone to a quartz sandy, tan to orange-colored coquina limestone or mollusk shell hash. It is perhaps best recognized as the coquina beach rock which outcrops sporadically along the east coast from St. Augustine southward to Boca Raton. Bearden (1972) believes the Anastasia Formation may comprise the core of the Atlantic Coastal Ridge and possibly the offshore barrier islands.

Near the Savannas Reserve, the Anastasia Formation is predominantly shelly sands or calcareous sandstone containing mollusk shell beds. The depth to the top of the unit is variable, generally ranging from between 10 and 20 feet bls in low swales to as much as 50 feet under dune ridges. It locally attains a thickness of 50 to 100 feet (FGS unpublished well data; Wedderburn and Knapp, 1983). The Anastasia Formation is overlain by a veneer of Pleistocene and Holocene sands, clays and silts.

Pleistocene and Holocene Series
Undifferentiated surficial deposits

Surficial deposits in the Savannas State Reserve are predominantly relict marine quartz sands, with sandy muds and silts forming the substrate in the wet, marshy areas. Much of the sand was deposited and reworked during sea level highstands of the late Pleistocene, having been carried south from the eroding Appalachians by longshore currents. As sea level retreated, Holocene fluvial muds and silts accumulated in low-lying areas, and winds formed the aeolian sand dunes along the crest of the Atlantic Coastal Ridge.

HYDROGEOLOGY

Three primary hydrostratigraphic units are present in the vicinity of the Savannas Reserve. In order of increasing depth they are: the surficial aquifer system, the intermediate aquifer system or intermediate confining unit, and the Floridan aquifer system (Southeastern Geological Society Ad Hoc Committee, 1986).

The surficial aquifer system

The surficial aquifer system occurs within the porous sands, sandstones, shellbeds, and limestones of the Tamiami through Anastasia Formations. This unit contains the water table, and is generally unconfined. However, in northeastern St. Lucie County, a low-permeability, dark gray, sandy, clayey, marl strata, lying at a depth of about 30 feet bls, may serve to partially confine the lower portion of the surficial aquifer system and form a low pressure artesian system (Parker et al., 1955). The portion above the confining strata is primarily white to brown quartz sands. Below the confining strata are a series of sands, shell marls, and shell beds. The City of Ft. Pierce developed a municipal well field within this system at the northern end of the Savannas (Parker et al., 1955).

The surficial aquifer system also locally serves as a source of potable water for domestic use. Most of wells into the surficial aquifer system were completed between 15 and 170 feet bls. A typical 2 inch diameter domestic well may yield 40 gallons per minute (Bearden, 1972).

The surficial aquifer system varies from about 100 to 150 feet thick; it is confined at its base by low-permeability clays of the Hawthorn Group, part of the intermediate confining unit (Scott et al., 1991). Its upper limit is the water table, which varies with surface topography and degree of drought. It is close to the surface in low areas, and probably controls the surface water levels in many of the pools within the Savannas. Recharge to the surficial aquifer system is mostly through local precipitation.

The intermediate aquifer system or intermediate confining unit

Low permeability strata within the lowermost Tamiami Formation and the upper Hawthorn Group sediments form the base for the surficial aquifer system, and also serve to confine the underlying Floridan aquifer system. This hydrostratigraphic unit is named the intermediate aquifer system or intermediate confining unit (Southeastern Geological Society Ad Hoc Committee, 1986). The confining beds are comprised primarily of phosphatic, clayey, and dolomitic quartz sands (Wedderburn and Knapp, 1983). Interbedded within the low-permeability units are thin, well indurated porous carbonates, which may contain limited quantities of freshwater. Due to the thinness and low permeability of these units, they are generally not considered a source of water (Wedderburn and Knapp, 1983). Porous carbonates at the base of the Hawthorn Group may be in hydrologic continuity with the underlying Floridan aquifer system.

The top of the intermediate confining unit in St. Lucie County lies between about 110 and 160 feet deep, and it reaches a thickness of over 450 feet (Wedderburn and Knapp, 1983; Scott et al., 1991). Underlying the intermediate confining unit are porous limestones of the Floridan aquifer system.

Floridan aquifer system

Paleocene through Oligocene carbonates locally comprise the Floridan aquifer system (Southeastern Geological Society Ad Hoc Committee, 1986). The highly porous nature of the rocks comprising the Floridan aquifer system, with few interbedded confining units, make it a highly productive unit. It underlies all of Florida at varying depths, and extends northward into parts of Georgia, Alabama, and South Carolina.

The top of the Floridan aquifer system occurs under eastern St. Lucie and Martin Counties at a depth of approximately 700 feet bls (Scott et al., 1991). Here, it is between 2,700 and 3,000 feet thick (Miller, 1986). It includes Paleocene and Lower Eocene strata, as well as the Eocene Avon Park Formation and Ocala Limestone, and the Oligocene age unnamed carbonate unit.

The Floridan aquifer system is confined by overlying low-permeability beds in the Hawthorn Group, and is under artesian pressure. Water will rise in tightly cased Floridan aquifer system wells to a potentiometric elevation of 35 to 50 feet above mean sealevel in eastern St. Lucie County (Bearden, 1972; Barr, 1987). It therefore supplies most wells through natural flow.

The Floridan aquifer system is not used as a source of domestic water in the St. Lucie and Martin County area because of its local highly mineralized, non-potable nature (Klein, 1975; Causey and Leve, 1976). Such mineralized water is used primarily in commercial cooling and in some industrial and agricultural applications. A number of

County-owned supply wells drilled to depths of between 800 and 1,200 have produced yields of about 200 gallons per minute (Bearden, 1972).

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