

The Conservation and Preservation of Coquina



A Symposium on Historic Building Material in the Coastal Southeast

Held January 24-26, 2000
at St. Augustine, Florida



Division of Historical Resources
Florida Department of State

Katherine Harris
Secretary of State

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Co-sponsored By:

Florida Division of Historical Resources, Florida Trust for Historic Preservation, National Park Services (Castillo de San Marcos National Monument and National Center for Preservation Technology and Training)

*Cover: Fort Marion (Castillo de San Marcos),
St. Augustine, Florida (circa 1912 postcard)*

*Above: Coquina Stairway, Castillo de San Marcos
from early postcard (photo courtesy Florida State Archives)*

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Conservation and Preservation of Coquina**

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Introduction

David Ferro, R.A

Coquina, a limestone conglomerate material named for the shells of the small mollusks it contains, was used as building stone in St. Augustine as early as 1598 for construction of a powder house. This was the beginning of a building tradition that extended into the 1930s along Florida's Atlantic Coast.

In the St. Augustine vicinity, Castillo de San Marcos, Fort Matanzas, the Old City Gates, the Cathedral, Spanish and British Period residential structures, property line walls and tombs were constructed of coquina quarried on Anastasia Island. To the south in New Smyrna, a large storehouse and wharf were constructed of coquina at the ill-fated 1770s Turnbull colony. Around 1816, John Addison constructed a kitchen house of coquina on his plantation on the Tomoka River. The material was also used in the construction of mill structures on sugar plantations in the 1820s and 1830s. Examples are the Bulow, Dunlawton and New Smyrna Sugar Mills. In these early structures, the porous coquina was protected by lime plaster. With the exception of a few residences that have been restored in St. Augustine, the coquina masonry of these structures is today exposed to the elements and is slowly deteriorating.

The Edward Porcher House in Cocoa is an early 20th century residential example of the use of coquina. Through the 1930s, the material was used for construction of foundation piers, entire structures for various uses, and as a decorative material. In the 1930s, significant public works in the region were constructed of coquina. Two examples are Government House in St. Augustine and the Daytona Beach Bandshell, both WPA projects. In these 20th century examples, the coquina was never protected by a plaster finish. The bandshell exhibits serious deterioration and is the subject of a current stabilization effort.

In addition to the numerous resources in Florida, historic coquina structures and quarries have been identified in the southern coastal region of North Carolina. At present, there are no known quarries or structures constructed of the material elsewhere.

Although coquina is one of the simplest of building materials, issues relating to its preservation are complex. There is little known research on coquina as a building material. Federal state and local government site managers, and private groups responsible for stewardship of coquina are faced with a broad range of threats to this fragile material, ranging from natural erosion to damage from vibration induced by vehicular traffic. Of possible preservation and stabilization measures known, which would be most effective in addressing threats to historic coquina resources, with the least chance for long-term adverse effects.

The Florida Division of Historical Resources has a special interest in identifying the most appropriate preservation and conservation treatments for this material. Some of the most important historical resources in the state are constructed of coquina. Most are in coastal areas where they are exposed to a severe natural environment. While governmental and private stewards of these resources struggle to "do the right thing" in their preservation efforts, with no

solid scientific data, it is not possible to know the long-term effects of treatment actions taken today. A recent well-meaning proposal put forth for preservation of historic coquina at one Florida property could have actually accelerated the rate of failure of the material over the long term.

To address this problem, the Florida Division of Historical Resources, in conjunction with the Florida Trust for Historic Preservation, Castillo de San Marcos National Monument, and the National Center for Preservation Technology and Training have co-sponsored the symposium Conservation and Preservation of Coquina.

This symposium was planned to complement the Conservation and Preservation of Tabby symposium conducted by the State of Georgia in 1998. The January 2000 symposium provided an opportunity, over a three-day period, for participants representing the disciplines of history, historic preservation, architecture, archaeology, and geology, as well as craftsmen with hands-on experience, to discuss:

- a. the pathology of coquina;
- b. its use in historic structures;
- c. causes of its deterioration;
- d. recent and current preservation treatments; and
- e. additional research needs.

The symposium format combined formal presentations and round table discussions with an opportunity to visit several coquina resources located between St. Augustine and New Smyrna Beach. Technical presentations from the symposium have been documented in these proceedings, and may be accessed on the Internet at www.flheritage.com.

The Coquina Resources of Florida's East Coast

Thomas M. Scott, Ph.D., P.G.

Introduction

Spanish explorers settled on the eastern coast of Florida in the 1500s where they built a settlement and a fort utilizing local building materials. The most important local building material was the native “rock” of the St. Augustine area— coquina. Were the Spanish aware of the presence of the coquina when the site was selected or was it a fortuitous occurrence? Because the Spanish colonists extensively utilized the coquina, it could be referred to as Florida's most historically significant building material.

What is Coquina?

Coquina is a poorly indurated (cemented) rock composed of a mixture of quartz sand and mollusk shells. The percentages of quartz sand and shell vary widely, ranging between nearly pure sand to completely shell. The mollusk shells are both whole and fragmented. Some of the shells are quite abraded indicating transport or movement by waves and currents prior to deposition. The primary fossil mollusk in the coquina along Florida's eastern coast is a small pelecypod (clam) – *Donax* sp. Other mollusks are present including oysters and the large gastropod (snail) *Busycon* sp.

Coquina Distribution

Coquina deposits occur primarily along the eastern coast of peninsular Florida (Figure 1). This coquina is named the Anastasia Formation after Anastasia Island where the Spanish quarried the poorly indurated rock to construct the Castillo de San Marcos in St. Augustine (Sellards, 1912). The Anastasia Formation occurs from just north of St. Augustine in St. Johns County, to southern Palm Beach County. The Anastasia Formation and associated sand form part of the Atlantic Coastal Ridge, a Pleistocene barrier island chain that extends from Duval County to Dade County. Other coquina deposits are found in the state but occur only in limited areas.

The Anastasia Formation is exposed in a number of places along the east coast. The best and most impressive places to see the Anastasia Formation naturally exposed along the coast are at Washington Oaks State Park (The Rocks, Flagler County) (Figure 2), Gilbert's Bar House of Refuge, Hutchinson Island (Martin County) (Figure 3) and the Nature Conservancy's Blowing Rocks (Palm Beach County). The House of Refuge site in Martin County is the most spectacular with as much as 10 feet of coquina exposed. The exposures of coquina along the beaches vary in size and shape. At times sand piles up around the outcrops, covering much of the exposure. Following storms, more rock is often exposed.



Figure 2. Anastasia Formation coquina exposed at “The Rocks” in Washington Oaks State Park



Figure 3. Anastasia Formation exposed at Gilbert’s House of Refuge, Hutchinson Island, Martin County

Manmade exposures of coquina generally occur in mining operations. A few exposures are known to occur in road cuts. The single, best exposure of the Anastasia Formation is in a road cut in Palm Beach County. The road cut on Country Club Road in Palm Beach (Figure 4). The outcrop is approximately 20 feet (6 meters) high and 600 feet (180 meters) long (Lovejoy, 1992).

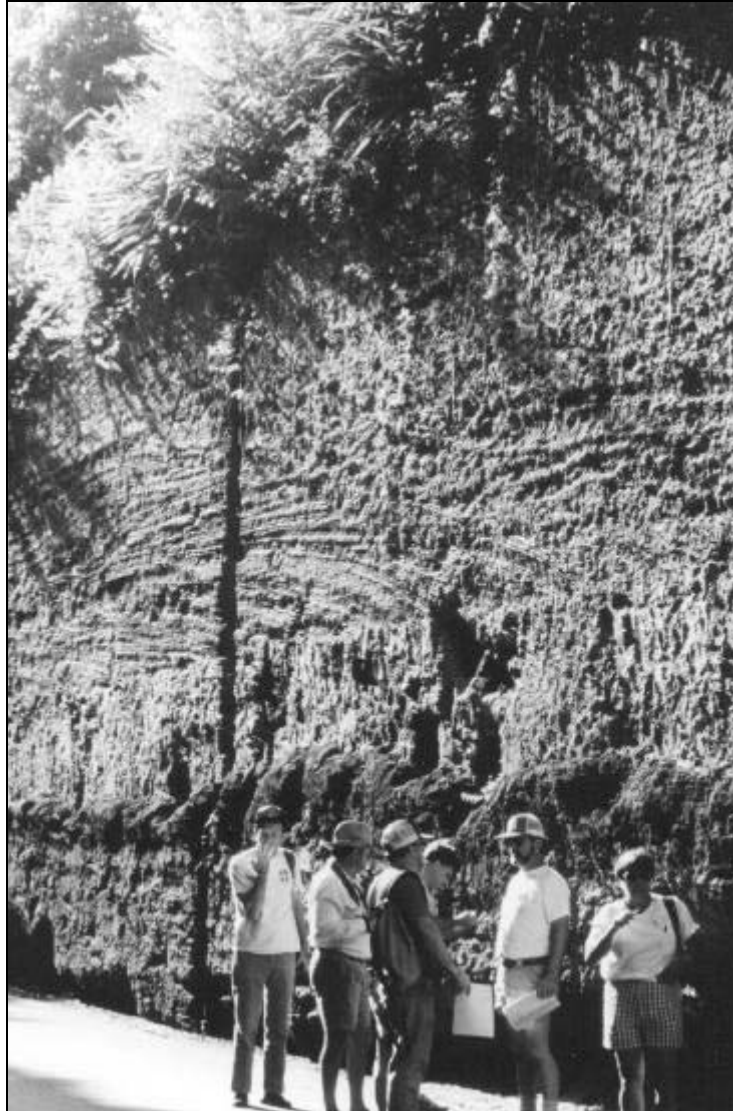


Figure 4. Road cut exposure along Country Club Road in Palm Beach, Palm Beach County

Coquina Formation and Characteristics

Florida formed as the result of the interaction of many geological factors. Fluctuating sea levels have had important effects on the state's development. During the Pleistocene Epoch (1.6 million to 10,000 years ago), sea levels varied from as much as 100 feet (30 meters) above the present sea level to more than 400 feet (120 meters) below the current level. Coastal features formed and coastal sediments were deposited in areas that now are well above sea level.

Coquina forms as the result of sediment deposition on beaches by waves and currents. Mollusk shells, from organisms living in the near-shore zone, are moved on to the beach and mixed with quartz sand (Figure 5). The quartz sand is the result of the weathering and erosion of older rocks and sediments. The sand is transported into the marine environment by streams and rivers then moved by currents and waves along the coastline. Wave and current action deposits shell and sand forming beaches and barrier islands that are common along Florida's coasts. When sea level dropped, shell-bearing sediments were influenced by rainwater soaking into them as the surficial aquifer system was recharged. Rainwater is naturally acidic and as the water seeps through the organic matter on the ground it becomes more acidic. The shell material is composed of calcium carbonate so acidic groundwater dissolves it until the water becomes saturated with calcium carbonate. Once the water is saturated with calcium carbonate, calcite can be deposited cementing the sand and shell together creating coquina (Figure 6). The coquina is weakly cemented or indurated with calcite.



Figure 5. Loose sediment composed of shell debris and quartz sand

The Anastasia Formation coquina lithologies exhibit significant variation in both a vertical (deeper underground) and lateral (north to south) sense. The sediment characteristics vary from a rock composed of poorly cemented shell material with minor sand to more cemented quartz sand with little to no shell. There are layers within the formation that consist of loose, uncemented sand and shell. There is a general trend of the coquina containing more shell from St. Augustine

to Cape Canaveral and more sand from Cape Canaveral to West Palm Beach. Descriptions of the Anastasia Formation can be found in Cooke (1945) and Puri and Vernon (1964).



Figure 6. Anastasia Formation coquina

Florida's coquina "rock" is relatively soft when compared to other limestone found in the southeastern United States. Rather than making a hammer "ring" as when it hits a brick, hammering on a piece of coquina delivers a soft "thud." Quarrying of the coquina is relatively easy due to the soft nature of the rock. Quarrying for building stone is done by cutting blocks of the soft stone. The Anastasia Formation is currently mined primarily for fill material and road base.

Since the rock is composed of shells made of calcium carbonate and it is cemented together by calcite, once the rock is exposed to weathering it will begin to disintegrate. Weathering of the coquina will also cause the surface of the rock to blacken and case harden. Other calcareous rocks including marble, a metamorphic rock, and limestone, a sedimentary rock, will also disintegrate when exposed to weathering.

Anastasia Formation outcrops reveal some interesting and intriguing features. Cross beds of sand and shell (beds dipping at an angle to horizontal) are a common feature of the formation. Fossilized burrows of marine organisms are frequently encountered. One of the most intriguing features is the bowl-shaped depressions on the upper surface of the coquina (Figure 7). These features are formed by cabbage palms that grew on the surface of the coquina. The cabbage palm roots dissolve the coquina forming the bowl. Occasionally, there will be calcified root structures associated with the depression.



Figure 7. Exposure of features on top of the Anastasia Formation, Martin County

Restoration of Weathered Coquina

A number of individuals attending the Coquina Preservation Symposium were quite interested in stabilizing disintegrating coquina utilized in historical structures. Although there does not appear to be any geological literature reporting on coquina stabilization or restoration techniques, there may be methods to investigate. One suggestion was the stabilization and hardening of the coquina through the use of non-water soluble glue. Another interesting discussion revolved around the hardening of weathered coquina by precipitating calcite from solution. It would be most interesting to attempt this by submerging coquina in a hot, supersaturated calcium carbonate solution. As the solution cools, the calcite may be deposited, essentially recementing the rock.

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Coquinas Of Coastal North Carolina: A Preliminary Assessment

John J. Mintz

Abstract

Coquina, also known locally as marl or shell rock is a medium to very coarsely grained fossiliferous sand to arenaceous fossiliferous limestone composed of broken shells, corals, and other organic debris. It has a very limited distribution in southeastern North Carolina. The best known and perhaps the only well documented outcrop is located in southern New Hanover County, North Carolina near Fort Fisher. This paper will attempt to map its distribution, and discuss the distribution of coquina in the southern coastal region of North Carolina, discuss its use as a building material of Colonial Period residences, and finally discuss both past and present mining practices. Brief attention will be directed toward the preservation of structures assembled with Coquina.

The purpose of this paper is threefold: first it will map the distribution and briefly discuss the distribution of coquina in the southern coastal region of North Carolina; second it will discuss, utilizing several examples, its use in North Carolina as a Colonial-era building material; and finally it will review both past and present mining practices and current use. However, before beginning it is important to point out that the identification, distribution, use as a building material, and preservation practices of coquina in North Carolina is in its infancy. Indeed, during the course of researching and preparing this study it became readily apparent that there are several definition of coquina; the geologist's definition, the architectural historian and/or preservation planner definition, and the laypersons definition and many times they are not the same. For example a careful perusal of the relevant literature and conversations with homeowners finds the terms, marl, shell rock, tabby, and coquina used interchangeably. For the informed this could lead to less than desired results if a self-restoration project is the goal. Nevertheless a beginning is a beginning and that is the overall goal of this paper.

The study area is situated within the lower Cape Fear region of the Coastal Plain province of southeastern North Carolina. Geographers have divided this area into two physiographic regions, the Tidewater and the Inner Coastal Plain (Stuckey 1965:6). The Coastal Plain is described as "a low-relief plain underlain by beds of shallow-marine, estuarine, shoreline, and fluvial sediments (Feiss et al. 1994: 339)." These beds were deposited during numerous episodes of sea level rise and fall.

The Tidewater region of North Carolina has the distinction of being one of the world's more complex coastlines. The region is constantly changing in response to wind and wave action, sedimentary deposition, tidal movements, and changes in sea level. The Inner Coastal Plain is considered to be more stable and is generally comprised of gently sloping sandy and loamy uplands that have been dissected by large rivers with broad well-developed floodplains.

The following discussion of the geology and distribution of Coquina found in the Neuse Formation is drawn from research conducted by James A Dockal, *The Coquinas of the Neuse Formation, New Hanover County, North Carolina*.

Coastal Geology

The Coastal Plain of North Carolina was inundated by repeated marine transgressions due to fluctuating sea levels during the late Pliocene and early Pleistocene. These periodic inundations coupled with minor tectonic adjustments altered the elevation of the continental shelf relative to sea level and realigned basin configurations. These two factors along with variations in marine paleoclimate controlled the deposition of geologic stratigraphic units along the coast (Ward et al. 1991:274-282). Included within these geologic units are bands of fossiliferous sands dating to the Pleistocene that historically have been referred to as Cape Fear Coquina. Dockal (1996), however, has proposed that this name be replaced by the name Neuse Formation. Coquina is the product of post-depositional diagenesis of carbonate shell bearing shore face sands where dissolution, cementation, and calcitization of aragonite occurred at near the paleo-water table (Dockal 1996:11).

Distribution

Dockal (1996:11) notes that the coquina found along the southern tip of Coastal North Carolina, in the area of Fort Fisher in New Hanover County represents one of the very few naturally occurring rock outcrops in the Coastal Plain Province of North Carolina. This outcrop is not laterally extensive nor very thick but occurs as sporadic isolated patches in a north-south arcuate band over an area roughly 15 km long by 3 km wide. The best exposure of the coquina is found on the northern bank of Snow Cut immediately west of the US 421 bridge. The coquina present at the Snows Cut locale range from a medium to very coarsely grained fossiliferous sand to an arenaceous fossiliferous limestone. Dockal (1996:13) notes that there are coarser zones that contain whole molluscan shells, including *Mercenaria*, *Busycon*, *Crassostrea*, and *Rangia*. The coquina situated at the west end of the north bank of Snow Cut had a maximum thickness of 1.5 meters and narrows rapidly both eastward and westward; coquina present on the south bank are over 2 meters thick but generally exhibit a poor exposure.

The coquinas identified at Fort Fisher are very similar to the present at Snow Cut, as they are not laterally extensive. A comparison of borings made in 1931 (the 1931 study suggested that the coquina was approximately 9 feet thick), those made in 1982, and the present outcrop suggest that the main body of coquina was to the east of the beach and since 1931 has generally eroded away. This rapid erosion is thought to be the direct result of the mining that took place at Fort Fisher in the early 1930s. It is known that this mining accelerated the shore face erosion.

Mining

From historical records and extant buildings, foundations, basements, and retaining walls, it is known that the mining of coquina was being conducted by at least 1760. This is witnessed by the extant architectural ruins at the colonial-era Clear Springs plantation located near New Bern in Craven County, North Carolina. According to Peter Sandbeck and others it is quite probable that the Coquina used in the construction of Clear Springs, the Green House and Barn, and the Coor-Gaston House was mined at the Clear Springs house site. Sandbeck notes that a one-story one-room addition to the Green House,

located in the Spring Garden vicinity was heated by a stepped single-shoulder chimney built upon a rare coquina base. Another Colonial-era home, the Sedgley Abbey plantation site located near Carolina Beach in New Hanover County, North Carolina was constructed not only out of locally available coquina but the cellar was actually quarried out of an outcrop that coursed underneath the house. Here one question begs to be asked. Was Sedgley Abbey intentionally sited to take advantage of the coquina outcrop or was it a fortuitous siting? To fully and accurately answer questions like these, more information including architectural, historical, and archaeological is needed. For example architectural historians can provide information on the structures relative age, style, and building treatments; historians can provide information on land tenure, past use, and possible genealogical information, and finally archaeologists can provide data regarding below surface features including foundations, piers, and artifact distributions. More recent (ca 1930s) the large-scale mining of coquina for use in highway construction was undertaken at Fort Fisher. An unanticipated and regrettable consequence of this mining was the increased and accelerated erosion at Fort Fisher.

Currently, the North Carolina Geologic Survey lists 22 quarries or borrow pits mines that have identified themselves as coquina mines. Of these 11 are in Brunswick County and 11 are in Onslow County. Seven of the mines are listed as active, 4 are listed as inactive (i.e., not currently being mined), and the remaining 11 are listed as retired mines (i.e., mines that have been exhausted of the available coquina). Information obtained from the North Carolina Geologic Survey to date suggests that the coquina removed from these mines was primarily used in road construction.

Comparative Sites

Clear Springs

Clear Springs Plantation also known as Green's Thoroughfare or the Dawson Place is a vernacular story and a-half, Georgian dwelling that was probably built around 1763 for James Green (1710-1788) a prominent planter from Craven County, North Carolina (Peter Sanbeck, personal communication 2000). According to Sandbeck the dwelling was constructed on or near a coquina outcropping just west of Bachelor's Creek. The structure fronts the creek, which is fed by a spring that flows out of a coquina hummock. It is interesting to note that Clear Springs was built on an outcropping of natural marl (i.e., coquina/shell conglomerate) and this material was used in constructing the foundation and chimney bases of the house. Indeed, the outside entrance to the basement is through a coquina bulkhead at the rear bay of the southwest side. Sometime between 1864 and 1891 a newspaper article described the property as:

Belonging to Mr. Cicero Green, distant 12 miles from New Bern, is probably one of the most beautiful and picturesque places in eastern North Carolina. Through the portion of the farm in front of the dwelling runs a beautiful, clear, cold stream of water fed from a gushing spring running from under a huge boulder of conglomerate shell rock... both banks of this stream, for distance of several hundred yards, are of this rugged rock lying in detached boulders of enormous size... The foundation of the building is a shell rock (coquina) wall rising to the height of six feet, laid in mortar which is now as hard as the hardest granite, unlike the contract mortar so freely used in New Bern.

It is possible that the successful use of coquina as a building material may have led to its use as a foundation material in several of the earliest houses in New Bern (Peter Sandbeck, personal communication 2000). The Coor-Gaston House, circa 1792, and the Green House and Barn (ca 1850) and several others of the same era have marl foundations. When the wall was constructed around Cedar Grove Cemetery in New Bern in the 1850s, it too was made of marl. It seems certain from existing records that most of the material for the Cedar Grove wall came from quarries for the stone are known. Remains of the quarries, immediately to the front of the Clear Springs House, are still obvious, and it is likely that the cutting of marl provided considerable income for the Green family.

Sedgley Abbey

The opening of the lower Cape Fear region to settlers and merchants was largely due to the efforts of proprietary and later royal governor George Burrington. Governor Burrington along with Maurice Moore, and other prominent planters from South Carolina were largely responsible for the development of the colonial port, Brunswick Town which from the time of its founding in 1725 to its abandonment around 1812 was the political, social, and commercial center of the lower Cape Fear settlement. Benefiting their status many of these wealthy planters and merchants built large and fine homes. Among these, was one that was constructed adjacent to a newly completed coastal road that extended from the eastern terminus of the Brunswick ferry into Onslow County. Located south of Wilmington and just northeast of Doctor's Point along present-day Telfair's Creek was built a fine home and plantation in the mid 1700s, possibly by one William Lord. Later named Sedgley Abbey by its then owner, (ca 1780) the Scottish merchant Peter Maxell. Peter Maxwell and his wife Rebecca resided at Sedgley Abbey until December 1801, when they offered their home on the beach for rent and moved into nearby town Wilmington. An advertisement for the plantation appeared in the Wilmington Gazette, December 14, 1801.

To Rent

For a term of years, as may be agreed on, that fruitful, healthful, and beautiful plantation, near the head of the sound, known by the name Sedgley Abbey, on which there is a commodious and well furnished dwelling house, open to the sea beach by an avenue, and about half a mile from the sound... There is also on the same a good kitchen; smokehouse, barn, stables, and chairhouse {i.e., carriage house}, with a remarkable peach orchard...

Other advertisements soliciting renters appeared in 1802, 1805, and 1806, thereby suggesting that the Maxwell's were not successful in their efforts to obtain renters "for a term of years". After Rebecca and Peter Maxwell's death (1810 and 1812, respectively). The plantation was sold and then resold to local prominent landowners and merchants. As time progressed, the once grand home of Peter Maxwell began to suffer from neglect and multiple owners. By the 1870s the once grand, colonial era plantation, Sedgley Abbey lay in ruins, and by the early 1900s only the cellar was visible (Jackson 1995). In 1896 the noted historian of the lower Cape Fear region James Sprunt described the ruins of Sedgley Abbey:

It was said to be the grandest colonial residence of the Cape Fear. It was about the dimension and appearance of the Governor Dudley mansion in Wilmington, and was erected about 170 years ago... by an English gentleman of

wealth and refinement... The house was built of coquina, a rock up of marine shells slightly consolidated by natural pressure and infiltrated calcareous matter... The cellar remains having been cut out of solid rock...

In 1909 Alfred Waddell in describing the plantation of the lower Cape Fear region stated that according to tradition the house had a tradition of “some pretensions to unusual elegance of structure and equipment ... but there is no record which the tradition may be corroborated” (Wadell 1909:68).

Since its fall to ruin in the late 19th century, the site of Sedgley Abbey has been well known to bottle collectors, amateur history buffs, and local antiquarians. Unfortunately, some, in their quest for information and souvenirs excavated large holes in and around the exposed foundations and removed artifacts and blocks the coquina. It was not until 1978 that Mark Wilde-Ramsing, an archaeologist with the North Carolina Department of Cultural Resources relocated the cellar ruins during a state sponsored survey of New Hanover County. According to Wilde-Ramsing the cellar had been excavated by the original builders some eight feet (2.4m) into the underlying coquina outcrop. Limited pedestrian investigations of the site in 1992 determined that the foundation measured some 30 feet by 12 feet (9.1-3.6m), with the western elevation measuring some 6 feet (1.8m) below current ground surface. According to Wilde-Ramsing (1992) the house site is situated approximately 20 feet east of a dirt road that was reportedly the original road connecting Wilmington to Federal Point. He notes that the site was heavily overgrown and well hidden in dense secondary growth vegetation. Further investigation of the house site in 1995 resulted in the partial exposure of what was though to be the main structure foundations. This subsurface investigation revealed a 35 by 22-foot (10.6 by 6.7-m) coquina block foundation and a 30 by 30 foot area located approximately 60 feet east of the foundation. Wilde-Ramsing (1995) noted that the building foundation was too badly disturbed to warrant additional archaeological research, but that it may retain is significance for architectural studies, he continues... “ A full basement structure built of coquina is extremely rare this far north. The area located east of the house site was determined to be a possible outbuilding.”

Since the inception of this study, two other uses of coquina have been noted. During the archaeological investigations at Brunswick Town, a Colonial-era river port located on the west bank of the Cape Fear River immediately south of Wilmington three millstones and scattered fragments of a fourth, all possibly manufactured out of coquina were discovered (Fugur6)(south 1967). According to South (1967) the stones were made of fossiliferous limestone and were in an extremely fragile state. These stones are currently curated in Raleigh, North Carolina and have been scheduled to receive an in-depth examination to determine if they are actually manufactured out of coquina. The geographic location suggest that there is, at this time a strong possibility that they may once have been part of the Neuse Formation of Coquina that is present approximately three miles due east of Brunswick Town.

According to a local informant (Jim McKee, personal communication, 2000) there is a shoreface retaining wall constructed out of coquina in Southport, North Carolina. This wall is reported to be approximately 20-30 feet in length and 4 feet high. McKee, a long time resident of Southport notes that Coquina blocks measuring approximately four inches in diameter were used to make this wall sometime in the early 1920-1930s. This probable construction date coincides with the mining of the Coquina outcrop at Fort Fisher, located a scant one mile due east. He further states that Hurricane Hazel buried

the in wall in 1956 and that Hurricane Fran uncovered and partially destroyed it in 1996. I guess one could say that the ocean giveth and the ocean taketh away.

Summary and Conclusions

In this brief presentation I have attempted to answer several questions regarding coquina, including its distribution, use as a building material, its possible use as a raw material for Colonial-era millstones and as an erosion barrier, something akin to a precursor of everybody's favorite, riprap. These questions, at least in North Carolina, are not well researched nor fully understood. Not surprisingly, as with most cultural resource and/or historic preservation related topics, this study raised almost as many questions as it answered. However, one unanticipated question was answered, that is at least in North Carolina, Coquina is a non-renewable resource with beach erosion and mining being the primary culprit. However, using North Carolina as an example, if any research topic in the preservation community is worthy of a concerted, multidisciplinary study, the distribution, use and preservation of Coquina is. Symposia such as this are a vital first step. Nevertheless a beginning is a beginning and that was the focus of this study.

Florida's Coquina Heritage

Walter S. Marder, AIA

In order to best appreciate Florida's coquina heritage, we need to have a short look at Florida history for a backdrop. There are four cultural threads to follow: the Spanish, the British, the American Territorial period, and finally, the resurgence of the use of coquina in the early 20th century.

The Spanish colonization of Florida, begun in the mid-16th century, started our state off on its architectural tradition. Little is left from that very early period except the Castillo in St. Augustine which dates from 1672. Most of what remains of other structures in St. Augustine dates from 1702, after the British burned the city although on-going research continues to turn up first Spanish Period structures, albeit for the most part, in the form of foundations.

In 1763, the British had defeated the French and Spanish, ending the Seven Years War and, as a result of the Treaty of Paris, Britain gained control of East and West Florida as its two newest colonies in the Americas. These British colonies were not long-lived and were ceded back to Spain in 1783 as a result of the American Revolution but, in that short time, an architectural/construction style based on the extant Spanish work was refined which would influence Florida well into the 19th century.

The British embraced the Spanish tradition of coquina as a building material. Stone construction was well known in western and northern England, as well as Scotland, and as it was from these areas that many of Florida's English colonists came. Additionally, the famous Turnbull Colony established at New Smyrna in 1764, was peopled with Minorcans. Brought to Florida by Turnbull, these Minorcans were well acquainted with stone construction due to the scarcity of wood in their homeland. As coquina is a type of limestone, the staple building material of Minorca and the Cotswolds and southern Scotland, working with coquina came naturally to both the English and Minorcan masons brought to the colony.

Stone construction in our tropical climate does have its drawbacks. A stone building usually consists of heavy bearing walls with few openings. That results in a closed atmosphere not suitable for the tropics. More typically, early Florida housing had open walls, to allow breezes for cooling and keeping interiors dried out. Stone is good though for foundations, fireplaces, and chimneys, especially in Florida where brick was not manufactured and had to be imported. On top of a stone foundation, a lighter, more open (and consequently less durable) construction could be erected.

In her book Mullet on the Beach, Patricia Griffen also discusses housing types at New Smyrna, writing, "Frame upper stories were not uncommon on the coquina stone houses ..." and "Old World techniques used with the freestone found in Minorca were applicable to the coquina of Florida's east coast."¹ The principal building material of Minorca is indeed the easily cut limestone. Albert Manucy, in The Houses of St. Augustine, also describes the Spanish architecture and construction methods of the first Spanish period to 1763, the English modifications to 1783, and finally, the second Spanish period to 1821².

Unfortunately, little remains of these buildings. The coquina work, though, is a very permanent construction as can be seen in those examples which are left to us. The upper walls of many of the buildings in St. Augustine, as elsewhere on the East Coast, were often of lighter

¹ Griffen, Patricia. Mullet on the Beach, Jacksonville: University of North Florida Press, 1991, page 154.

² Manucy, Albert. The Houses of St. Augustine, St. Augustine: St. Augustine Historical Society, 1978.

construction, as noted, usually tabby or wood, or wattle and daub, few of which withstood our tropical climate well. Griffen also notes that, “In contrast with carpentry, which was an exacting trade, the craft of mason and stonecutter required less skill, and a mason occupied a lower status ...”³ The later work, that of the Second Spanish Period and the Territorial Period as seen in the sugar mills, shows, however, stonework which has been done with extraordinary skill, not something which would have been produced by someone of “less skill” than a carpenter.

Why are there so very few remaining examples of these early works? Several events contribute to the paucity of historic examples. First, the second Spanish period was not a prosperous one for the colony. Originally, in the First Spanish Period, Florida acted as a protective barrier between Spain’s trade routes from the Americas to Europe and the British to the north: building was not widespread save for St. Augustine, the forts and the occasional ranch. After the American Revolution, the new United States was not seen by Spain as a threat in the way the English had been. Relative to its status before 1763, the returned colony was all but ignored.

Secondly, after the transfer of Florida to the United States in 1821, a great upheaval and relocation of the population took place. This followed the abandonment of Florida by the Spanish in 1763 and then by the English in 1783. The population was unstable at best. The result was the desertion of the existing buildings and little new construction. Deteriorating rapidly and without maintenance, these buildings soon disappeared. Finally, the late 19th and early 20th centuries saw large-scale demolition of these older buildings for new development in the newer prevailing styles.

One dramatic and positive result of the short-term English presence was the introduction of large scale agriculture to the colony. Citrus, cotton, sugar, and indigo were planted intensively and vast plantations sprouted in great numbers. After the English left, many of these thriving plantations were taken over and improved by the residual Spanish and Minorcan population and new settlers from the new states to the north. The Spanish government welcomed these settlers and their industrious pursuits. The English had set up a vast plantation system that would prosper under these new owners through the 1820’s, until it came to a violent end in the Seminole wars.

In December 1835, the longest war the United States ever fought against an American Indian tribe began with the defeat of Frances Dade in what is now Sumter County. After that all hell literally broke loose and towns, plantations, mills, and mansions were burned and destroyed; the plantation owners and workers fled to St. Augustine for protection, abandoning their lands and buildings. In 1845, a scant three years later, Florida became a state with fewer than 60,000 residents. Although the state made rapid gains in agriculture, primarily cotton, the new plantations were being settled in the northern tier. The sugar mills and plantations on the East Coast were abandoned and left to fade back into the tropical forest. And then a short sixteen years later, Florida was again plunged into war, this time the Civil War, and once again the economy faltered.

Of all of the coquina resources, the sugar mills that remain are particularly symbolic of this once thriving plantation system which faded away. These huge factories, their plastered coquina walls embracing this major industry, today stand as mute evidence of that former time. And even today, they are still graceful, their stonework a wonderful testimony to the skill of their builders. Beautifully cut stone, fine, thin mortar joints, clean, precise lines, all bear witness to the once thriving society and the masterful workmen who populated the region.

Then, the early 20th century produced a small share of coquina building, again most frequently for foundation work. In the 1930’s, the Civilian Conservation Corps undertook several massive coquina projects, most notably the Bandshell and Clock Tower complex in Daytona

³ Griffen, page 155.

Beach. Coquina was also used for Daytona's famed Tarragona Arch. The 1930's also saw the stabilization and reconstruction of many of St. Augustine's First Spanish Period buildings under the auspices of the Carnegie Foundation. There are notable differences in the masonry techniques between this newer work and the earlier construction. The new work tends to be rubble construction, uncut stones randomly laid, while the first works were ashlar, finely cut stones carefully fitted.

Today, our understanding of the construction and the material is so slight that the fact that any of the 18th and 19th century coquina structures are still here is somewhat miraculous. But their longevity, now more than ever, is reliant on our ability to investigate, comprehend, protect, and preserve these elegant examples of our built history.

Current Coquina Conservation and Preservation Technology

Judith J. Bischoff, Ph.D.

Introduction

Historic buildings constructed from coquina provide unique challenges for conservators, preservation architects and maintenance staff, who are charged with their care, preservation and restoration. Deterioration is an inevitable consequence of natural processes and arrest of these changes can be costly, labor-intensive and time-consuming. Coquina buildings face several areas of concern in terms of preservation. For example, portions of coquina walls need to be repaired, there need to be efforts to stabilize existing coquina and many coquina structures are covered with biological growth that must be removed. This article is intended to give an overview of coquina as a material, the factors that may affect its deterioration, some of its conservation and preservation issues and current related research ongoing in my laboratory. Some possible avenues of future research will also be presented.

Coquina is a naturally-occurring sedimentary rock composed of shells, fossilized organic matter, calcareous sandstone and salts, "cemented together" by limestone (calcium carbonate). It is found underlying much of the Atlantic shore of Florida. Although covered by sand in most regions, coquina outcroppings and quarries can be found in several Florida counties including Flagler, Martin and Palm Beach.

Coquina formed as an offshore bar through accumulation of sand and shells when sea levels were higher and today's coast was underwater. Later, during a glacial period (between 125,000-150,000 years ago), the sea level dropped, leaving the bar exposed to the air and weather. Geologically it is considered a "young limestone", compared with other stones like marble, which are more than one million years old. The calcium carbonate from the shells dissolved in rainwater, which upon evaporation, cemented the loose shell-containing sediment into rock. Because it is a less compressed form of the sedimentary limestone, it is soft and quite porous, with a grainy, sponge-like texture and strata that vary in density.
(<http://www.abfla.com/parks/Anastasia/anastasia.html>)

It is easy to quarry and is done so wet. Once quarried, it is allowed to season by leaving it outdoors for a period of time before use. During the seasoning process, it is washed free of any soluble salts from the marine environment and becomes hard as it is allowed to dry and age. Because its physical structure and density are quite varied, it can be found in a variety of grades, from very fragile material that crumbles easily, to a denser more durable stone. The lowest grade material is crushed and used in road beds, while the finer grade is used for veneers and construction. A nice example of an outcropping of coquina can be found at Anastasia Island quarry, the source of the coquina from the Castillo de San Marcos can be seen in Figure 1.



Figure 1. Anastasia Island coquina quarry. (Photo courtesy of the author.)

Our interest in coquina derives from its historical use as an architectural building material. Coquina was used by the early settlers of Florida, most notably along the coast of northeastern Florida, in St. Augustine and New Smyrna and the environs. Because of its chemical and physical properties, historic coquina presents some unique challenges to preservationists, historic architects and architectural conservators and maintenance workers.

Some examples of coquina structures dating from the 17th to the 20th centuries can be seen in Figures 2-7.



Figure 2. The Castillo de San Marcos National Monument (completed 1695).
(Photo courtesy of the author.)



Figure 3. Turnbull ruins in New Smyrna, Florida (1767). (Photo courtesy of the author.)



Figure 4. Dunlawton Sugar Mill (1830). (Photo courtesy of the author.)



Figure 5. Ruins of New Smyrna Sugar Mills (1830). (Photo courtesy of the author.)



Figure 6. Tarragona Arch (20th century). (Photograph courtesy of the author.)



Figure 7. Daytona Band Shell (20th century). (Photo courtesy of the author.)

The focus of this paper is on the agents of stone deterioration as they pertain to coquina composition and their implications for coquina conservation and preservation. However, because there are many articles on the treatment of limestones, this paper is not intended to be a review of the conservation and preservation literature.

Conservation and Preservation Issues

Because there is so little conservation literature dealing specifically with the preservation of coquina, its preservation may be understood in the broader context of stone preservation and conservation issues. Preservation is defined as "the protection of cultural property through activities that minimize chemical and physical deterioration and damage and that prevent loss of informational content. The primary goal of preservation is to prolong the existence of cultural property." Conservation is "the profession devoted to the preservation of cultural property for the future. Conservation activities include examination, documentation, treatment and preventive care, supported by research and education." (AIC Directory 2000)

Conservation professionals are concerned with slowing down or arresting deterioration of the objects in their care. Thus, they are concerned with the chemical composition, mechanical characteristics and deterioration mechanisms of materials, construction or technology, environmental conditions, history of use, prior preservation or restoration efforts, cultural interpretation and economics. Each of these concerns must be addressed by those involved in efforts to preserve coquina as an important and non-renewable cultural and natural resource. Although all of these factors are important considerations in the preservation of coquina, this article will focus only on the chemical composition and agents of deterioration.

Chemical Composition and Agents of Deterioration

Although the literature dealing specifically with the deterioration and preservation of coquina is limited (Fenn 1987; Harrison 1971; Johnson 1993; Rands 1984 and 1986), one can look to the literature on stone deterioration and conservation for answers in dealing with coquina preservation. While it would be worthwhile to examine the extensive literature on limestone deterioration and conservation treatments, it is outside the scope of this paper to do so. However, some general information about the chemical composition and mechanical properties of coquina will be discussed.

Coquina is a limestone conglomerate composed primarily of limestone and shell fragments. Both limestone and shell are calcium carbonate (calcite, CaCO_3) minerals. Thus, one can think of preservation of coquina in terms of its chemical composition. It follows that, agents which contribute to the deterioration of limestone, are the same ones that are responsible for the deterioration of coquina.

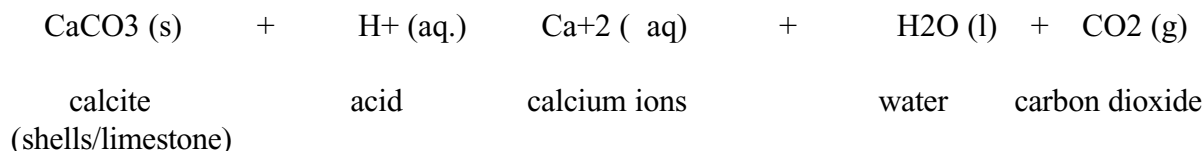
Amoroso describes the following agents of stone deterioration: (Amoroso 1983)

- Chemical attack
- Mechanical disruption
- Disfigurement from leaching or migration
- Abrasion, attrition and stress-cracking

- Biological attack
- Exfoliation and disintegration
- Disfigurement from surface deposits
- Damages from repairs or restoration

Chemical Attack

Coquina is susceptible to attack by acidic materials because it is composed predominantly of the alkaline mineral, calcium carbonate (CaCO_3). Materials such as industrially-produced acid rain or naturally-acidic rainwater can react with the calcium carbonate in the limestone and shells. In this reaction, calcium ions, water and carbon dioxide are formed. The carbon dioxide evolves as a gas from the surface of the reacting stone. This chemical reaction is shown below.



Because the products from this reaction are either water soluble or gaseous, their formation by reaction of coquina with acidic materials results in loss of material from the surface of the stone and, over time, can cause serious erosion and surface losses. An example of such losses from erosion can be seen in Figures 8 and 9. Figure 8 shows the circular eddies or the “river and tributary” pattern of erosion of coquina.

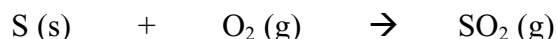
Figure 8. Circular and river-like erosion pattern on coquina at the Castillo de San Marcos.
(Photo courtesy of the author.)

In Figure 9, one can see that the entire surface of the stone has been eroded to a depth of several inches. Because the mortar joints are composed of materials that do not undergo the same chemical reaction, the joint does not undergo erosion and overhangs the edge of the stone. The cavity formed by this overhang offers a site for accumulation of dirt, vegetation and other organisms, as well as for entrapment of water and pollutants.

When the acid reacting with the calcite is sulfuric acid, gypsum is formed. Gypsum is a water-insoluble, white crystalline material which can build up on the surface of the stone. Although it could be viewed as a protective layer, it is not part of the historic fabric. Surface deposits of gypsum can be quite disfiguring and their removal is difficult without causing harm to the coquina.

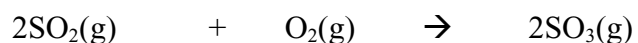
Sulfuric acid is found in acid rain and is formed when high-sulfur coal is burned. The product of this combustion is sulfur dioxide, which can be oxidized further to sulfur trioxide in atmospheric oxygen. When sulfur trioxide reacts with atmospheric moisture, sulfuric acid is produced. The reactions for this multi-step process are shown below.

Combustion of sulfur-containing fossil fuel:



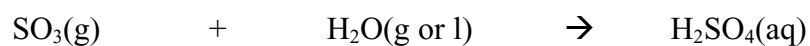
Sulfur + oxygen → sulfur dioxide

Oxidation of sulfur dioxide:



sulfur dioxide + oxygen → sulfur trioxide

Reaction of sulfur trioxide with water:



Sulfur trioxide + water vapor or rain → sulfuric acid rain

Reaction of sulfuric acid with calcite from shells and limestone in coquina:



limestone + sulfuric acid → gypsum + water + carbon dioxide



Figure 9. Erosion of surface of coquina stones. (Photo courtesy of the author.)

Mechanical Disruption

Mechanical disruption of coquina stone can occur in a variety of ways. For example, dissolved salts, formed from reaction of the calcium carbonate with acids, can penetrate the porous structure. When evaporation of water occurs, the non-volatile salts can crystallize inside the pores beneath the surface of the stone in a process called “subflorescence”. When this occurs inside the microscopic pores, the forming crystal masses can expand and pressure can be exerted on the pores to cause microfissures. Over time, such fissures can lead to large cracks and loss of pieces of material, called “spalling”. This damaging event is a particular problem in porous materials such as coquina.

A second type of mechanical disruption can occur when water penetrates into the porous coquina structure, either from rain or rising damp, followed by freezing of the water. When this occurs, expansion of the ice in the porous structure can also cause spalling of a structure. While this would not generally be a problem with coquina structures along the southern coast of Florida, freezing temperatures do occasionally occur in the northern part of the state. Thus, structures like the fort at the Castillo de San Marcos can be vulnerable to spalling from freezing of imbibed water.

A third type of damage can result from corrosion of metal structural elements embedded in a structure. If the corrosion product has a greater volume than the metal, as is the case with corrosion of iron, the expansion of this corrosion product inside the structure can exert enough pressure on the stone to cause the stone to explode. For example, the iron bars at the Castillo were the recent cause of serious damage to the windows facing the inner courtyard, necessitating replacement of both the bars and the surrounding coquina stone.

Disfigurement from Leaching or Migration

Coquina structures containing metal supports or architectural elements can be disfigured from leaching or migration of soluble corrosion products onto the stone. If the metal is brass or bronze, oxidation of copper in the metal alloy can leave green or blue streaks of copper salts on the surface. Oxidation of iron will leave rust-colored stains on the surface.

Even white or colorless salts can be deposited on the surface of coquina in a process called “efflorescence”. This occurs when salts inside the porous structure of the coquina are wicked to the surface during rain events or when the relative humidity is high. Upon evaporation of the water, the salts crystallize on the surface, and can disfigure it with a white hazy accumulation. Figure 10 shows salt efflorescence on the mortar between the coquina stones at Tarragona Arch in Daytona Beach.

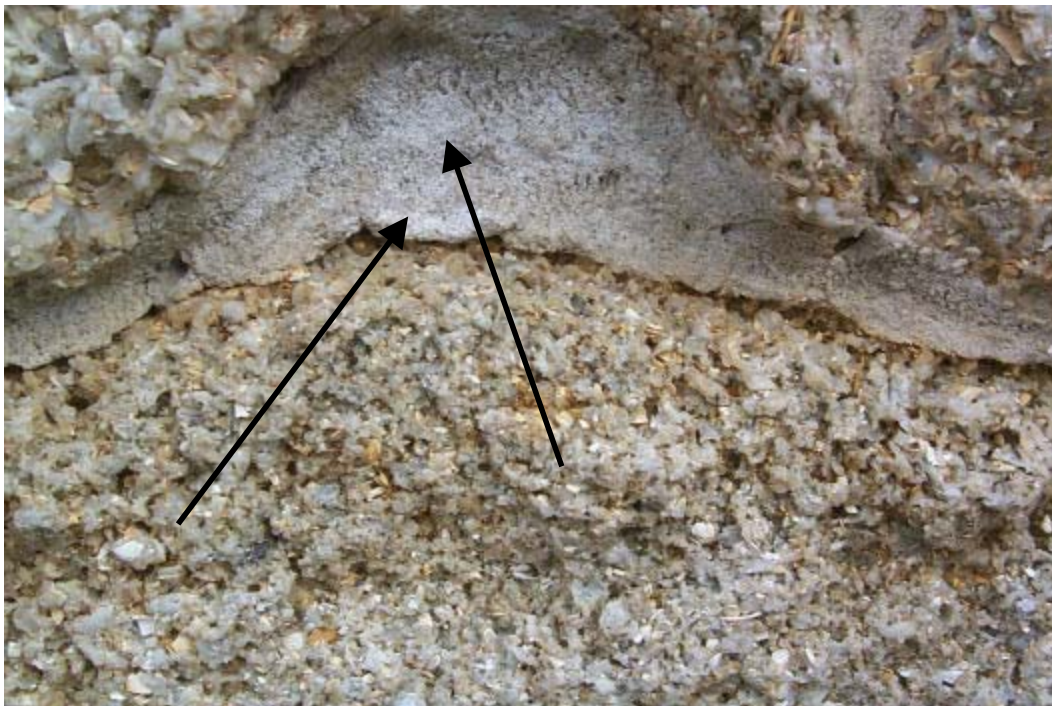


Figure 10. Salt efflorescence (indicated by arrows) from the mortar joints in the coquina structure, Tarragona Arch, Daytona Beach, FL. (Photo courtesy of the author.)

Abrasion, Attrition and Stress-Cracking

The relative softness of coquina makes it susceptible to abrasion, attrition (gradual wearing away of a surface by repeated, long-term exposure), and/or stress cracking. Wind-driven particles, seismic shock and vibrations from vehicular traffic, accidents, human contact or even battle reenactments can all contribute to losses.

Human contact with fragile cultural resources like coquina can take two forms. Vandalism is one type of human contact in which there is wanton destruction of the resource. This contact is often limited to isolated events. More ubiquitous however, is the human contact by visitors to whose desire to make that deep emotional connection with their cultural heritage. It is this form of contact that often poses the greater risk to the resource and it is this continuous and repeated contact which can, over prolonged periods, cause cumulative losses to historic fabric.

This is a particular problem with resources at NPS sites which arises from the NPS mission which is "...to promote and regulate the use of the national parks...which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The conflict between conservation/protection and use/enjoyment an important consideration in how a historic National Park site is preserved. No doubt, this problem is not unique to the National Park Service. For many visitors to parks and historic sites, even with signage indicating that physical contact is prohibited, the tactile quality of the coquina surface can tempt a much too close human interaction. One obvious solution to this problem is to limit access to particularly vulnerable areas. As seen in Figure 11, visitors (both human and pets) to the Castillo de San Marcos during the 1950's, and even today, enjoy intimate contact with the park's resources. The park now prohibits visitors from bringing pets into the fort

itself and access has been limited by cordoning off some areas that are particularly vulnerable to damage such as the wall on which has been scratched images of ships and the case around the niche in the chapel, as seen in Figure 12.



Figure 11. Visitors to the Castillo de San Marcos National Monument. (Photos courtesy of the NPS Photo Archives.)



Figure 12. Images of ships scratched into the wall in the gunner's room and the niche in St. Mark's chapel at the Castillo de San Marcos National Monument. (Photos courtesy of the NPS Photo Archives.)

Biological Attack

The tropical climate of the Florida coastal areas is an ideal environment for the growth of a huge array of biological organisms from microorganisms such as slime molds and bacteria to larger vegetation. Some of these organisms are benign, that is, they rest on the surface of the structure but exert no adverse effects on that surface. However, organisms such as algae, bacteria, fungi, lichens and mosses are capable of causing deterioration and discoloration. They can trap dirt and moisture, leading to accelerated soiling and aiding in the establishment of higher plants, which increase water retention. Moreover, many lichens produce and secrete acidic substances that may react with the alkaline components of coquina and may darken, damage and disfigure the exterior surfaces of buildings. (Jones 1985; Lloyd 1971). In the past, such growths were encouraged, since they gave a desired mature appearance to a building, as illustrated in Figure 13; however, their presence is now known to be destructive, and therefore is a preservation concern.



Figure 13. Historic “fern room” at the Castillo de San Marcos. (Photo courtesy of National Park Service-Harper’s Ferry Center Photo Archives.)

In addition to vegetation, damage can be caused by higher organisms such as birds, insects and reptiles. Parks such as the Castillo de San Marcos have dealt with bird problems in their garrita (the corner watchtowers) by placing of strips of metal with prongs pointing up along ledges and window openings. This helps to reduce damage from birds nesting or perching in these areas.

Exfoliation and Disintegration

Poor design and/or construction can be the cause of exfoliation and disintegration of a coquina structure. Thus, it is important to understand the mechanical properties of coquina so that the appropriate grade of stone can be chosen for replacement, or so that stones can be placed so as to minimize stress from the bedding plane of the sedimentary coquina stone. Knowing how coquina behaves mechanically can minimize future structural damage and lower risk of additional damage to already vulnerable areas.

Another problem that can contribute to exfoliation and disintegration is the strength of the mortar used in the joints. A mortar poorly matched in mechanical properties to the coquina stone may cause stress fractures or structural weaknesses depending upon whether the mortar is too strong or too weak, respectively.

Damages from Repairs or Restoration

Problems with inappropriate mortars are not limited to the materials used historically in the original structure, but can arise from poor quality repairs or restoration efforts. For example, in Figure 9, we see the use of Portland cement mortar in the joints. (These joints can be seen to extend out from the surface of the coquina stones.) These early restoration efforts were probably done in the 1950's. In fairness to these early restorers, the use of the very strong Portland cement predates systematic and solid conservation decision-making. Today it is well established by the conservation profession that a repair should be weaker in strength than the original structure so as to not induce any stresses that can lead to damage to the historic fabric.

It was interesting to note during our tour of the Castillo de San Marcos, that the team of masons and preservation specialists had developed three different mortars. These were being used for different purposes in their restoration efforts to replace severely deteriorated window frames. The sensitivity of the preservation team to the importance of appropriate material choices for restoration will significantly help to preserve this important cultural resource.

Disfigurement from Surface Deposits

Surface deposits such as soot, dirt, grease, or paint can disfigure the surface of a coquina structure. While a certain level of such deposits might be considered as an acceptable patina, some deposits may detract from the appearance of a structure.

Preservation and conservation options

While it is beyond the scope of this article to discuss specific preservation and conservation treatments, the following should be considered as viable options for preservation of coquina resources:

- Engineering monitoring
- Sheltering and/or re-roofing
- Limiting access
- Creating barriers to or removing vegetation
- Re-directing moisture
- Providing sacrificial protective coatings
- Shoring up
- Replacing lintels and other non-coquina structural features

The Castillo de San Marcos has for several years taken advantage of the first option of engineering monitoring. Several of the large cracks in the walls have been outfitted with motion sensors for the continuous monitoring of vertical and horizontal shifts in the structure. This process has given them important information on whether or not the structure is in immediate danger. They were happy to report that very little movement has been observed. The initial

expense of installing these devices, I am sure, has outweighed the labor and resource costs of attempting to fix the cracks in the walls when it is not currently necessary.

All preservation and conservation treatment decisions need to be guided by sound conservation principles and practice. Architectural conservators look to the American Institute for Conservation's *Guidelines for Practice* which state, "Choose materials which do not adversely affect cultural property or its future examination, scientific investigation, treatment or function." (AIC 2000) There are a myriad of materials used in the treatment of stone, including solvents, cleaning agents, resins, adhesives, pigments, in-filling materials, coatings and materials which can change porosity or surface appearance. In addition, some of these materials are toxic to the user or the visitor. All of these materials require a thorough understanding of the physical and chemical properties, as well as the human and environmental safety factors. In addition, the preservation or conservation specialist must have a good understanding of the long-term behavior of these materials under the particular environmental conditions of the historic structure.

The implications are that materials used in preservation need to be compatible with and must "do no harm" to the historic fabric. In addition, any treatment performed must be reversible, that is, the structure can be returned to its original state as it existed before the conservation treatment. When at all possible, the materials used need to have been rigorously tested for their long-term wear and studies of the usefulness of these materials reported in peer-reviewed literature.

The choice of treatment materials absolute presupposes a good understanding of the material being treated, *i.e.*, the coquina. This means, of course, that the preservation specialist must be able to diagnose the obvious and rampant damage, as well as any dormant and potential damaging situation. Moreover, the specific environmental conditions of a structure and the types of decay most prevalent in that environment need to be understood by the preservation team. It cannot be emphasized enough that the literature on stone conservation needs to be rigorously consulted when making decisions about treatments of historic coquina structures.

The decisions as to the type of treatment to use, as well as whether to restore or merely stabilize, may be made based on the historical accuracy, the aesthetic to be achieved for the structure, and/or the acceptable level of invasiveness of the treatment. For example, protection of the surface of a coquina structure could be achieved by the application of a breathable protective coating such as a stucco or limewash. While this might be both historically accurate and a sound preservation choice, the aesthetic of the structure would be radically changed. Not only would one have to consider the labor costs to maintain this protective coating, such a decision could easily be fraught with controversy and result in public outcry or even litigation.

Current related research

What began as a project to investigate suitable agents for the removal of vegetation growth on the coquina at the Castillo de San Marcos has instead led to a more fundamental study on the physical and chemical effects of commonly-used vegetation removal treatments on the coquina itself. (Bischoff 2000) It became clear early in our study that the biodiversity of vegetation growth was too great to assess the efficacy of various chemical treatments on each organism. The purpose of this study then is to identify chemical treatment methods which show promise for effective vegetation removal, but which also cause no damage to the historic coquina fabric. We hope that this work will lead to on-site testing of these methods to assess their efficacy for vegetation removal. We also hope to work with parks to develop appropriate testing protocols for materials that we have determined to be safe to use from a conservation, preservation and environmental standpoint.

Future research

In order to understand where preservation efforts need to be concentrated, surveys of the condition of existing coquina structures need to be conducted. Such surveys would provide information on the:

- Geographical distribution of such structures
- Number of extant structures
- State of deterioration of these structures
- Nature of the deterioration problems

It would also be beneficial to identify and study historic or new quarries of coquina. The purpose of this work would be multifold:

- Protection of these resources from being over-quarried
- Identification of available sources of coquina for future preservation and restoration needs
- Comparative study of the mechanical and chemical properties of the different sources of coquina

Detailed studies need to be done on the composition and physical structure of coquina and how these properties change upon deterioration. These studies could lead to the design and creation of materials and techniques for the safe and effective preservation and conservation of historic coquina.

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St. Augustine Coquina, History and Quarrying Techniques

Shelley Sass

Introduction

The city of St. Augustine is known as the oldest city in the United States. Many of its buildings have the distinction of being the earliest surviving structures built by Europeans in the New World dating to the early seventeenth century. St. Augustine's recognition of the value of its cultural property reflecting its heritage has resulted in the restoration and upkeep of numerous structures and monuments.

Several cemeteries are located in the historic old city, including Old Huguenot Cemetery. Old Huguenot Cemetery's visibility has grown as the city's tourism has increased. The St. Augustine Visitor Information Center and parking lot surround the cemetery to the north and west. With automobile traffic restricted on St. George Street of the nearby historic downtown area, many visitors to St. Augustine begin their visit at the Information Center walking by the cemetery to enter the historic district through the coquina city gates.

Old Huguenot Cemetery

With the 1821 outbreak of a yellow fever epidemic St. Augustine established a public burying ground outside the city gates along Shell Road, now called San Marco Avenue. East of the entrance still stands the Spanish fortifications, Castillo de San Marcos, on the Matanzas River, beyond which lies the Atlantic Ocean. By 1832 the cemetery was acquired by the Presbyterian Church. Old Huguenot Cemetery functioned as an active burial ground until it was closed to interment in 1884.

The cemetery boundaries are depicted in a survey map of 1834-1835.⁴ The lot is marked off in ink with no identification. A gully or creek was pencilled in running from the northwest to the east. On the Official Map of St. Augustine, surveyed and drawn by Robert Ranson for the City Council in 1905, the cemetery is identified by the name "Huguenot Cemetery" in the southeastern corner of lot 1 of the San Marco Tract.⁵

Today, known as the Old Huguenot Cemetery, the half-acre site is enclosed by a stuccoed wall to the east and south, with a wrought iron fence to the west and a wire and concrete post fence to the north. Full grown trees, including magnolias, evergreens, and oaks, shade much of the southeast of the grounds. Patches of grass survive in the northwest. In the shadier areas the sandy ground is bare with many tree roots exposed.

The cemetery has both family plots and individual graves and markers. Stuccoed walls surrounding several grave markers often define the family plots. Several of the plots have beautiful examples of nineteenth century decorative cast iron fences, such as the corn stalk pattern of the Robertson plot in the southeast corner. These plots would have been landscaped with

⁴Benjamin Clements, Survey Map, fourth quarter 1834 and first quarter 1835, in the collection of The Department of Natural Resources, Land Records and Title Section, Tallahassee, Florida. The southeast corner of a large rectangular block, no. 14 shows the cemetery boundaries.

⁵Robert Ranson, Official Map of St. Augustine, Jan. first, 1905, in the collection of The Department of Natural Resources, Land Records and Title Section, Tallahassee, Florida.

native flowers, plants, and trees. In fact many bushes and trees are located at the corners of plots and presumably are part of early plantings.

Use of Coquina for funerary monuments

Many of the traditional Floridian funerary monuments are represented in the Old Huguenot Cemetery, including box tombs, headstones and footstones, and monuments. Funerary sculpture is limited to several examples of low and high relief and crosses. By the date of the cemetery coquina was a commonly used material for building construction and readily available in St. Augustine. Its presence in the cemetery reflects its prevalence as a major construction material.

Coquina and brick comprise the majority of the masonry used throughout the cemetery for the construction of curbing or walls defining family plots, for the foundations and bases of monuments, and for the walls of box tombs. For several of the gravesites in Old Huguenot Cemetery these masonry structures are all that remain. A stuccoed wall of large blocks of coquina delineates the parameters of an unmarked plot in the southwest quadrant. Low masonry supports of brick or coquina are used to raise marble slabs above the ground. The Whilden grave, located near the front gate is an example of such a support. Coquina is also used for a modified design of the box tomb that consists of stuccoed coquina walls on which the top is rounded and stuccoed creating a loaf shape. The most notable use of coquina in the Old Huguenot Cemetery is the use of carved coquina for grave markers. The several examples of carved markers located in the Old Huguenot Cemetery are a valuable and unique feature of the cemetery. Several examples are found near the main entrance, including two large coquina crosses, two tall coquina obelisks, and several footstones. Since the stone is not suitable for inscribed letters, marble plaques have been inserted to identify the graves.

History of St. Augustine's Coquina

Definition of Coquina

In geological terms, coquina refers to a stone composed of shells, shell fragments, and fossil debris. The size of typical shell fragments is generally greater than 2 mm, equivalent to the size of coarse sand or fine gravel.⁶ The Florida coquina is part of the Anastasia formation of the Pleistocene epoch which extends 250 miles along the Florida coast from St. Augustine south to Key West. It is a light buff color with fragments of shells just discernible on close inspection. With and without magnification the shells appear aligned in a fairly uniform bedding plane. It consists of the shells of *Dorax variabilis* cemented together with calcium carbonate leached from the shells themselves.⁷ This yellowish sponge-like, porous material is soft when quarried increasing in strength upon evaporation of its high moisture content.⁸ As it ages it darkens to a grayish yellow color, a characteristic noted in 1843, in the observation of the "shell-rock" of Castillo de San Marcos as "dark with time".⁹

Analysis of the Anastasia Island coquina determined the composition as:

95% calcium carbonate

5% quartz grains, primarily, with a few grains of magnetite¹⁰

The material of quartz and magnetite is similar to the local beach sand. The stone is characterized by high water absorption, low dry density, and low compressive strength.¹¹ Upon evaporation of water after quarrying its compressive strength increases slightly. Although relatively easy to cut the porous, high textured surface does not lend itself to detailed carving.

Coquina Quarries of St. Augustine

⁶ Standard nomenclature for grain size according to DIN 4022 (fine gravel) and W. v. Englehardt (course sand), Walter Schumann, *Handbook of Rocks, Minerals, and Gemstones*, Boston and New York: Houghton Mifflin Co., 1993, p. 266.

⁷ Joni A. Rosenow, *Deterioration of Coquina by Acid Rain at Castillo de San Marcos National Monument*, thesis, Department of Chemistry, Southern Illinois University, Edwardsville, Illinois, 1985, p.1.

⁸ Verne E. Chatelain, *The Defenses of Spanish Florida, 1565 to 1763*, Washington D. C.: Carnegie Institution of Washington. Publication 511, 1941, p. 31.

⁹ William W. Dewhurst, *The History of St. Augustine*, Florida, New York: G. P. Putnam's and Sons, 1881, p. 75.

¹⁰ Marilyn McGovney, *The Formation of Coquina Rock and an Analysis of Sand Samples from the St. Augustine Area*, unpublished report, 1979, p. 8, 11.

¹¹ L. I. Knab and J. R. Clifton, *Mechanical and Physical Properties of Coquina Stone from the Castillo de San Marcos National Monument*, Gaithersburg, MD: US. Dept. of Commerce, National Bureau of Standards, Building Materials Division, 1988, p. 2.

Coquina has been in use in the United States for at least three hundred years or possibly four hundred years.¹² Some historic sources indicate coquina may have been used as early as 1598 in St. Augustine in one or two structures, including a powder magazine built by Governor Canço. Its use by the Spanish military in the construction of Castillo de San Marcos is more completely documented in Spanish military records in Spain and the United States. These documents record that although the existence of coquina in St. Augustine was known to the Spanish as early as 1580,¹³ the cost of quarrying and transportation prohibited Governor Pedro Menéndez Marqués from replacing the wooden fort of San Marcos with a stone construction.¹⁴ After almost 100 years of petitions for allocations from the Spanish royal court to build a stone fort the request was granted. The Spanish had located a vein of coquina near the surface of the ground at the north end of Anastasia Island and had only to saw the stone, load it on oxcarts to transport to a barge to cross the river.¹⁵ Once funding was obtained the governor of Florida, Manuel de Cendoya, assembled a work force of Indians and slaves to quarry the material.¹⁶ By 1671, coquina was quarried in large quantities to begin construction of the stone fort.

In the late seventeenth century the new governor, Diego de Quiroga y Losada, successfully petitioned for the use of coquina for civilian construction with the assurances of the superintendent of the quarry that the supply of stone would be ample for the houses and forts of four other cities.¹⁷ In the eighteenth century many structures were built from coquina exhausting the old quarry. The Spanish opened a second quarry on Anastasia Island to replace it. Many of the public and residential buildings were constructed with coquina from Anastasia Island as reflected in the historic district. During the British period, 1763 – 1784 a third vein near the inlet was located.¹⁸ In the 1774 *An Account of East-Florida* William Stork mentions the Anastasia Island quarries of a whitish stone – “a concretion of small shells petrified” – all the more valuable due to the rarity of quarries in the South. The 1783 plan of the Harbor of St. Augustine illustrates the proximity of the stone quarry on Anastasia Island to the fort.¹⁹

When the Spanish returned to power in St. Augustine, several large churches and public buildings were built with coquina. Nineteenth century records show coquina was quarried on Anastasia Island across the Matanzas River from St. Augustine in the vicinity of the earlier Spanish quarries.²⁰ This would be a likely source for the coquina used in the cemetery.

¹² Chatelain, *Defenses of Spanish Florida*, p.129, note 5, p. 147, note 62. For detailed description of the construction of the fort see Luis Rafael Arana and Albert Manucy, *The Building of Castillo de San Marcos*, Eastern National Park and Monument Association, 1977.

¹³ Marques’ letter to the king is the earliest reference to both coquina and tabby as construction materials. The eighteenth century use of these two materials is similar. For a discussion of the history of tabby, see Janet H. Gritzner, “Distributions of Tabby in the Southern United States A Geographical Perspective”, *The Conservation and Preservation of Tabby*, Georgia Dept. of Natural Resources, 1998, p. 8.

¹⁴ Chatelain, *The Defenses of Spanish Florida*, p. 53.

¹⁵ Ibid, p.74.

¹⁶ Jean Parker Waterbury, ed., *The Oldest City: St. Augustine, Saga of Survival*, St. Augustine: The St. Augustine Historical Society, 1983, p 57.

¹⁷ Waterbury, *The Oldest City*, p.60-61.

¹⁸ Albert Manucy, *The Houses of St. Augustine: Notes on the Architecture 1565 to 1821*, St. Augustine: St. Augustine Historical Society, 1962, p. 67.

¹⁹ *Plan of the Town and Harbour of St. Augustin, in East Florida*, London, 1783, Hargrett Rare Book & Manuscript Library/University of Georgia Libraries, Map 1783 B4 Neg. 5735 (Bew 1783) <http://www.libs.uga.edu/darchiv/hargrett/maps/1783b4.jpg>.

²⁰ A. M. Randolph, *U. S. Field Notes: Florida*, Vol. 184, 1850, p.378. The field notes identify old quarries at N. Line Sec. 33, West, that are indicated on the map *T7S - R30E East Florida*, near the origin of the Escorta Creek. This creek was identified later as Quarry Creek on the *Map of St. Augustine, Fla.*, U.S. Engineer Office, Jan. 26th,

By the second half of the nineteenth century, the old Spanish Quarries of Anastasia Island became a curiosity for Victorian visitors spending a day at the beach.²¹ Tourism increased in the last quarter of the nineteenth century with the arrival of the railroads and steam ships, as St. Augustine became a winter and summer destination. New churches and hotels were designed incorporating a coquina-type material comprised of poured concrete embedded with coquina shells, such as the grand resort Hotel Ponce de Leon.²² The use of this new material extended into the twentieth century replacing the earlier widespread use of coquina in St. Augustine.

Although the Anastasia Island quarries are no longer open one vein in the St. Augustine area, located west of the old city, was opened in the early 1990s. The unquarried stone is covered with water in a wetland environment before being cut into blocks for use in modern construction, primarily as stone veneer. Recently this quarry was closed. Other quarries are active in the vicinity with limited production. The National Park Service secures its stone for the restoration of the Castillo de San Marcos and Fort Matanzas from a St. Johns County quarry.²³

Quarrying Techniques

As Henry Little of the Seventh Regiment, New Hampshire recorded in 1862:

*Built of the beautiful "coquina," a sort of stone composed of shells and shell fragments, and which was principally quarried on Anastasia Island, where, as history informs us, for more than a century, hundreds of men toiled in the quarries, wresting out of the material now contained in its massive walls, which have withstood both the attacks of time and armies, it stands as a grand old monument of past ages.*²⁴

Natural coquina's properties of low density, high porosity and high moisture content produce a soft stone that is easily cut in comparison to the typically denser limestones. At first consideration, it appears the quarrying of coquina with traditional methods of the eighteenth century would be relatively easy. However, these simpler methods required substantial labor as implied in the Henry Little's observation during the Civil War.

Coquina was mined into the nineteenth century using the same technique as used in the eighteenth century. For mining the quarries the Spanish drew on the Indians, who were associated with the St. Augustine missions. By the late eighteenth century the Indian population was severely reduced with the introduction of European diseases. The labor for coquina quarrying was provided by African slaves.

1891, in the collection of The Department of Natural Resources, Land Records and Title Section, Tallahassee, Florida as well as late nineteenth century nautical charts.

²¹ Waterbury, *The Oldest City*, p. 202.

²² A guide to Florida's Historic Architecture, Gainesville, FL: University of Florida Press, 1990, p. 77 – 79.

²³ Wilson's Lakeview Dirt Co., on Holmes Boulevard, owner: Greg Wilson. Margo C. Pope, "For it to continue to endure, coquina needs preservation", The St. Augustine Record Online, March 13, 2000, http://www.staugustine.com/stories00/031300/coquina_needs.shtml.

²⁴ Little, Henry F. W. The Seventh Regiment New Hampshire, *Letters, Volunteers in the War of the Rebellion*, Concord, New Hampshire: The Seventh New Hampshire Veteran Association, 1896, pp. 75-76.

It is estimated that as many as 300 native people worked on the construction of the fort.²⁵ Such numbers would have been employed first to remove any superficial soil or overburden from the identified vein of coquina. Teams would have worked together to separate blocks of an adequate dimension for construction and transfer blocks to the construction site. Once removed the blocks of stone would be left to cure for as much as a year to allow the moisture to escape toughening the stone.

Although the quarries on Anastasia Island are within a few miles of the fort, the blocks had to be transferred several times in the trip across the river. The stone was carried to Escolta Creek (later known as Quarry Creek) where it would have been loaded on to barges. The barges would travel the short distance across the river and be unloaded. The blocks would then have to be transported to the location of construction. Ox drawn wagons were probably employed to haul the stone for longer distances. Usually at the point of construction the blocks would be shaped for the desired function. This work would call for stone cutters with the most skill and expertise. For most wall construction smaller masonry units were used. The blocks would be trimmed and the exterior faces finished.

A nineteenth century illustration²⁶ shows men working with a crow bar, pick, and jump bar, perhaps. No text describing the particular method for removal has been identified. Speculation on method of removal is based on the illustration and methods in use since the time of the Egyptians. Typically, stone was quarried in one of three ways:

1. Separation trenches cut around each block
2. Wedges pounded into aligned holes until a stress crack was produced.
3. Pointillé – creation of a series of holes with a point combined with separation trenches or wedge method

The selection of quarrying method was determined by the nature of the stone. Typically the more crystalline stones, such as granites and marbles, were quarried with the wedging or, later, plug and feather.

The tools illustrated suggest a separation trench method was used. For this method, long handled picks, such as seen in the illustration, were used to create two narrow trenches into the stone perpendicular to the exposed vertical face. A rear trench was cut behind connecting the first two trenches. The blocks could have been removed at this point or numerous small grooves could be chiseled horizontally and vertically splitting off blocks of stone. To free the rectangular mass crowbars and jump bars were used to pry the blocks. These tools could then be used as levers to help maneuver large blocks of stone onto a carrying device, such as a stone boat or pung. Such pallets were either constructed of wood with a flat bottom (stone boat) or raised on low runners (pung) to reduce friction and surmount small obstacles. Typically, these large blocks were transported away from the main quarry area for curing and finishing.²⁷ Close examination of quarry walls could help identify which of the methods was used. A series of parallel grooves in the remaining stone would support the combination of trenching and a pointillé method.

Twentieth century quarrying techniques incorporated mechanical methods. The quarries of the late twentieth century use circular saws to remove the coquina in small blocks. In the early

²⁵ Jerald T. Milanich, “When Worlds Collided: Native Peoples of the Caribbean and Florida in the Early Colonial Period”, *Myths and Dreams*, digital exhibit co-sponsored by Jay I. Kislak Foundation, Inc. and the Historical Museum of Southern Florida. <http://www.millennium-exhibit.org/milanich1.htm>.

²⁶ Waterbury, *The Oldest City*, p. 56.

²⁷ Late eighteenth century stone quarrying techniques are described in detail in Lee H. Nelson, *White House Stone Carving: Builders and Restorers*, Washington DC: U. S. Department of the Interior, National Park Service, 1992, p.4-6.

1990s most of the coquina quarried at the St. Augustine quarry was used in modern construction, often as stone veneer. An attempt was made to use coquina for statuary. Smaller blocks of the coquina were carved as sculpture using chain saws.

Conclusion

The history of the use of coquina is intimately entwined in the heritage of St. Augustine. It was the favored material of the Spanish, British, and Americans. The primary landmarks from the Castillo of the seventeenth century, the eighteenth and nineteenth century historic houses of St. George Street, to the nineteenth century entrance through the city gates celebrate the usefulness of this unique local stone. Its popularity as a material is reflected in its use in funerary monuments of the nineteenth century Old Huguenot Cemetery. Even as the nineteenth century quarries were depleted its influence continued with the introduction of concrete with coquina aggregate for a similar effect. Without coquina, St. Augustine would have a substantially different appearance today. The conservation of coquina structures and monuments as well as its quarries is necessary to the preservation of the cultural heritage of St. Augustine and Florida.

Coquina Repair at the Prince Murat House

Kenneth R. Smith, FAIA

The prince Murat House is located at 250 St George Street in St. Augustine, Florida. The building is a one and one-half story Spanish Colonial Period house built about 1790. Load-bearing exterior walls of the building are constructed from coquina blocks quarried on nearby Anastasia Island. A stucco finish covered the coquina at the exterior wall surfaces and a plaster finish covered the coquina at the interior wall surfaces. Stucco and plaster finishes were applied directly to the coquina blocks.

The stucco exterior has been painted a distinctive pink color for many years (possibly since the 1930's) that resulted in a look and character for the building.

The house has gabled ends at the north and south facades. The main façade faces St. George Street to the east. A fancy Victorian wood balcony with novelty shingle sides, chamfered wood posts and jigsaw balustrade was added on the south façade at the second floor level around 1890.

The Prince Murat House is part of a group of seven St. Augustine homes being restored as the Old St. Augustine Village Museum Complex by the Museum of Arts and Sciences of Daytona Beach, Florida. Dana Ste. Claire is the Museum Director and oversees the restoration work.

The firm of Kenneth Smith Architects was retained to serve as architect for Phase I Restoration of the Prince Murat House in early 1994. The scope of work to be completed included repair of the exterior coquina walls and stucco and plaster finishes plus roof repairs, exterior door, window and shutter repairs, and similar work. The project had a construction budget of about \$48,000 and was partially funded by a State of Florida Matching Grant. The grant required the project to be competitively bid to contractors. Terry Hayes of Butera Waterproofing and Restoration, Inc. was the low bidder for the project. Restoration work was completed in May 1995.

Prior to the start of the restoration, the south wall of the building had a severe vertical crack in the stucco finish. The east façade had several vertical cracks above the second floor level. When the loose cracked areas of the stucco finish were removed at the south façade, we discovered two layers of stucco with the earlier layer having 2 inch +/- diameter gouges in the finish at approximately 12 inches on center in both directions to help bond the stucco finish to the earlier stucco layer.

The coquina blocks behind the stucco were cracked with an irregular crack from the grade to the top of the wall. In some areas the crack in the coquina was 2 to 3 inches in width. The crack extended through the wall to the interior plaster finish. The crack worked up the wall through vertical mortar joints, between coquina blocks, and through broken blocks. The coquina blocks were random shapes and sizes.

After review, we decided this crack resulted from differential settlement of the west side of the wall. The footing in this area were then pressure-grouted to prevent further settlement. No effort was made to try to lift the settled area.

We tied the wall areas on each side of the crack together with stainless steel ties constructed from ½ inch diameter bars in the shape of “staples” about 16 inches in width with 6 inch long ends. The metal ties were let into the coquina blocks 2 or 3 inches and set in epoxy repair mortar (Sika “Sika Repair 223”). Ties were spaced about 12 inches on center vertically over the crack with ends of the ties inserted into openings drilled into the coquina block at each side of the crack. Crack voids were filled with coquina rubble and mortar.

Galvanized wire lath was installed over the repaired area and a lime stucco finish was patched into the void where the stucco finish had been removed. The exterior wall was then finished with an acrylic waterproof coating. (Thorocoat).

A second problem was corrected at the upper area of the east exterior wall. The top of this wall was being pushed outward by the thrust of the roof framing that was supported on the top of the wall approximately 4-1/2 feet above the second floor line. The second floor structure consisted of wood floor joists spanning east to west that were pocketed into the east wall for support without any ties or physical connection to the wall.

There were several 2 to 3 inch wide vertical cracks in the upper part of the wall that started at the tops of corners of the first floor door and window openings and worked their way to the underside of the roof framing. The top of the wall was displaced outward to the east by several inches.

A steel beam was placed on the exterior east side of the wall and the wall was pulled back into vertical alignment. Second floor wood joists were anchored to the east and west walls with metal tie straps. A horizontal wood beam was installed about 3 feet above the second floor at the inside (west) face of the wall. The wood beam was braced by new vertical wood framing at the second floor, constructed from 2 x 4 wood stud with plywood sheathing. The framing was installed to create two fin wall about 3-1/2 wide to tie the horizontal beam to the second floor framing.

The wood beam was then through-bolted to the coquina block wall at 12 to 16 inches on center with galvanized metal through-bolts with large washers at the exterior face of the coquina. The braced wood beam provides horizontal bracing for the upper coquina wall area.

The exterior stucco finish was repaired and refinished as noted above for the south wall repairs. Exterior coquina crack repairs have worked well and have prevented further cracking or deterioration of the repaired wall areas.

Bulow and Dunlawton Plantations

Herschel E. Shepard FAIA

Bulow Plantation

During or shortly after 1812, John Russell, an Englishman from the Bahamas, traded a schooner to the Spanish government in Florida for 4,675 acres of land near the Tomoka River, north of St. Augustine and east of present-day Bunell, near the coast. In 1821 Florida became an American territory, and during that year the land was sold to Charles Wilhelm Bulow, who immediately began improvements for the cultivation of sugar cane. However, Charles Wilhem died in 1823, and his son, John Joachim, developed the prosperous plantation that became known as Bulowville.

By 1835 the plantation had become the largest in East Florida. Its resources included extensive cane fields, cotton fields, fields for providing staples for the plantation, a massive coquina sugar mill, a steam-driven cane crusher, a two-story frame “great house,” slave quarters lining Bulow Creek, and an estimated 300 slaves. Sugar and cotton were transported from the plantation landing on Bulow Creek down the Halifax River to Mosquito Inlet, where they were loaded on schooners bound for St. Augustine. John Bulow, was a wealthy bachelor, educated in Paris, and he maintained an extensive library as well as a busy social life. The plantation landing was lined with imported wine and ale bottles.

The prosperity of Bulowville was forever ended by the Second Seminole War. The majority of planters, including Bulow, were friendly with the Seminoles and resented the intrusion of the Florida militia under the command of Major Benjermin Bulow Putnam. When the militia occupied and fortified Bulowville as an advanced headquarters, apparently Bulow was so uncooperative that he was placed in irons. On January 23, 1836, the militia and civilians abandoned Bulowville and withdrew to St. Augustine. On February 7, dense smoke could be seen south of St. Augustine in vicinity of Bulowville. The entire plantation was burned to the ground and never rebuilt. The ruins have remained virtually untouched to the present day, and the site was eventually acquired by the State of Florida.

The sugar mill ruins were stabilized and a small museum was constructed in 1965-66. Parts of the steam engine may remain buried at the site.

The 1965-66 restoration budget was limited to \$18,000. Measured drawing were completed as the first task. In order to preserve the extraordinary natural beauty of the site, provide minimal interference with photography, and at the same time indicate that certain areas were “off limits,” a concrete walk flanked by low chain fences was provided throughout the ruins. Stabilization of the coquina walls was limited to the poisoning and careful removal of plant material and the provision of a concrete wash on elevated horizontal surfaces; no extensive repointing was accomplished or believed necessary. The small museum was designed as a dehumidified exhibit case with wide roof overhangs, viewed by the public from the exterior. The museum is not visible from the ruins.

(Historical summary by H. Shepard from documented research notes provided by Ms. Elizabeth Ehrbar from the files of the Florida Museum of Natural History. Gainesville, Florida, in 1965.)

Dunlawton Plantation

In 1804 the Spanish government awarded Patrick Dean 995 acres of land that had been part of the Andrew Turnbull New Smyrna plantation, in what is now the modern community Port Orange, Volusia County. Dean began sugar cane and cotton cultivation, but was killed by an Indian in 1818. After several transfers of the title the land was acquired by the Anderson family in 1832. By 1835 a steam driven coquina sugar mill had been constructed, but it was completely destroyed during the Second Seminole War in 1836. The plantation was not rebuilt until acquired by John F. Marshall in 1846. Marshall constructed a new coquina building on the old foundation and installed a horizontal steam engine, a rolling cane crusher, and other equipment, apparently purchased second-hand from William Kemble around 1847. The 30 nominal horsepower one-cylinder engine and crusher are believed to have been manufactured by the West Point Foundry Company, New York, in the early 1830's. The dynamically unbalanced machinery was anchored to a coquina masonry base by long threaded rods that passed through the coquina to timbers built into the lower courses of masonry.

Successful operations continued until a few years before the Civil War, when the making of sugar was abandoned. However, during the war the mill was returned to operation and supplied sugar and salt to the Confederate army. The mill was undamaged by the war, and ownership changed hands several times from 1865-1870. Although the mill continued to produce sugar and salt through 1870, by 1890 it had been abandoned and fallen to decay. For many years the site was a privately owned tourist attraction, but following World War 2 the site was acquired by Volusia County. Stabilization of the ruins of the mill and machinery began in the late 1970's and continues today.

The 1970's stabilization centered upon the steam engine and cane crusher. The mill designed as one building which contained the purgery, the kettle room, and the engine and cane crusher under one roof. Only the lower masonry portions of the building remains. However, the cane crusher has survived virtually intact, and the steam engine could be restored to working order, although one boiler, the piston, crankshaft, sliding valves, and other minor parts are missing. The work included preparation of measured drawings and archaeologist and architectural documentation. Stabilization was accomplished by Volusia County personnel and additional labor provided under a grant. Each coquina block in the masonry engine and cane crusher base was marked, removed, and relaid in new mortar, deteriorated wooden supports were replaced; and the machinery was removed, by Florida Division of Archives personnel, and reassembled in its original configuration. The wooden supports were again replaced and additional work was accomplished recently.

(Historical summary by H. Shepard from Bathe Greville, "The Dunlawton Sugar Mill at Port Orange," in *An Engineer's Note Book*, St. Augustine, Florida, 1955, pp 102-122.)

Coquina Resources Tour Overview

Walter S. Marder, AIA

Castillo de San Marcos

Work began on the Castillo in 1672. Constructed of solid coquina, the Castillo is the nation's oldest and largest masonry fortification. The fort protected Spain's interests in Florida and its Caribbean trade routes, and went on to serve the English, and later the American government as Fort Marion. Work continues on restoration of the structure's coquina by the National Park Service under the direction of its Harper's Ferry Training Center. The Castillo is a National Historic Landmark and World Heritage Site.

Anastasia State Recreation Area

[Site of earliest known coquina quarry]

The quarry on Anastasia Island was established c. 1565, when the Spanish first settled along the Matanzas River. Quarried coquina was barged across the river for the building of Castillo de San Marcos, as well as other defensive structures, governmental and religious structures, and dwellings in St. Augustine. Two hundred years later, these same quarries were visited by the famous naturalists John and William Bartram, who admired this durable rock that had been used to building the Castillo.

Bulow Plantation Ruins State Historic Site

In 1821, Major Charles Bulow acquired 4,675 acres south of St. Augustine and planted 2,200 of them in sugar cane, rice, cotton, and indigo. Bulow died in 1823, leaving the plantation to his son John Joachim, who in 1831 began the construction of a sugar mill. The building was constructed of coquina and exemplifies the highest degree of the quarrying and mason's craft, with finely cut stone and pencil-thin joints. The largest mill in East Florida, it was burned during the Second Seminole War in 1836 and was never reconstructed. It stands now as a massive ruin.

Dunlawton Sugar Mill

The original Dunlawton Mill was constructed by the Anderson family in 1835. It was a coquina structure with a steam driven mill which, like the Bulow Mill, was destroyed during the Second Seminole War in 1836. John F. Marshall constructed a new coquina mill on the site in 1846. That mill continued in use sporadically until around 1890 when it fell into disrepair. The ruin was acquired by Volusia County and stabilized around 1970.

Daytona Beach Bandshell and Clock Tower

The Mediterranean Revival styled Bandshell, its perimeter wall, and the adjacent Clock Tower were constructed in 1936 of coquina rubble with a finished coquina facing. The project was completed with Works Progress Administration funds. The Bandshell is currently being rehabilitated in a project involving a number of structural issues that have heretofore not been addressed relative to coquina construction.

Tarragona Arch

Constructed in 1924, the Tarragona Arch served as the entrance to a development of the Daytona Highlands Company in Daytona Beach. Of coquina throughout, the structure was originally designed with two automobile arches and a tower at the center. The widening of U.S. Highway 92 during World War II resulted in removal of one of the arches and the whole structure was moved south several hundred feet in the 1980's to allow further widening of the highway.

The "Old Fort" at New Smyrna

The purpose of New Smyrna's "Old Fort" has never been satisfactorily explained. Built during the heyday of Dr. Andrew Turnbull's New Smyrna colony, which began in 1764, the structure has been variously thought to have been a church, Turnbull's home, a storehouse, or, most popularly, a fort. The extensive coquina foundation that remains was somewhat altered during stabilization by the Works Progress Administration in the 1930's. The "old fort" site is now a city park in downtown New Smyrna. Archaeological investigations continue to probe into the "fort's" past.

English Wharf

Little remains of the wharf constructed by the Turnbull Colony. Located at the end of the "King's Road" from Georgia, the wharf was used to ship the colony's produce to England and to the Caribbean colonies. Its plan was an "L" shape, typical of the period, in order to keep the mooring area scoured. Today only rubble remnants of the wharf can be seen at low tide.

New Smyrna Sugar Mill

Thought to be the ruins of a Spanish mission until the late 1950's, the New Smyrna Sugar Mill was constructed in 1830. One William Kemble contracted to build the sugar and a sawmill for William DePeyster and Eliza and Henry Kruger of New York. As with most other mills in East Florida, it was destroyed in 1836 and never rebuilt. Its massive arches exhibit extremely fine stone masonry work. The ruin is now owned by Volusia County and has been designated a county park.

Roundtable Discussion Summary

Edited by David Ferro, R.A

On January 26, symposium participants were divided into discussion groups, each with two faculty members, to discuss the preservation treatments presented in the case studies and the site visits of the previous day, as well as specific coquina preservation problems they may be dealing with. At the conclusion of the 1 hour and 45 minute discussion period, a representative of each panel outlined the principal points of his or her group's discussion. The following summarizes the various issues addressed by the discussion groups:

A. Identification of Preservation and Conservation Problems

1. Weathering

Weathering or surface erosion is due principally to exposure to the elements.

Contributing factors include: wind driven sand, water (e.g., scupper wash and splash-back), acid rain, evaporation of moisture containing ionized salts.

2. Damage Due to Maintenance and Repairs

Potential causes of such damage include:

- a. cleaning techniques (pressure washing and possible steam cleaning), mowers and weed whackers, herbicides;
- b. Inappropriate repairs, including use of power grinders in preparing joints for repointing, use of repair materials having physical properties (compressive strength and porosity) that are inconsistent with the historic materials used (e.g., high-strength mortar for repointing), and application of coatings, sealers and consolidants that prevent or inhibit moisture migration.
- c. Use of metal anchors or reinforcing that is subject to corrosion or exfoliation, resulting in displacement, cracking and spalling.

3. Rising Damp

Potential causes include poor drainage conditions and a high watertable.

4. Spalling

Potential causes include: application of an inappropriate surface consolidating treatment, surface repair composition, or coating (e.g., portland cement stucco).

5. Delamination

Potential causes include: improper bedding of stone (bedding plane vertical instead of horizontal).

6. Biological Growth

Threats include: growth of lichen, and other plants. Acids, which are a byproduct of plant growth, can dissolve limestone (calcium carbonate) and encourage moisture retention in masonry. Root growth can displace stone and break down mortar joints.

7. Vibration

Vibration can cause settling, sheer cracking, displacement, and, in severe cases, disintegration of building stone.

- a. Causes relate to vehicular movement (cars, trucks, buses, as well as railroad equipment);
- b. Causes related to construction or demolition activities (e.g., driving pilings, use of explosives or wrecking ball);
- c. Noise (e.g., from aircraft landing and takeoff operations) is also a potential source of damaging vibration.

8. Cracking

Causes of structural cracks may include: differential settlement due to inadequate foundations or changing foundations or subgrade conditions (i.e., change in the watertable), and changes to loading on walls as a result of construction modifications (i.e., additions) or deterioration of elements of the structural system.

9. HVAC System Installation

In adaptive reuse projects, air conditioning changes moisture migration patterns in historic masonry, pulling water (often containing ionized salts) to the interior face of the wall, where it evaporates, causing deterioration of paint, plaster or exposed stone. Air conditioning can also severely reduce the moisture content of coquina and other materials. This reduction in moisture may also have an adverse effect on the structural integrity of the stone.

B. Treatments Employed in Correcting Preservation and Conservation Problems

1. Weathering

- a. Application of sacrificial or other types of coatings to protect the historic stonework. If possible, such coatings should be consistent with historic treatments in composition and method of application. Use of plasters or stuccos that prevent or inhibit moisture migration, or that, because of other incompatible physical properties (i.e., compressive strength) may have damaging long-term effects on coquina should be avoided.

Disadvantages: This treatment may drastically change the appearance of the historic property and typically must be renewed periodically.

Other Possible Treatments Discussed:

- b. Application of a modified or synthetic non-porous capstone to the top of coquina walls to reduce moisture absorption. This is a treatment similar to one used in efforts to preserve adobe walls. The new capstone could be set in a mortar bed directly on top of existing masonry in the case of a ruin wall, or could replace the top course of coquina in the case of a structure such as a parapet wall. To the extent possible, this new work should match the appearance of the historic masonry.

Disadvantages: The protection afforded by this treatment is very limited.

- c. Construction of a shelter to protect the masonry from the elements.

Disadvantage: Such a structure would drastically alter the context of the historic property.

- d. Modification of drainage structures such as scuppers to prevent or reduce erosion due to storm water discharge. Modifications could include means to reduce water pressure or to distribute the flow over a greater area.

Disadvantages: Modifications may affect integrity of historic drainage structures.

2. Maintenance and Repairs

- a. Cleaning techniques must be carefully tested to ensure that they cause no harm to either the coquina or mortar. All cleaning treatments should utilize gentle hand application or low-pressure spray application and rinses to avoid possible erosion of coquina. There is a question regarding the effectiveness of steam as a means of killing lichen and other damaging plants (the steam may stimulate growth of certain previously dormant species). Landscape buffers zones, which require no mowing, or trimming should be established at the base of historic masonry walls. It is important that these buffers are not so constructed as to retain moisture or cause water to stand against the masonry. Ensure that herbicides

used to control plant growth do not react chemically with the coquina or otherwise change its appearance or physical properties.

Disadvantages: No studies have been done to determine the effect of various cleaning techniques and materials for coquina. The recommended landscape buffer zones are visually intrusive.

- b. In repointing, hand chisels tools should be used, unless it can be demonstrated that workmen can use power tools (grinders, saws, pneumatic chisels) without damaging the coquina. Only deteriorated mortar joints should be repointed. Mortar should match the appearance, compressive strength and porosity of the original mortar. Joints should be finished to match the original work.

Disadvantages: None noted.

- c. In the absence of extensive testing to determine their effectiveness and long-term effects on coquina, use of waterproof or water repellant coatings is discouraged, as is use of consolidants. Consolidants may have application in localized treatment of failing coquina to slow deterioration of material that will ultimately require replacement.

Disadvantages: Because of the porous nature of coquina, waterproof and water repellant coatings are expected to be largely ineffective in preventing water intrusion. Also, there is good reason to believe that the long-term effects of using waterproof and water repellant coatings and consolidants will be as disastrous to coquina as they have been in treating other types of stone and brick masonry (accelerated deterioration due to spalling).

- d. Any mechanical ties or anchors used in repair of coquina construction should be of corrosion resistant material (stainless steel, hot dipped galvanized steel, or of an appropriate plastic material. To the extent possible, ferrous metal that is embedded in coquina masonry should be removed (by drilling or core extraction). Masonry damaged by expansion of exfoliated metal features should be repaired following removal of all ferrous material. These repairs may make use of specially formulated epoxies and, where visible, coquina aggregate. While use of epoxy materials for such repairs is common, there is little understanding of the effectiveness of such repairs.

Disadvantages: Unless the causes of structural cracks in masonry are identified and addressed, use of metal ties (staples) or epoxy repair materials may be ineffective, simply transferring the damaging shear forces to an adjacent portion of the wall. Often the exfoliating ferrous material damaging the coquina is of historic importance. Removal involves loss of significant historic fabric. Alternative means of anchoring such features, to avoid embedding them in masonry should be developed where possible.

3. Rising Damp

- a. The most obvious treatment of this condition is to ensure adequate drainage of storm and irrigation water away from the building. Minor regrading may be required to accomplish this. Foundation drains can be effective in “short circuiting” the capillary action that results in rising damp, they must conduct collected water “to the light,” to a functional French drain or storm sewer system.

Disadvantages: Regrading can adversely affect archaeological resources. Sometimes site conditions are not conducive to development of an effective foundation drain without extreme measures such as collecting and pumping water to remote retention facilities or drains.

Other Possible Treatments Discussed:

- b. A more effective method of eliminating this problem may be to install a moisture barrier in the masonry, either by chemical treatment (consolidation) or by installing a continuous sheet flashing through the wall material at or below grade. These methods have been used in Europe for decades to treat rising damp.

Disadvantages: Installation of either a chemical or flashing-type moisture barrier is time consuming and very costly, and is not applicable to properties with thick masonry walls (such as the Castillo de San Marcos).

4. Spalling

- a. In-kind replacement of severely deteriorated coquina can be accomplished for a permanent repair that is fully compatible in appearance and physical performance with the surrounding historic masonry. In lieu of replacing a full width piece of stone, a veneer or Dutchman can be inserted after the spalling stone is chiseled back to stable material. The Dutchman is adhered to the existing stone on five sides with mortar matching the physical properties of the original mortar.

Disadvantages/Limitations: The greatest limitation is in the scarcity of “new” coquina that is comparable in compressive strength to the material used in the historic masonry. Also, because there are so few active quarries, that a virtual monopoly on the material exists, the cost of such repairs may be prohibitive.

Other Possible Treatments Discussed:

- b. Spalling coquina can be treated with a consolidant to impregnate the deteriorated surface and “glue the material back together”. Various epoxy-based products are available to cosmetically repair the stabilized spalled masonry. It is assumed that there would be no difficulty in formulating such a patching material containing coquina shell and crushed coquina. The cured patching material should match the appearance (color, texture, reflectance) of adjacent stable coquina.

Disadvantages: Typically, the referenced consolidation materials, the consolidated coquina surface and the cosmetic patching material are have physical properties substantially different than stable untreated coquina. It is anticipated that this disparity will ultimately cause failure of the repair. Use of concealed corrosion- resistant mechanical anchors installed within the patching material may provide longer life for such repairs.

- c. Use of a substitute or synthetic stone material may be necessary if coquina stone of adequate strength or size is not available. Possible substitute materials may be natural stone with similar physical characteristics (possibly oolitic limestone) or a concrete product with shell aggregate (similar to traditional tabby).

Disadvantages: Use of substitute materials would have an adverse effect on the historic integrity of the structure. In addition, if not compatible in physical characteristics, substitute material could have an adverse effect on structural integrity, causing damage to sound masonry into which the substitute material has been incorporated.

5. Delamination

- a. Treatment of historic masonry that is failing due to incorrect bedding will be similar to the treatments discussed in “Spalling” above. In replacing deteriorated coquina with matching material, it will be important to bed the material correctly (bedding planes horizontal). The same concern should be shown in use of a natural stone substitute material.

Disadvantages: See “Spalling” and “Substitute Materials” above.

6. Biological Growth

- a. Typical removal techniques involve application of a herbicide to control biological growth. “Round-up” is one of the proprietary products mentioned as being used with no apparent adverse effect on coquina. Steam has been used by the National Park Service to kill plants growing in the masonry at Fort Frederica in Georgia. It is recommended that plants be killed, allowed to dry and then carefully removed with a bristle brush to avoid damage to the fragile masonry. Pulling live plant material out by the roots should be discouraged because it can damage masonry. Root trimming is routinely undertaken to prevent damage from tree roots.

Disadvantages: Runoff of herbicides is a concern, and should be controlled to the extent possible. Steam generators are bulky and may not be feasible for use on larger structures. Aggressive root trimming can affect the health and stability of mature trees, allowing them to be easily toppled by wind. This work should be done under the direction of an arborist. In root trimming, care is required to assure that archaeological resources are not disturbed in the process of exposing the potentially damaging roots.

7. Vibration

- a. Control of vibration due to vehicular traffic is difficult. The most direct means of such control is to reroute heavy traffic. Vibration is sometimes reduced by reduction of traffic speed. More complicated treatments employed in protecting historic properties have included special roadway construction that reduced transmission of vibration to the roadbed.

Disadvantages: Effectiveness of speed reduction and special roadway construction is expected to reduce but not eliminate the danger of damage due to vibration.

- b. Construction related vibration can be reduced substantially by using alternative methods of installing pilings (e.g., jetting or drilling). In demolition, alternatives to “headache balls” and explosives are available and should be required in areas in proximity to historic properties. Vibration attributable to such activities can be monitored. Standards have been developed for allowable levels of vibration; however, these may not be sufficiently restrictive to protect fragile coquina resources.

Disadvantages: None noted.

- c. Aircraft takeoff and landing operations generate vibration. Takeoff typically generates the greatest vibration. When it can be shown that the intensity of such vibration is damaging to significant historic resources, actions can be taken to modify takeoff paths to reduce such vibration. As jet aircraft engines become more efficient, this source of vibration is expected to be greatly diminished.

Disadvantages: Like the treatments above, modification of takeoff path reduces but does not eliminate vibration or the related danger to historic structures.

8. Cracking

- a. Cracking due to differential settlement can be arrested by improving deficient or deteriorated foundation construction. This can be done by constructing new foundations (typically reinforced concrete, often supported by pilings) beneath the historic foundation. Less invasive is use of epoxy grout injection to solidify the earth in which the foundation has been constructed, thus increasing the effective mass of the foundation and the support beneath the structure. Changing conditions such as a rising or dropping water table or expansive soils are more difficult to deal with and require treatment on a case-by-case basis. The techniques described in “Maintenance” and “Spalling” above are applicable to repair of cracks.

Disadvantages: Excavation required for construction of supplemental foundation systems can adversely affect archaeological resources, destroying the original builders’ trench and possibly other significant features. Epoxy injection renders future excavation of these sensitive areas impossible. Also see “Maintenance and Repairs” and “Spalling” above.

- b. Imposition of new loads (concentrated or uniform) on coquina masonry should be avoided. If modifications are made to a coquina structure, it is recommended that new construction be supported by an independent structural system that transmits all loads directly to the ground, avoiding any change in the loading of the historic masonry. If masonry is threatened by deterioration of associated framing systems, framing repairs or shoring should be undertaken for structural stabilization. If coquina walls have been dislocated because of such forces, it is usually considered best practice to stabilize the walls in their altered attitude rather than trying to force them back into place.

Disadvantages: Changes in loading, even if carried on an independent foundation system can affect the integrity of historic masonry. Careful attention is required to existing soil conditions and the design of such new foundation construction.

9. HVAC System Installation

- a. In recent adaptive reuse projects, owners have been urged to reconsider the need for air conditioning. In some cases, with improved ventilation, air conditioning is not necessary. In cases where careful environmental control is needed (e.g., protection of artifacts in a museum), freestanding display cases have been developed in which the environmental control systems are self-contained. Air conditioning, as provided in contemporary construction is not considered compatible with historic masonry construction, and should be avoided when possible. If air conditioning is unavoidable, one approach to avoiding surface deterioration and drying of coquina would be to construct a room within a historic room, with an effective vapor barrier at the new construction and an airspace between the historic masonry and new construction which is well vented to the exterior. Other approaches that have been attempted include the application of sealers or waterproof coatings (e.g., Acryl 60 and Thoroseal) at the interior wall surface in an effort to create a vapor barrier. There is insufficient experience with this treatment to establish its success.

Disadvantages: The “room-within-a-room” approach will adversely affect the historic character of the structure. If this approach is used in adaptive reuse work, it will be important that all construction is accomplished in such a manner that damage to historic materials and finishes is minimized and the new work can be readily removed without further harm to the historic structure. There is evidence, from use of sealers on other types of fragile masonry, that they can accelerate deterioration.

C. Recommendations for Further Action

Based on roundtable and closing summary discussions, the following actions are recommended to assist more effective preservation and conservation of historic coquina resources:

1. Survey of Coquina Resources

A survey of all known historic coquina resources should be conducted. The survey, providing information consistent with typical cultural resource surveys, should also include contact information for (a) the organizations and individuals having responsibility for preservation and maintenance of these resources, (b) architects and engineers that have been or are involved in such work, as well as (c) the craftsmen who have carried the work out.

2. Materials Research

Basic materials research is needed to allow better understanding of the nature of coquina and the forces that affect it as a building material. What physical changes take place within the material after it is quarried (e.g., does its compressive strength increase with exposure to air and/or sunlight?). What are the most significant forces affecting erosion or deterioration of the material? Are there relatively simple ways to slow deterioration (e.g., a periodic low-pressure wash that may naturally reestablish coquina's resistance to chemical attack)? At what rate does exposed coquina erode? Is surface erosion a serious preservation problem -- one serious enough for some of the radical and controversial preservation and conservation treatments discussed (e.g., application of a sacrificial plaster coating to coquina of Castillo de San Marcos)?

3. Coquina Grading Standard

A grading standard should be established, reflecting the key physical properties of coquina (density, compressive strength, color, range in shell size, etc.). This standards should be correlated, to the extent possible, to the historic uses made of coquina of various grades (e.g., a particular grade may have been used for below grade foundation construction as opposed to above grade wall construction, and yet another grade may have been used for interior masonry rather than masonry with exterior exposure).

4. Mortar Mixes for Restoration

Research and testing should be conducted to establish appropriate mortar mixes for work with the various grades of coquina, as established in 3 above.

5. Substitute Materials

Anticipating increasing scarcity of coquina for use in repairs, research and testing is needed to identify and develop suitable substitute materials. Alternative calciferous stone materials, concrete and other cementitious compositions should be considered in this work.

6. Historic Quarrying and Construction Practices

Additional research is needed to allow better understanding of historic quarrying techniques, material grading practices, and masonry techniques used in coquina construction.

7. Coquina Quarry Survey

A survey of known coquina quarry sites is needed to identify potential sources of the material to meet future preservation and conservation needs. The grading standard in 3 above should be applied to the material available from each quarry site.

Some of these sites, such as the one on Anastasia Island visited during our tour, are in public ownership for preservation as historic quarries. Based on current information, these sites may contain the most suitable material for future preservation work. The possibility of limited quarrying at these sites for preservation and educational purposes should be explored. Such quarrying should be restricted to the preservation needs of only the most significant coquina resources, such as Castillo de San Marcos, a National Historic Landmark and a World Heritage Site. These quarrying operations could be carried out as part of an interpretive program, utilizing historic tools and methods.

Consideration should also be given public acquisition of additional quarry sites, but only if it can be established that such sites contain material of sufficient quality and quantity to contribute to anticipated preservation needs. If non-historic quarry sites can be acquired, there would be no need to consider use of material from historic sites as discusses above.

8. Possible Restrictions on Use of Coquina in New Construction

If the survey in 7 above substantiates that the supply of coquina is as limited as is currently believed, consideration should be given to imposition of restrictive policies on the use of the material in new construction.

9. Contemporary Materials – Preservation Applications

Testing is needed to determine the effectiveness and effects of use of various sealers, consolidants, adhesives and coatings proposed for use in stabilizing deteriorated coquina, repairing cracks in the material, and preventing damage due to rising damp and exposure to the elements.

10. Control of Biological Growth and Cleaning Coquina

Testing is also needed to determine the optimum methods to be used for cleaning and removing biological growth from coquina, as well as optimum methods for otherwise controlling biological growth on the material.

11. Effectiveness of Past Preservation Treatments

Historical research and assessment are needed to document and evaluate the effectiveness of past preservation treatments. The best archival material for this work will likely be available from the National Park Service for Castillo de San Marcos and Fort Matanzas.

12. Coquina Preservation and Conservation Web Site

It is recommended that a Web site be established and maintained to provide access to the results of the above activities, and to facilitate information sharing among the researchers, property managers, architects and engineers, and craftsmen who are actively engaged in the preservation and conservation of historic coquina resources. Perhaps this site could be maintained by the Florida Trust for Historic Preservation, The National Center for Preservation Technology and Training (National Park Services), or a regional university Architecture or Building Science program that includes historic preservation studies (e.g., University of Florida, University of Georgia).

13. Interim Preservation Guidelines for Coquina

Because of the significant number of coquina resources identified during the course of this symposium, and the numerous preservation efforts involving these resources that are being planned or are in progress, it is recommended that interim guidelines be developed, based on current knowledge, for treatment of coquina in historic structures. Such guidelines should be sufficiently conservative as to discourage treatments that, based on experience with other types of masonry, may have negative long-term effects on historic coquina.

14. Coquina Masonry Restoration Training

A program of preservation training for masons is recommended to ensure that personnel responsible for maintenance of historic coquina resources are proficient in the masonry repair skills needed for their jobs. This type of training will help prevent damage to these irreplaceable resources due to well intended but misguided maintenance activities. The National Park Service conducts similar programs, and would be the logical organization to develop and conduct this training.

15. Coquina Preservation and Conservation Task Force

To facilitate the above work, it is recommended that a task force be established to identify funding and institutional programs and resources that may be available to contribute to the research and other needs identified above. At a minimum, the task force should include representatives of the following organizations and institutions:

- a. National Center for Preservation Technology and Training
- b. Florida Trust for Historic Preservation
- c. State Historic Preservation Offices in states where coquina resources have been identified (Florida and North Carolina, to date)
- d. Universities in the region with geology, engineering, architecture, building science, history, historic preservation, chemistry and materials science programs
- e. National Park Service (Southeastern Regional Office and individual properties with coquina resources)

- f. Association for Preservation Technology International
- g. Others engaged in related research

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