Geologic Resources Inventory Scoping Summary
Castillo de San Marcos National Monument, Florida

Prepared by John Graham
August 7, 2009

Geologic Resources Division
National Park Service
US Department of the Interior

The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a Geologic Resources Inventory report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

The National Park Service held a GRI scoping meeting for the park units of the Southeast Coast Network (SECN) during the week of April 20–24, 2009 at Jacksonville, Florida. These units included Canaveral National Seashore (CANA), Castillo de San Marcos National Monument (CASA), Cumberland Island National Monument (CUIS), Fort Caroline National Memorial (FOCA), Fort Frederica National Monument (FOFR), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), and Timucuan Ecological and Historic Preserve (TIMU). Castillo de San Marcos National Monument was discussed on April 22. Bruce Heise (NPS GRD) facilitated the meeting, presented an overview of the GRI program, and led the discussion regarding geologic processes and features at the monument. Stephanie O'Meara (CSU) led the discussion of map coverage. Randy Parkinson (RWParkinson Consulting) presented an overview of regional coastal geology, especially as it relates to Georgia. Participants at the meeting included NPS staff from the park, Geologic Resources Division (GRD), and Southeast Coast Network (SECN) and cooperators from the U.S. Geological Survey (USGS), Florida Geologic Survey (FGS), University of West Georgia (UWG), University of Georgia (UGA), Polk Community College (PCC), and Colorado State University (CSU) (see table 2).

This scoping summary highlights the GRI scoping meeting for Castillo de San Marcos National Monument including the geologic setting, the plan for providing a digital geologic map, a summary of geologic resource management issues, a list of significant geologic features and processes, and a record of meeting participants.

Park and Geologic Setting

Castillo de San Marcos National Monument preserves the oldest masonry fort in the continental United States. The monument encompasses 8.18 ha (20.21 ac) in the city of St. Augustine, Florida and lies 2.75 km (1.70 mi) west of the Atlantic Ocean. Overlooking Matanzas Harbor, which is part of the Matanzas River and the Intracoastal Waterway, Castillo de San Marcos is sheltered from the Atlantic Ocean by Villano Beach (to the north) and Anastasia Island (to the south).

Castillo de San Marcos National Monument, along with the entire state of Florida, lies on the Floridian Plateau, a physiographic province approximately 800 km (500 mi) long and 400 – 640 km (250 – 400 mi) wide. The plateau, which has existed for millions of years, includes both emergent land and submerged continental shelf. Areas on the plateau have been alternately covered by

seawater and exposed as dry land many times in the past so that marine and terrestrial deposits have been deposited one on top of the other.

Holocene (10,000 years ago to present) sediments, primarily derived from a beach environment, comprise the surface geology of the monument. Undifferentiated sand, clay, shells, and limestone dating from the Upper Miocene (11.6 – 5.3 million years ago) to the Holocene extend to 30 m (100 ft) in the subsurface. Although the Anastasia Formation is not exposed at Castillo de San Marcos National Monument, fossilized shells from this unit were used to construct the fort.

Regional Coastal Geology (Randy Parkinson)

Five major northeast-southwest trending geologic zones define the landscape in the southeastern United States. From northwest to southeast, these geologic zones include the Appalachian Plateau, Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain provinces. With the exception of the Coastal Plain province, these zones record a history of continental collision at a time when all the major landmasses came together to form the supercontinent, Pangaea. When Pangaea began to split apart in the Early Triassic, approximately 250 million years ago, rifting began along the eastern seaboard that would eventually open the Atlantic Ocean.

The Coastal Plain formed approximately 100 million years ago to less than 1,000 years ago from sediments transported into the region from the other provinces and by south-flowing longshore currents. A "Fall Line," an abrupt change in elevation recognized today on topographic maps by a series of waterfalls, separates the low-lying Coastal Plain from the rolling topography and foothills of the much older Piedmont Province. As the Coastal Plain formed, terrigenous (land derived) sediments dominated deposition north of the fall-line. In contrast, the offshore Florida Platform formed from calcium carbonate (limestone). A northeast-southwest trending channel located across the neck of the Florida Peninsula isolated the Florida Platform from the terrigenous sediments of the Coastal Plain. Terrigenous sediments eventually filled the channel and spilled over onto the peninsula.

Marine terraces on the Coastal Plain mark the location of various shorelines through time. A stable sea level is a rare geologic event. About seven paleo-coastlines can be mapped on the Georgia plain, for example. Over the past 250 million years, sea level has oscillated by as much as 300 m (980 ft). Global controls on sea level include the available volume of the ocean basins and the volume of sea water in those basins. Fluctuations in relative sea level continue to influence Coastal Plain geomorphology. Locally, subsidence and compaction of sediments may influence the local rise and fall of sea level.

Glacial and interglacial periods have an indirect effect on sea level by influencing the volume of sea water in the ocean basins. Once the last Pleistocene glaciers melted, the north Atlantic coastlines, once depressed under thousands of feet of ice, began to rebound so that the rising land surface currently keeps pace with the relative rise of sea level.

Rivers flowing from the melting glaciers carried large volumes of sediment to mid-latitude coastlines, including coastlines from Georgia to north Florida. Atlantic coastlines in central and southern Florida illustrate a transition from a mix of carbonate and clastic (broken fragments of

preexisting rock) sediments to coastlines dominated by carbonates. For example, Canaveral National Seashore contains about 50% clastic sediments and 50% carbonate sediments whereas Miami has mostly carbonate beaches and the Florida Keys are 100% carbonate.

Worst case scenarios of relative sea level rise along the Atlantic coast projected in 2007 are now considered to be the "lower limit" of 2009 predictions. Using various sea level models, resource managers may wish to incorporate "trigger points" and "adaptation strategies" into management policy. These trigger points may signal a potential shift in habitat, depositional environments, or other natural processes that may initiate a significant change to the estuarine ecosystem.

Geologic Mapping for Castillo de San Marcos

During the scoping meeting, Stephanie O'Meara (CSU) briefly displayed some of the main features of a GRI digital geologic-GIS map, which includes source map notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic-GIS map model using ESRI ArcGIS software. Final digital geologic-GIS map products include GIS data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, an Adobe Acrobat PDF help document that captures ancillary map data, and an ESRI ArcGIS ArcMap document file that displays the map, and provides a tool to access the PDF help document directly from an ArcMap document. Final data products are posted at http://science.nature.nps.gov/nrdata/. The data model is available at http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 1). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps (table 1) and mapping needs in the vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data or develop a plan to obtain new mapping, if necessary.

Map coverage is available for all of the quadrangles of interest for CASA from updated geomorphic digital data expected to be published by the Florida Geological Survey in January 2010. Harley Means (FGS) stated the new geomorphic map will incorporate updated mapping and will provide more detail than the existing geologic map of Florida (Scott et al. 2001).

The GRI will evaluate the quality of the FGS digital data and distribute an image of the data to Andrew Rich (NPS CASA, FOMA) and Linda York (NPS SERO) to determine the usefulness of the data to CASA park resource management. The GRI will, in all likelihood, use this new work as the basis for the digital geologic map for the park.

At the scoping meeting Andrew Rich stated that the FGS digital data could prove useful to general park management issues outside the monument boundaries, however, more detailed geomorphic mapping may be needed for areas within and immediately adjacent to the monument.

Table 1. GRI Mapping Plan for Castillo de San Marcos National Monument

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Saint Augustine	Includes CASA park boundary	Unpublished Geomorphic Map of the State of Florida, Florida Geological Survey, 2010	digital	The digital map has not been finalized, and requires review by GRI, the park and others	Obtain GIS data from Florida Geological Survey in early 2010 and evaluate data quality and distribute map image to the park and others to assess the usefulness to the park
Saint Augustine Beach	Near CASA park boundary				

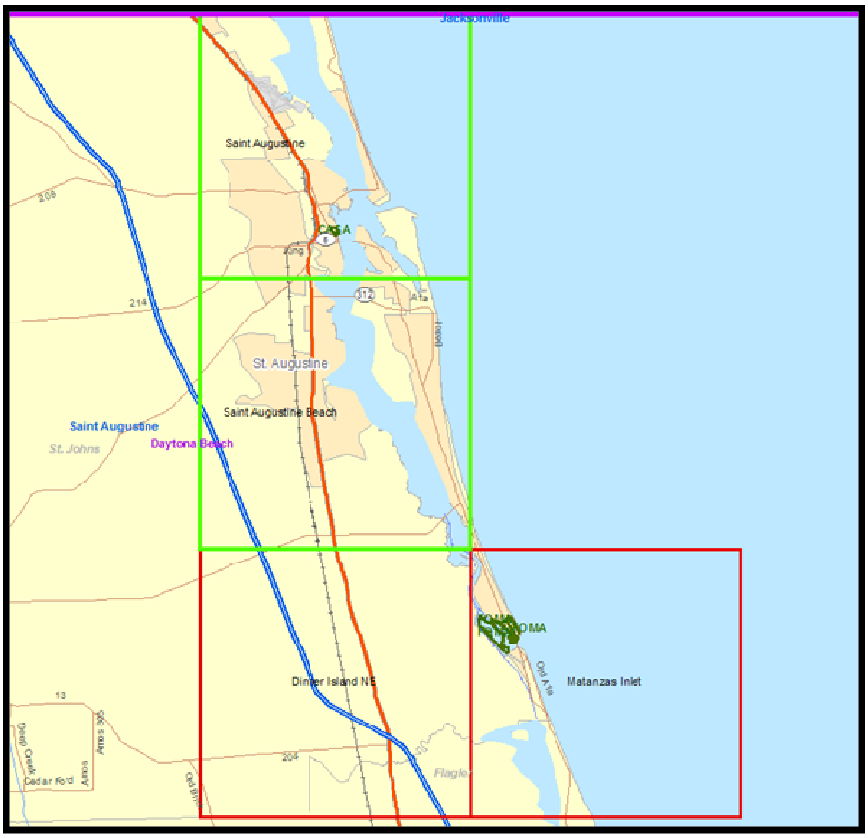

Figure 1. Area of interest for Castillo de San Marcos National Monument (CASA) and Fort Matanzas National Monument (FOMA). The 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30-minute by 60-minute quadrangles, whereas names and lines in purple indicate 1x2 degree quadrangles. Green outlines indicate national preserve and memorial boundaries.

More detail geomorphic mapping, as determined by Andrew Rich or Linda York, would require new mapping that leverages from recent LIDAR data. USGS Coastal Geologist Jim Flocks agreed to investigate what LIDAR coverage might be already available. Depending on the level of GRI funding, a solicitation for bids for a new map of the park could be announced in 2010 on the Federal Business Opportunities website, FedBizOpps.gov. Standards for the map product will be detailed in the solicitation but would likely include delivering a product similar to the detailed geomorphic mapping produced in the GRI Geology-GIS Geodatabase Data Model format for the GRI at Canaveral National Seashore.

Geologic Resource Management Issues

The principal geologic resource management issues discussed during the scoping session involved the stability of the historic seawall, flooding, the structural integrity of the fort, and impacts from climate change. Other issues included potential subsidence, very minor seismic (earthquake) potential, and issues related to climate change.

Stability of Historic Seawall

In the 1930s, a housing subdivision was constructed on man-made fill about 0.5 km (0.3 mi) across the inlet from the monument. The subdivision initiated the construction of the seawall to protect the monument's shoreline. Located on the inlet, the seawall is subjected to wind-driven wave action, especially during high tides, and is being undercut by erosion. The seawall cement shows signs of failing, and subsidence is currently creating drainage issues. The inlet has been manipulated by dredging to maintain navigation in the Intracoastal Waterway and construction of jetties, seawalls, and other shoreline hardening structures. The manipulated shoreline may negatively impact seawall stability by increasing wave action and erosion. Management is currently considering repairing or replacing the seawall.

Flooding

During tropical events, flooding may inundate the park and parking lot with 15-25 cm (6-10 in) of water. Built on a hill constructed from material dug from an old Indian village, the fort usually is not under water. However, flooding may negatively impact the fort's structural integrity by causing subsidence and limestone dissolution in the subsurface. Spring tides may also cause flooding in the parking lot.

Structural Integrity of the Fort

In the past, water in the moat and heating and cooling of the fort caused groundwater to percolate through the subsurface. Percolating groundwater may have initiated local subsidence and subsequent expansion cracks in the fort's foundation. No further subsidence has occurred since the water was removed from the moat and the cracks filled.

Potential Impacts from a Changing Climate

Sea level rise due to changing climate may permanently submerge the monument's parking lot, which is currently at sea level. With climate change, storm intensity is expected to increase, and this will potentially increase the damage to the seawall from wind-driven waves and erosion. The fort's walls, constructed as they are from shell material (coquina), may dissolve more quickly if the water chemistry in the inlet changes to produce more corrosive sea spray. This may result in more maintenance issues. Habitat may be altered and exotic plant and animal species introduced into the area.

Other Geologic Management Issues

Dissolution of subsurface limestone. There are no cave or karst issues on the surface, but limestone in the subsurface may dissolve, creating the potential for sinkholes and subsidence.

Seismic issues. A 2007 earthquake in the Gulf of Mexico was felt in St. Augustine, and a historic earthquake in Charleston, South Carolina rang the bell in St. Augustine. However, the potential for earthquake damage at Castillo de San Marcos National Monument is believed to be very minor.

Features and Processes

The scoping session for Castillo de San Marcos National Monument provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRI report. Please note that the National Park Service monitoring manual (R. Young and L. Norby, editors. *Geological Monitoring*. Special paper. Geological Society of America, Boulder, CO.) is currently in press and will contain information on monitoring of geologic features and processes found in NPS coastal units. These features at Castillo de San Marcos National Monument include:

- *Fluvial features*. Stream channel morphology and the interaction of river and tidal inlet processes.
- *Coastal features*. Shoreline hardening.
- *Paleontological resources*. Larry West (NPS SECN) suggested consulting the recently published Paleontological Resource Inventory and Monitoring report for the SECN to review the paleontological resources in the monument (Tweet et al. 2009). The following information is from that report.

  Although no definite fossils are housed at Castillo de San Marcos, twelve specimens from the monument are stored at the Southeast Archeological Center (SEAC). All of the specimens are chondrichthyan (fishes with a cartilaginous skeleton) and are probably shark teeth. Fossils may be found associated with cultural resources at Castillo de San Marcos. The most obvious example of fossils in a cultural context is the coquina fort, but there may be other archaeological sites in the subsurface of the monument that contain fossil shells, bones, and tools.

References

Scott, T.M., K. M. Campbell, F. R. Rupert, J. D. Arthur, T. M. Missimer, J. M. Lloyd, J. W. Yon, and J. G. Duncan. 2001. Geologic map of the state of Florida. Scale 1:750,000. Map Series 146. Tallahassee, FL: Florida Geological Survey.

Tweet, J. S., V. L. Santucci, and J. P. Kenworthy. 2009. *Paleontological resource inventory and monitoring: Southeast Coast Network*. Natural Resource Technical Report NPS/NRPC/NRTR – 2009/197. Fort Collins, CO: National Park Service, Natural Resource Program Center.

Table 2. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
Bryant, Richard	NPS TIMU & FOCA	Chief, Resource Management	904-221-7567	richard_bryant@nps.gov
Bush, David	U. of West Georgia	Professor of Geology	678-839-4057	dbush@westga.edu
Byrne, Mike	NPS SECN	Terrestrial Ecologist	912-882-9203	michael_w_byrne@nps.gov
Corbett, Sara	NPS SECN	Botanist	972-882-9139	sara_corbett@nps.gov
Curtis, Tony	NPS SECN	Coastal Ecologist	912-882-9239	tony_curtis@nps.gov
DeVivo, Joe	NPS SECN	Network Coordinator	404-562-3113 x 739	joe_devivo@nps.gov
Flocks, Jim	USGS CCWS	Geologist	727-803-8747 x 3012	jflocks@usgs.gov
Fry, John	NPS CUIS	Chief, Resource Management	912-882-4336 x 262	john_fry@nps.gov
Graham, John	Colorado State U.	Geologist – Report Writer	970-581-4203	rockdoc250@comcast.net
Heise, Bruce	NPS GRD	Geologist - GRI Program Coordinator	303-969-2017	bruce_heise@nps.gov
Jackson, C.J.	University of Georgia/Polk CC	Coastal Geologist	863-258-4226	jackson.cwjr@gmail.com
Means, Harley	Florida Geological Survey	Geologist	850-487-9455 x 112	guy.means@dep.state.fl.us
O'Meara, Stephanie	Colorado State U.	Geologist, GRI Map Team Coordinator	970-225-3584	Stephanie_O'Meara@partner.nps.gov
Parkinson, Randy	RWParkinson Consulting	Coastal Geomorphologist	321-373-0976	rwparkinson@cfl.rr.com
Rich, Andrew	NPS CASA & FOMA	Chief, Resource Management	904-471-0116	andrew_rich@nps.gov
Spear, Denise	NPS FOFR	Cultural Resource Specialist	912-638-3639	denise_spear@nps.gov
Spechler, Rich	USGS WRD	Hydrologist	407-803-5523	spechler@usgs.gov
Stiner, John	NPS CANA	Chief, Resource Management	321-267-1110	john_stiner@nps.gov
West, Larry	NPS SER	IM Coordinator	404-562-3113	larry_west@nps.gov
Wester, Mary Beth	NPS FOFR	Superintendent	912-638-3639	mary_beth_wester@nps.gov
Wester, Randy	NPS FOPU	Acting Superintendent	912-786-5787	randy_wester@nps.gov