U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Timucuan Ecological and Historic Preserve, and Fort Caroline National Memorial

tifo_geology.pdf

Version: 9/16/2014

Geologic Resources Inventory Map Document for Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial

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Geologic Resources Inventory Map Document

Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial, Florida

Document to Accompany Digital Geologic-GIS Data

tifo_geology.pdf

Version: 9/16/2014

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Timucuan Ecological and Historic Preserve (TIMU) and Fort Caroline National Memorial (FOCA)

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

National Park Service (NPS) Geologic Resources Inventory (GRI) Program staff have assembled the digital geologic-GIS data that accompanies this document.

For information about the status of GRI digital geologic-GIS data for a park contact:

Tim Connors
Geologist/GRI Mapping Contact
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2093
fax: (303) 987-6792
email: Tim_Connors@nps.gov

For information about using GRI digital geologic-GIS data contact:

Stephanie O'Meara
Geologist/GIS Specialist/Data Manager
Colorado State University Research Associate, Cooperator to the National Park Service
1201 Oak Ridge Drive, Suite 200
Fort Collins, CO 80525
phone: (970) 491-6655
e-mail: stephanie.omeara@colostate.edu

About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the Earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. To find GRI data for a specific park or parks select the appropriate park

(s), enter “GRI” as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: http://www.nature.nps.gov/geology/inventory, or contact:

Bruce Heise
Inventory Coordinator
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2017
fax: (303) 987-6792
email: Bruce_Heise@nps.gov

The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Maps and FGS Source Map Citations

The GRI digital geologic-GIS maps for Timucuan Ecological and Historic Preserve (TIMU) and Fort Caroline National Memorial (FOCA):

GRI Digital Geomorphic Map of Timucuan Ecological and Historic Preserve, and Fort Caroline National Memorial, Florida (*GRI MapCode TIFG*)

GRI Digital Geologic Map of Timucuan Ecological and Historic Preserve, and Fort Caroline National Memorial, Florida (*GRI MapCode TIFO*)

Both maps were produced from digital data from the following Florida Geological Survey (FGS) preliminary digital data and map.

Williams, C.P., Cichon, J.R. Hartman, L.M. and Apolinar, B., 2014, Geomorphology and Geology of Selected Coastal Regions in Northeastern Florida (Timucuan Ecological and Historic Preserve, and Fort Caroline National Memorial): Florida Geological Survey, preliminary digital data and map, scale 1:24,000. (*GRI Source Map ID 75810*).

Additional information pertaining to each source map is also presented in the Source Map Information (TIFOMAP) table included with the GRI digital geologic-GIS data.

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GRI Digital Geomorphic Map of Timucuan Ecological and Historic Preserve, and Fort Caroline NMEM

Geomorphic Map Unit List

The geomorphic units present in the GRI Digital Geomorphic Map of Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial, Florida are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qdn - Dunes). Units are listed by geomorphic environment as per the source map. Information about each geomorphic unit is also presented in this dataset's Geomorphic Unit Information (TIFGUNIT) table included with the GRI geomorphic-GIS data.

Supratidal Units
Qdn - Dunes
Qfd - Foredune
Qpd - Primary dunes
Qrdr - Relict dune and ridge
Qsd - Secondary dunes
Qu - Upland

Intertidal Beach Units
Qrsc - Relict spit complex
Qsb - Sand beach
Qsa - Sandstone
Qspi - Spits

Intertidal Marsh Units
Qnw - Non-vegetated wetland
Qsm - Salt marsh
Qso - Salt ponds
Qtc - Tidal creek

Intertidal/Subtidal Flat Units
Qb - Bioherms
Qcl - Channel levee

Subtidal Units
Qetd - Ebb tide delta
Qftd - Flood tide delta
Qic - Inlet channel
Qric - Relict inlet channel

Coastal-Riverine Units
Qfw - Freshwater wetland
Qol - Oxbow lakes
Qpn - Pond (natural)
Qs - Swamp

Anthropogenic Units
Qdm - Dams
Qdma - Docks/Marinas/Anchorage
Qdc - Dredged channels
Qds - Dredged spoil
Qf - Fill

Qg - Groins
Qhs - Historic structures
Qi - Impoundments
Qj - Jetties
Ql - Landfill
Qp - Piers
Qqbp - Quarry/Borrow Pit
Qrr - Rip rap
Qses - Shoreline engineering structures
Qsp - Stormwater ponds

Geomorphic Map Unit Descriptions

Descriptions of all geomorphic units were provided by the source map authors (FGS Geomorphic Map; *GRI Source Map ID 75810*).

Supratidal Map Units

Qdn - Dunes (Recent)

Dunes are low ridges related to either shoreline processes or windblown sediment deposition. They consist primarily of fine to medium quartz sands and shell material, with traces of heavy minerals and muscovite and occur along the entire coast in the study area. The more general dune category was reserved for areas removed from the more active dune environments along the Atlantic Ocean shoreline, but includes interpreted features that may not be of similar depositional age. A significant portion of the dune areas have been modified by development. Every effort was made to interpret the geomorphic unit rather than the development modifications.

Qfd - Foredune (Recent)

Consists primarily of windblown quartz sand and shell material that may also have some shoreline-related deposition. These range from vegetated with native dune grasses to non-vegetated, and are found in the zone between the beach and the primary dune in localities where excess sediment supply fosters formation of a new dune feature. Given time, these have the potential to be established as primary dunes if not destroyed by erosion in storm events.

Qpd - Primary dunes (Recent)

Primary dunes run parallel to the modern coast and occur between the beach and interior dune units. These are noted as the first and most significant dunes of elevation adjacent to the Atlantic Ocean shoreline. They may contain shoreline-deposited sediments, though the primary source is windblown quartz sand and shell material from the beach environment. Where found in urban areas, all attempts were made to map the natural dune system over urban modification.

Qrdr - Relict dune and ridge (Recent)

Relict dune and ridge covers the majority of the eastern study area with smaller remnants located in the salt marshes adjacent to the St. Johns and Nassau rivers and the Intracoastal Waterway. Sediments typically consist of quartz sand with clay, organics and shell fragments as minor constituents. The dune ridges parallel the modern shoreline and are related to deposition of coastal sediments of barrier island morphology formed over several stages of sea level transgressions in which sea levels were, for a time, higher than modern sea level. Lower elevation swamp to marsh habitats equate to dune swales formed between adjacent ridges. They are also significant predictors of location of surface water flow in the area that is dominated by a trellis drainage pattern. Relict dune units were interpreted in areas of urban modification. Anthropogenic units taking precedent over relict dunes include stormwater ponds, dredged channels and dredged spoil.

Qsd - Secondary dunes (Recent)

Secondary dunes occur between primary dunes and interior dune units. These may have elevations similar to or slightly lower than the primary dunes, but are removed from the immediate shoreline environment. The nature of their formation is akin to primary dunes, but by age of deposition or excess sediment supply they are no longer adjacent to the beach environment. Many secondary dunes occur within developed areas. Every effort was made to interpret the geomorphic unit rather than development modifications. In areas of extreme anthropogenic modification, it was not possible to recognize secondary dunes and they were lumped into a different geomorphic unit (most commonly dunes).

Qu - Upland (Recent)

The upland features are distinguished from Beach Ridge and Dune based upon surficial geomorphology. Upland areas may once have been Beach Ridge and Dune, but these areas are more dominated by dendritic drainage and have evolved to no longer have a clear coastal origin in their surface expression.

Intertidal Beach Map Units

Qrsc - Relict spit complex (Recent)

These complexes, particularly associated with former inlet locations, are identified by dune features perpendicular to the present shoreline. The dune ridges mark former inlet channel dunes that have not been eroded since deposition.

Qsb - Sand beach (Recent)

Sand beach is the dominant beach map unit occurring between the ocean shoreline and the modern dune complex. The beach is dominated by quartz sand and shell fragments. The ocean shoreline is estimated based on true color imagery (2010 Duval County, 2010 Nassau County).

Qsa - Sandstone (Recent)

These are isolated to the northern end of Big Talbot Island where sands cemented by clay, iron and humate crop out along the shoreline on Nassau Sound.

Qspi - Spits (Recent)

These are formed via longshore transport processes, and surrounded on three sides by water. In some instances they may now be surrounded by salt marsh. They are typically sandy peninsulas formed along shorelines near inlet or deeper water environments.

Intertidal Marsh Map Units

Qnvw - Non-vegetated wetland (Recent)

These are hydric surfaces that lack vegetation due to high levels of salinity and/or sediment disturbance at the toe of uplands and dredged spoil. The saline non-vegetated wetlands are caused by the precipitation of salts on sand flats or depressions that are normally only flooded during the spring portion of tidal cycles. This map unit is located throughout the salt marsh and is clearly delineated on the true color image as a bright white to white-gray feature.

Qsm - Salt marsh (Recent)

Salt marsh consists of areas where inundation is dictated by tidal fluctuations. The main salt-tolerant plant species are represented by *Spartina alterniflora* and *Juncus roemerianus*. This map unit extends the entire length of the study area between the dunes on the barrier island side and the relict dunes on the landward side of the lowland occupied by the St. Johns and Nassau rivers and the Intracoastal Waterway. Some areas contain large groupings of salt marsh islands interspersed with tidal creeks at a scale of 1:1,000 feet. Every effort was made to identify salt marsh islands separately. In those areas where this wasn't feasible, salt marsh islands were delineated by grouping islands together.

Qso - Salt ponds (Recent)

Naturally formed ponds, located within salt marsh environments.

Qtc - Tidal creek (Recent)

This map unit encompasses all natural rivers and creeks and the twentieth century anthropogenic Intracoastal Waterway located in the intertidal environment. Natural tidal creeks are most abundant in salt marsh and facilitate inundation and drainage of the marshland. They are mapped by delineating the high tide mark identified on the true color aerial imagery. If the image was taken at low tide, the area shown as mud was delineated as tidal creek to represent the highest point of inundation. The Intracoastal Waterway was partially delineated as tidal creek because there were no available historic photographs prior to dredging and it was, at times, unclear what was previously natural versus dredged.

Intertidal/Subtidal Flats Map Units

Qb - Bioherms (Recent)

Bioherms are comprised of oyster beds located in tidal flat and tidal creek environments and have highly variable shapes and sizes. Bioherms were mapped by grouping concentrated oyster beds into one

feature. If large enough, bioherms were mapped on their own by digitizing the characteristic brown outer rim of the oyster beds.

Qcl - Channel levee (Recent)

These are more anthropogenic than natural in origin, consisting of oyster shells deposited along tidal creeks partially by natural wave action, but primarily from boat wakes. Channel levees form a ridge that separates the tidal creek from the salt marsh. These map units appear as bright white linear features in the true color imagery.

Subtidal Map Units

Qetd - Ebb tide delta (Recent)

Mapped to include the extent of sandy sediment shoals formed seaward of a tidal inlet due to currents associated with the outgoing tide.

Qftd - Flood tide delta (Recent)

Mapped to include the extent of sandy sediment shoals or islands formed landward of a tidal inlet due to currents associated with the incoming tide.

Qic - Inlet channel (Recent)

Features that connect the Atlantic Ocean with the St. Johns, Nassau and Fort George rivers through the barrier islands within the study area. The seaward extent of the inlet channels were delineated based upon the location of the deeper water distributaries of the ebb tidal delta. The channel inland is mapped to the ends of the flood tidal delta and the points where loss of sand beach environments on the river shorelines occur. For the St. Johns River, the definition was arbitrary and extended inland through the first major set of dunes. The remainder of the mouth of the St. Johns River along its final west to east run to the Atlantic Ocean is highly modified by anthropogenic dredging activities.

Qric - Relict inlet channel (Recent)

This is only found at the south end of the Little Talbot Island where migration of the inlet channel has isolated a former part of the inlet channel.

Coastal Riverine Map Units

Qfw - Freshwater wetland (Recent)

Freshwater Wetland - Areas mapped as freshwater wetland tend to be open expanses of grasses, sedges, rushes and other types of non-salt tolerant herbaceous plants or shrub vegetation. They are located west of the salt marsh in the study area. Land use data developed by the St. Johns River Water Management District (SJRWMD) were used to aid in the identification of freshwater wetlands. LiDAR

elevation data further enhanced mapping efforts and the delineation of the wetland polygons.

Qol - Oxbow lakes (Recent)

These features form when the meander of a tidal creek is cut off to form a lake. Many oxbow lakes rapidly transform into salt marsh due to deposition of muddy sediments into these low relief and shallow depressions once cut off from the energy of tidal scouring.

Qpn - Pond (natural) (Recent)

Natural freshwater ponds are located west of the salt marsh in the upland and relict dune and ridge environments of the study area.

Qs - Swamp (Recent)

Swamps represent wetlands that are dominated by hardwood tree species and rare instances of Pond Pine, Pinus serotina. They are located west of the salt marsh in the study area. Land use data developed by the St. Johns River Water Management District (SJRWMD) was used to aid in the identification of swamps. LiDAR elevation data further enhanced mapping efforts and the delineation of the swamp polygons.

Anthropogenic Map Units

Qdm - Dams (Recent)

This unit depicts the earthen dams located south of the St. Johns River.

Qdma - Docks/Marinas/Anchorage (Recent)

Docks represent large commercial entities that comprise areas for storing boats along the tidal creeks in the study area. They are mapped by including all boats, boat slips and decks that encompass the dock area. This may include part of the tidal creek, Intracoastal Waterway or dredged channel.

Qdc - Dredged channels (Recent)

Dredged channels are anthropogenic channels in tidal creek marsh systems. They include canals and ditches used to drain the salt marsh, and the straightening of tidal creeks and areas near docks. Historical imagery dating back to the 1930s was used to verify dredged channels.

Qds - Dredged spoil (Recent)

Dredged Spoil (spoil islands) are usually seen as bright white mounds on the true color imagery. Older spoil islands may be partially or mostly covered by vegetation representative of salt marsh to dune environments. Regardless of the amount of vegetation, spoil islands are always mapped as dredged spoil rather than by the vegetative communities that may now inhabit them. Historical imagery dating to the 1930s aided in identifying dredged spoil and its extent.

Qf - Fill (Recent)

Fill represents the anthropogenic placement of sediment in wetland areas. Fill was delineated wherever it was clear that it has been used for development. Types of development may include roads, bridges, airports and residential or commercial buildings.

Qg - Groins (Recent)

Structures laid perpendicular to the shoreline used to trap sand and found at the south end of Amelia Island. The unit is mapped by enclosing the visible portion of their rock structures.

Qhs - Historic structures (Recent)

These include buildings that have an historical significance, such as forts and lighthouses.

Qi - Impoundments (Recent)

Water bodies formed by damming of creeks and small waterways.

Qj - Jetties (Recent)

Jetties occur as pairs adjacent to inlets in the study area. They are mapped by enclosing the visible extent of their rock structures.

Ql - Landfill (Recent)

A landfill is a site for the disposal of waste materials, delineated by selecting the outer boundary of the landform feature.

Qp - Piers (Recent)

This map unit represents piers extending oceanward from a beach into the breaker zone.

Qqbp - Quarry/Borrow Pit (Recent)

Quarries/borrow pits are rectangular- (or irregular-) shaped pits containing water. Pits are flooded due to the high water table. An active pit may be identified by blue, milky water while an abandoned (or inactive) pit would contain black water on the true color imagery. Borrow pits are frequently found along roads which required fill during roadway construction.

Qrr - Rip rap (Recent)

A layer of large rocks used to harden the shoreline by bridges and houses and other structures along waterways located in the study area. They are mapped by enclosing the visible extent of the rocks.

Qses - Shoreline engineering structures (Recent)

Shoreline engineering structures are built to alter the effects of ocean waves, currents and sand

movement. They are delineated by tracing the outer extent of the feature.

Qsp - Stormwater ponds (Recent)

Anthropogenic water features that usually appear black in true color imagery. They are easily identified by their rectangular or irregular shapes. The vast majority of stormwater ponds are found in urbanized areas. These are common in residential or commercial developed land as opposed to the quarry/borrow pit features that are typically more isolated from development sites.

GRI Digital Geologic Map of Timucuan Ecological and Historic Preserve, and Fort Caroline NMEM

Geologic Map Unit List

The geologic units present in the GRI Digital Geologic Map of Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial, Florida are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qh - Undifferentiated sediments). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in this dataset's Geologic Unit Information (TIFOUNIT) table included with the GRI geologic-GIS digital data.

Cenozoic Era

Holocene Epoch
Qh - Undifferentiated sediments

Quaternary Period
Qbd - Beach ridge and dune
Qu - Undifferentiated Quaternary sediments

Pliocene/Pleistocene Epochs
QTsu - Shelly sediments of Pliocene and Pleistocene *

Miocene Epoch
Th - Hawthorn Group
- Thcc - Coosawhatchie Formation, Charlton Member *
- Thc - Coosawhatchie Formation *
- Thmh - Marks Head Formation **
- Thpf - Penney Farms Formation **

Eocene Epoch
To - Ocala Limestone **

**unit only present in cross section (see unit description for additional information).*
unit is only present in the subsurface of the map area, but is not shown in cross section

Geologic Map Unit Descriptions

Descriptions of all geologic units were provided by the source map authors (FGS Geologic Map; *GRI Source Map ID 75810*).

Qh - Undifferentiated sediments (Holocene)

Undifferentiated Holocene sediments are interpreted to have been deposited during the Holocene. These include areas along the St. Johns River and salt marshes and freshwater wetlands adjacent to the Fort George, Amelia and Nassau rivers, and their tributaries, and the Intracoastal Waterway and portions of the barrier islands. They are typically noted at elevations less than 5 ft (1.5 m) above modern sea level, excepting the barrier islands which may have higher elevations. Lithology may include carbonate sands, quartz sands, carbonate and siliciclastic muds and organics (Scott 2001).

Qbd - Beach ridge and dune (Quaternary)

Significant portions of the study area are mantled with quartz sands which may at times include clay and organics. In coastal Duval and Nassau counties, these deposits have been identified as Quaternary beach ridge and dune due to the strong regional component of ridge and swale development in the overall geomorphology. These deposits are interpreted to be Pleistocene. The Florida Geological Survey attempts to apply quasi-geomorphological designations of the undifferentiated Quaternary units for the benefit of constituent readers in order to provide more information about the nature of their deposition. Without these designations, all the undifferentiated sediments would be labeled Qu. The beach ridge and dune complex strongly influences the patterns of uplands and wetlands in the region as well as the development of distinct trellis drainage.

Sediments of Qu or Qbd in cuttings and cores are lithologically similar, if not the same. They consist of quartz sand that may, at times, have clay and organics present. In the study area, these range in colors from pinkish grey to moderate dark grey, very light orange to greyish orange to light yellowish orange, and brownish grey to greyish brown to dark yellowish brown, and even black humate-cemented sands. Quartz sand grain size may range from very fine to gravel because these are beach ridges and dunes that were dominated by coastal transport and deposition, and not simply aeolian. Grain size is also related to the source material which includes deposits of widely variable grain size, such as the Cypresshead Formation.

Qu - Undifferentiated Quaternary sediments (Quaternary)

Significant portions of the study area are mantled with quartz sand, which may at times include clay and organics. In the study area, these range in colors from pinkish grey to moderate dark grey, very light orange to greyish orange to light yellowish orange, and brownish grey to greyish brown to dark yellowish brown. These deposits are interpreted to be Pleistocene, however without diagnostic fossils or direct dating techniques, it is not possible to ascertain the absolute age. Quartz sand grain size ranges from very fine to gravel—variable due to the different transport mechanisms ranging from fluvial, to inlet and littoral and longshore coastal transport and deposition. Grain size is also related to the source material which includes deposits of widely variable grain size, such as the Cypresshead Formation.

The Florida Geological Survey attempts to apply quasi-geomorphological designations of the undifferentiated Quaternary units for the benefit of constituent readers in order to provide more information about the nature of their deposition. Without these designations, all the undifferentiated sediments would be labeled Qu. Areas mapped as Qu tend to have dendritic drainage and, although they may have been deposited originally in a beach ridge and dune environment (see following description), do not have strong evidence remaining of a specific type of depositional environment or setting.

QTsu - Shelly sediments of Pliocene and Pleistocene (Pliocene/Pleistocene)

The shelly sediments of Pliocene and Pleistocene are undifferentiated and have varying amounts of quartz sand and clay, and is sometimes dominated by molluscan shell material. In southern Florida, these units are among the most abundant and diverse fossil molluscan faunas in the world (Scott 2001). There have been various attempts to divide formations out of these deposits, but most of the work has been centered on biostratigraphy, particularly molluscan (Scott and Wingard 1995). Formational units for geologic mapping center on the dominance of lithostratigraphy in distinguishing rocks of different formations. Therefore, even though formation names such as the Caloosahatchee, Bermont, Fort

Thompson or Nashua, the latter in northern Florida, have been applied to these units, they are not distinct in lithology, only in paleontology. These are complex sedimentary deposits that are typically unconsolidated with varying calcareous and fossiliferous components in quartz sand with clays and muscovite typically present. Toward the base of the TQsu, phosphatic sand and gravel are sometimes reworked from the underlying Hawthorn Group sediments. Scott (2001) notes that the TQsu deposits may also consist of well indurated, quartz sandy, fossiliferous limestones. These are rare in the study area with most of the limestones and dolostones occurring at the transition to the Coosawhatchie Formation of the Hawthorn Group.

***unit (QTsu) only present in cross section**. The GRI adopts a common standard that unit time symbols (e.g., Q and T) are listed with the younger time symbol, in this case Q, being listed first. The FGS presents unit time symbols with the older time symbol, in this case T, being listed first. The FGS unit symbol for this unit was changed from TQsu to QTsu, however the cross section graphics still present the unit as TQsu.*

Th - Hawthorn Group

The Hawthorn Group has complex lithology and high variability regionally in Florida. In northern peninsular Florida, within the current study area, there are three distinct, though not altogether dissimilar, formations and one member that are recognized. None of these crop out at the surface, but the Charlton Member of the Coosawhatchie Formation and the Coosawhatchie Formation are shown on the cross-sections. All of the Hawthorn Group deposits in this region are Miocene.

Thcc - Coosawhatchie Formation, Charlton Member (Middle Miocene)

The Charlton Member of the Coosawhatchie Formation occurs in the Jacksonville Basin and crops out along the St. Marys River in Nassau County. The key distinction of the Charlton Member from the upper portion of the Coosawhatchie Formation is that dolostone and limestone are the dominant lithologies with reduced quartz sand and phosphatic sand. The Charlton Member is a distinctive facies of the upper portion of the Coosawhatchie Formation with which it both overlies and interfingers laterally (Scott 1988).

unit (Thcc) only present in cross section

Thc - Coosawhatchie Formation (Middle Miocene)

The Middle Miocene Coosawhatchie Formation does not crop out in the study area, but does outside the study area in other parts of northern Florida. This is the deepest formation depicted on the study area cross-sections. Within the study area, the upper portion of the Thc typically consists of quartz sands with dolostone or calcareous matrix, occasionally being well indurated. The carbonates are too sandy to be considered part of the Charlton Member. The quartz sands typically contain phosphate and occasionally gravel. The lower portion of the Thc becomes darker in color and clay becomes more dominant than carbonate. Colors range from light olive grey to olive grey to greenish grey. The section of Thc in cores and cuttings is recognized by the occasionally well indurated upper section and dolomitic sands and sandy dolostones that transition with depth to more clays and quartz sands, and is darker in color than the upper portions of the unit. All samples typically contain phosphate. The contact with the Marks Head Formation is defined where the lithology changes to more clays and dolostones, and is typically finer grained and lighter in color than the overlying Thc.

unit (Thc) only present in cross section

Thmh - Marks Head Formation

The Lower Miocene Marks Head Formation, like the Penney Farms Formation, does not crop out in the study area. It is a subsurface unit encountered only in cores and cuttings. It is a variably quartz sandy, clayey, dolomitic unit and is the most lithologically variable of the formations in the Hawthorn Group in northern Florida (Scott 1988). The clayey and dolomitic beds in the Thmh typically also contain quartz sand. Colors are lighter than the Penney Farms Formation or the lower portion of the overlying Coosawhatchie Formation. Colors typically range from greenish grey to olive grey to pale olive. Phosphatic sands are common in much of the unit.

unit (Thmh) is only present in the subsurface of the map area, but is not shown in cross section*

Thpf - Penney Farms Formation

The Lower Miocene Penney Farms Formation is the basal stratigraphic formation in the Hawthorn Group in northeastern Florida. Near the Georgia border, it interfingers and grades northward into the Lower Miocene Parachucla Formation (Huddlestun 1988). This formation does not crop out at the surface and is only encountered in cores and cuttings. The upper portion of the Thpf is predominantly siliciclastic with scattered carbonate beds (Scott 1988). These have variable amounts of quartz sand, clay, phosphate and dolostone, and tend toward olive grey and greyish olive green colors. The lower portion of the Thpf is predominantly carbonate with some interbedded quartz sands and clays (Scott 1988). In the study area, the base of the Thpf consists of well indurated dolostone, often with intraclasts having phosphatized rims. The Oligocene section is missing in the study area such that the lower contact is with the Upper Eocene Ocala Limestone.

unit (Thpf) is only present in the subsurface of the map area, but is not shown in cross section*

To - Ocala Limestone

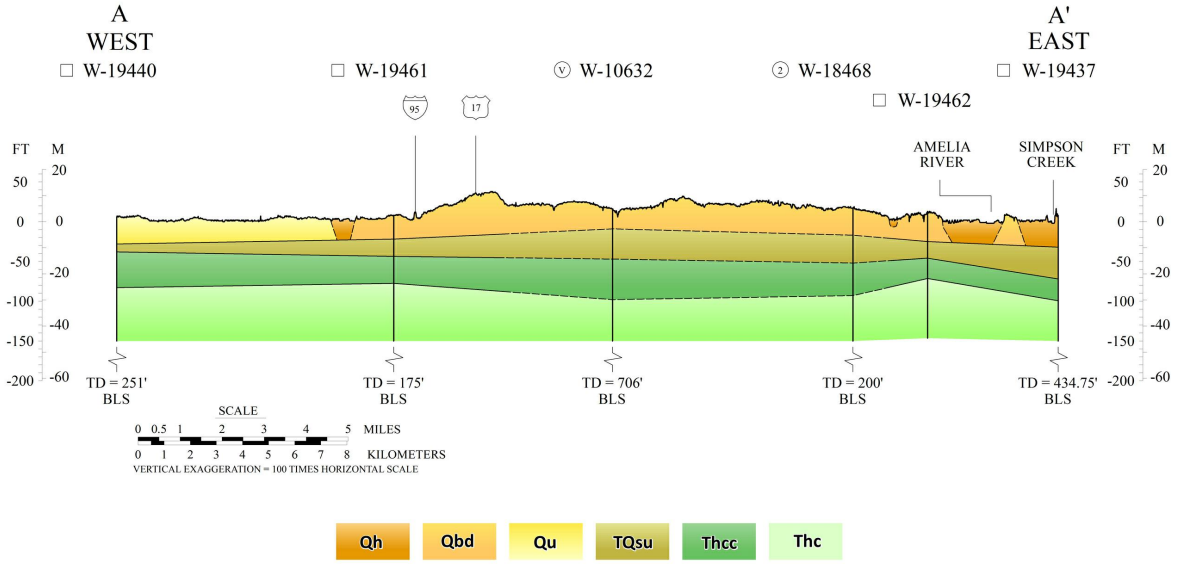
The Upper Eocene Ocala Limestone consists of nearly pure limestone with occasional dolostone (Scott 2001). It is grainstone, packstone or wackestone and fossiliferous with benthic foraminifera, echinoids, bryozoans and mollusks or mollusk molds commonly present. This formation is generally between 450-600 feet below land surface in the study area, and thus was not displayed on the cross-sections, but its presence below the Hawthorn Group is of regional importance.

unit (To) is only present in the subsurface of the map area, but is not shown in cross section*

Geologic Cross Sections

The geologic cross sections present in the GRI Digital Geologic Map of Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial, Florida are presented below. The cross section graphics were scanned at a high resolution and can be viewed in more detail by zooming in (when viewing the digital format of this document).

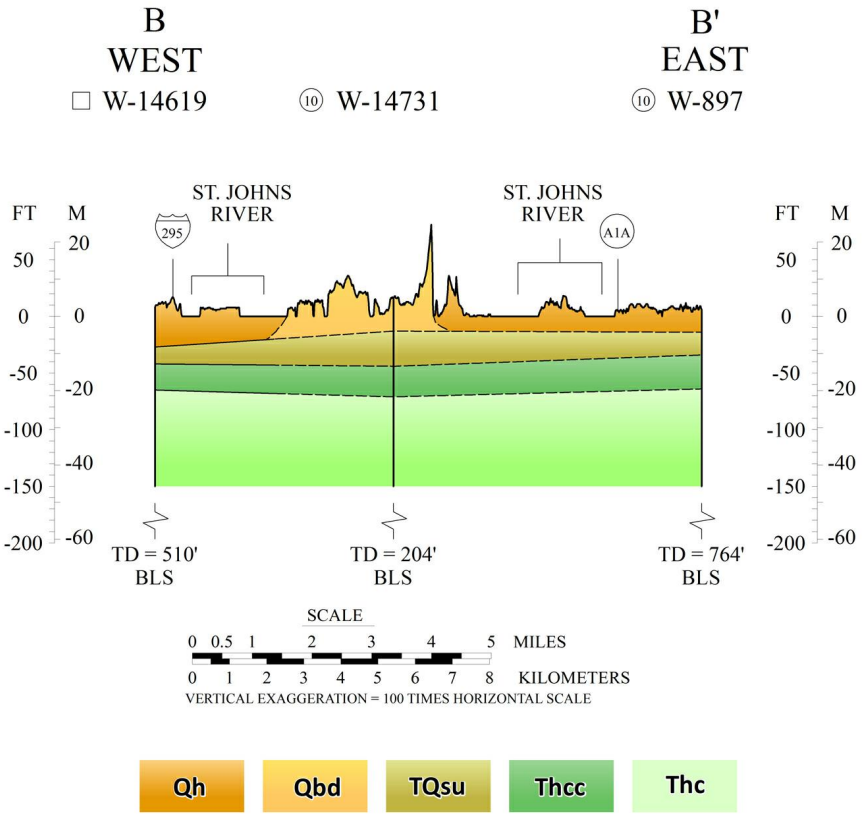
Geologic Cross Section A-A'



** Vertical exaggeration x 100. Full A-A' cross section graphic.*
*** Wells shown in cross section are present in the GRI digital GIS data.*
**** The unit symbol for the Shelly sediments of Pliocene and Pleistocene age unit is represented as QTsu in the GRI digtal map products, however, the cross section graphic still presents the unit as TQsu, as per the FGS source data, and the FGS unit age symbol listing convention.*

Extracted from: (FGS Geologic Map)

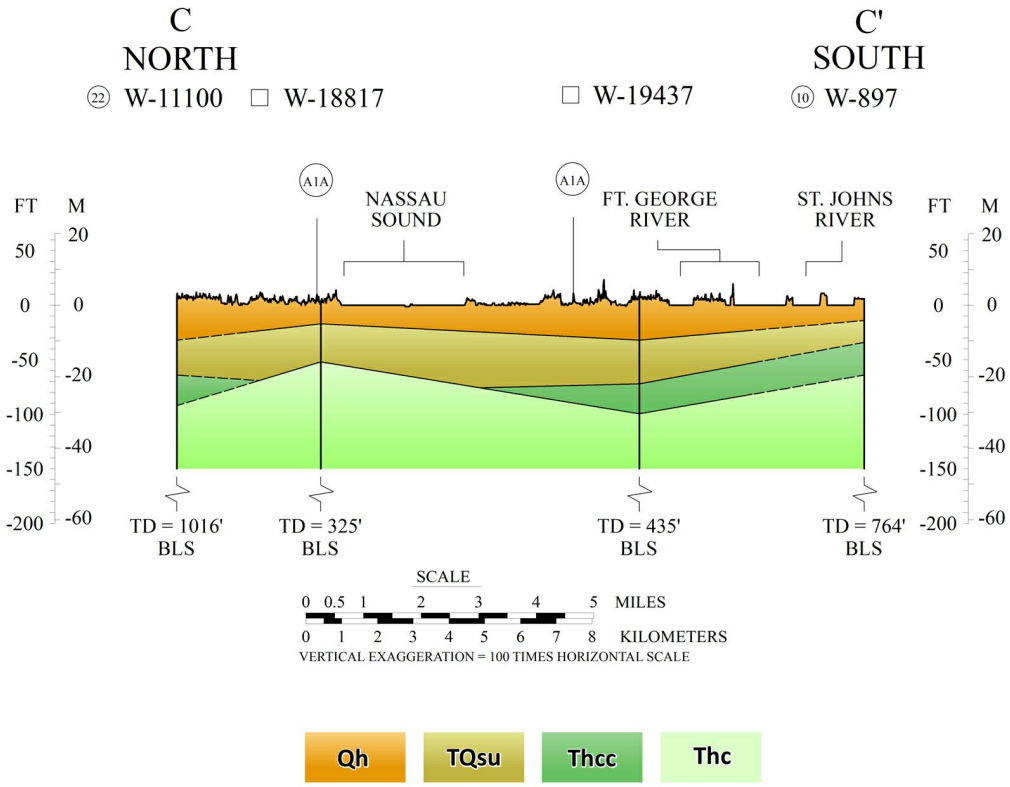
Geologic Cross Section B-B'



** Vertical exaggeration x 100. Full B-B' cross section graphic.*
*** Wells shown in cross section are present in the GRI digital GIS data.*
**** The unit symbol for the Shelly sediments of Pliocene and Pleistocene age unit is represented as QTsu in the GRI digtal map products, however, the cross section graphic still presents the unit as TQsu, as per the FGS source data, and the FGS unit age symbol listing convention.*

Extracted from: (FGS Geologic Map)

Geologic Cross Section C-C'



** Vertical exaggeration x 100. Full C-C' cross section graphic.*
*** Wells shown in cross section are present in the GRI digital GIS data.*
**** The unit symbol for the Shelly sediments of Pliocene and Pleistocene age unit is represented as QTsu in the GRI digtal map products, however, the cross section graphic still presents the unit as TQsu, as per the FGS source data, and the FGS unit age symbol listing convention.*

Extracted from: (FGS Geologic Map)

FGS Source Information, References and Acknowledgements

The Florida Geological Survey (FGS) provided brief descriptions of how geomorphic and geologic features were mapped and the GIS data produced. The FGS also provided use constraints, references, credits and acknowledgements relevant to both the geomorphic and geologic digital data.

FGS Description of Mapping and Digital Data Production

The geologic units for Timucuan Ecological and Historic Preserve, Fort Caroline National Memorial consist of geologic units mapped as area (polygon) features using the seven, seven and a half minute quadrangles of interest: Italia, Hedges, Amelia City, Eastport, Mayport, Arlington, and Jacksonville Beach. Geologic units used on this map are standard according to the North American Stratigraphic Code. The Florida Geological Survey additionally utilizes geomorphic interpretations for naming of undifferentiated sediments from the Tertiary and Quarternary. Within the study area, the distinctions used were to identify sediments deposited in the Holocene and Quaternary Beach Ridge and Dune sediments that are a common depositional sequence observed along the Atlantic coastal plain in the study area in northeastern Florida. Due to the vulnerability of Florida's groundwater aquifers to contamination, the Florida Geological Survey also chooses to map the first named geologic formation found within 20 feet of the surface, rather than the overlying undifferentiated sands and clays that commonly veneer much of the geology of the state. They were mapped by using well core and cutting samples from the FGS repository, outcrops found in the field, and historic geologic maps. Formations were delineated from the cores and cuttings descriptions. Using these formation picks, outcrops found in the field, and historic geologic maps, initial geologic units were placed on the map. The geologic units were further enhanced by looking at trends in the data and refining the polygon boundaries.

The geologic cross section lines for Timucuan Ecological and Historic Preserve, Fort Caroline National Memorial depict north-south and west-east cross section profile lines through wells with formation picks using the seven, seven and a half minute quadrangles of interest: Italia, Hedges, Amelia City, Eastport, Mayport, Arlington, and Jacksonville Beach.

The well locations for Timucuan Ecological and Historic Preserve, Fort Caroline National Memorial were used to assist in the construction of geologic map units by using the seven, seven and a half minute quadrangles of interest: Italia, Hedges, Amelia City, Eastport, Mayport, Arlington, and Jacksonville Beach. These wells come from the Florida Geological Survey (FGS) well repository. The repository is composed of core and cutting samples maintained by the FGS.

The geomorphic units for Timucuan Ecological and Historic Preserve, and Fort Caroline National Memorial consist of geomorphic units mapped as area (polygon) features by using the seven, seven and a half minute quadrangles of interest: Italia, Hedges, Amelia City, Eastport, Mayport, Arlington, and Jacksonville Beach. True color aerial imagery was classified using Geomatica (Remote sensing software package) to identify water and wetland features. This created a raster which was converted into polygons and then smoothed in ArcMap. True color imagery and LiDAR were further utilized to refine water/ wetland features and to identify additional surface geomorphic units. The listing of geomorphic features were selected from NPS-D-2269, Coastal geology mapping protocols for the Atlantic and Gulf National Park units. Details of these features as delineated are described within each coded value. These varied from simple interpretation and heads up digitizing of features to complex digital data filtering and combination.

The dune ridge lines for Timucuan Ecological and Historic Preserve, and Fort Caroline National Memorial consist of dune ridge lines mapped in seven, seven and a half minute quadrangles of interest: Italia, Hedges, Amelia City, Eastport, Mayport, Arlington, and Jacksonville Beach. Dune lines were created from a hillshade raster developed from LiDAR. Lines were drawn along the ridge at the highest elevation

points. Contour lines aided in the selection of highest elevation points. Ridges were extended through roads and urban development to maintain a continuous ridge line (where one had originally existed).

The data were completed as a component of the Geologic Resources Inventory (GRI) program, a National Park Service (NPS) Inventory and Monitoring funded program that is administered by the NPS Geologic Resources Division (GRD).

***The above text was summarized from metadata text associated with each feature class in the FGS digital data (geodatabase), and from a document supplied by the FGS that pertained to how the geomorphic data was produced.*

FGS Use Constraints

Not for use at scale greater than 1:24,000 (source map scale). These geologic data were developed by the Florida Department of Environmental Protection (FDEP) - Florida Geological Survey (FGS) to carry out agency responsibilities related to management, protection, and development of Florida's natural resources. Although efforts have been made to make the information accurate and useful, the FDEP/ FGS assumes no responsibility for errors in the information and does not guarantee that the data are free from errors or inaccuracies. Similarly, FDEP/FGS assumes no responsibility for the consequences of inappropriate uses or interpretations of the data. As such, these digital data are distributed on "as is" basis and the user assumes all risk as to their quality, the results obtained from their use, and the performance of the data. FDEP/FGS bears no responsibility to inform users of any subsequent changes made to these data. Anyone using this data is advised that precision implied by the data may far exceed actual precision. Comments on these data are invited and FDEP/FGS would appreciate that documented errors be brought to staff attention. The development of these data sets represents a major investment of staff time and effort. As a professional responsibility, we expect that the FDEP/FGS will receive proper credit when you utilize these data sets. Further, since part of these data were developed and collected with U.S. Government or State of Florida funding, no proprietary rights may be attached to it in whole or in part, nor may it be sold to the U.S. Government or the Florida State Government as part of any procurement of products or services.

FGS References

Huddlestun, P.F., 1988, A revision of the lithostratigraphic units of the coastal plain of Georgia: The Miocene through Holocene: Georgia Geologic Survey Bulletin 104, 162 p.

Scott, T. M., 1988, The lithostratigraphy of the Hawthorn Group (Miocene) of Florida: Florida Geological Survey Bulletin 59, 148 p.

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Scott, T.M. and Wingard, G.L., 1995, Facies, fossils and time—A discussion of the litho- and biostratigraphic problems of the Plio-Pleistocene sediments in southern Florida: in Scott, T.M. ed., Stratigraphy and paleontology of the Plio-Pleistocene shell beds, southwest Florida: Southeastern Geological Society Guidebook 35, unpaginated.

FGS Credits

Christopher P. Williams, James R. Cichon, Lee M. Hartman, Brianne Apolinar, Alan E. Baker, Clint Kromhout, David Paul, Cindy Fischler, Dan Phelps, Eric Thomas, Bob Cleveland, Jesse Hurd, Guy Richardson, Levi Hannon, Seth Bassett, Wade Stringer, Alexander Tanner, Alexander Johnson, Michelle Ladle, Rick Green, Harley Means, Jonathan Arthur, Jackie Lloyd, Traci Billingsley, Sarah Allen and Eric Harrington (Florida Geological Survey). Shauna Ray Allen, Jason King and Anne Lewellen (TIMU). Robert Joseph, Benjamin Faure, Edward Aaron Rodriguez, Kathleen Kelso, Mike Simmons (FDEP, State Parks).

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GRI Digital Data Credits

This document was developed and completed by Georgia Hybels (NPS GRD) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory(GRI) Program. Quality control of this document by Stephanie O'Meara (Colorado State University).

The information contained here was compiled to accompany the digital geologic-GIS maps and other digital data for Timucuan Ecological and Historic Preserve (TIMU) and Fort Caroline National Memorial, Florida developed by Georgia Hybels (NPS GRD) using source digital data produced by the Florida Geological Survey. Quality control provided by Stephanie O'Meara.

GRI finalization by Stephanie O'Meara.

GRI program coordination and scoping provided by Bruce Heise (NPS GRD, Lakewood, Colorado).