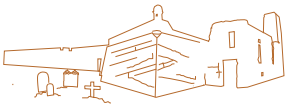


COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

ACADEMIC OUTCOMES/LESSON OBJECTIVES:

- Students read selections introducing them to the ways that archaeologists preserve and protect historical coquina ruins.

SUNSHINE STATE STANDARDS ASSESSED:

SOCIAL STUDIES 4TH-5TH

- (SS.D.1.2.1) Understands that all decisions involve opportunity costs and that making effective decisions involves considering the costs and the benefits associated with alternative choices.

SCIENCE 4TH

- (SC.4.E.6.4) Describe the basic differences between physical weathering (breaking down of rock by wind, water, ice, temperature change, and plants) and erosion (movement of rock by gravity, wind, water, and ice).
- (SC.4.L.17.4) Recognize ways plants and animals, including humans, can impact the environment.
- (SC.4.N.1.3) Explain that science does not always follow a rigidly defined method ("the scientific method") but that science does involve the use of observations and empirical evidence.
- (SC.4.N.3.1) Explain that models can be three dimensional, two dimensional, an explanation in your mind, or a computer model.
- (SC.4.P.9.1) Identify some familiar changes in materials that result in other materials with different characteristics, such as decaying animal or plant matter, burning, rusting, and cooking.

SCIENCE 5TH

- (SC.5.N.2.1) Recognize and explain that science is grounded in empirical observations that are testable; explanation must always be linked with evidence.
- (SC.5.P.8.2) Investigate and identify materials that will dissolve in water and those that will not and identify the conditions that will speed up or slow down the dissolving process.

RESOURCES:

Zomlefer, Wendy and David Giannasi. "Floristic Survey of Castillo de San Marcos National Monument, St. Augustine, Florida." Castanea. Vol. 70 (2005): 222-236.

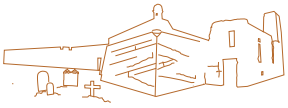
Florida Public Archaeology Network. 28 February 2008 <http://www.flpublicarchaeology.org>.

Lawson, Charles and John Cornelison. Archaeological Investigations of the San Pablo and San Pedro Bastions at Castillo de San Marcos National Monument, St. Augustine, FL. Tallahassee, FL: Southeast Archaeological Center, 2002.

The Conservation and Preservation of Coquina – A Symposium on Historical Building Material in the Coastal Southeast. 28 February 2008 <http://www.flheritage.com/preservation/architecture/coquina/coquina_document.pdf>.

MATERIALS LIST:

Popsicle sticks (16 per student team), jelly, plastic spoons or knives (1 per student team), glue sticks (1 per student team), Elmer's glue (1 per student team)



COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

ANSWER KEY FOR EXPERIMENT:

As with all experiments, the teacher should try this in the classroom environment before having the class attempt it. Variables like humidity and heat can affect the outcome. It doesn't really matter which mortar turns out to be best. The benefits of this activity are in the students' use of the scientific process and in their understanding of how mortars are used in conservation. Here is one possible outcome. The popsicle sticks attached with jelly mortar separate under light stress, making jelly too weak to use as a mortar. The sticks attached with Elmer's Glue mortar crack under extreme stress (because Elmer's Glue soaks into the wood and bonds with multiple layers). This makes Elmer's too strong to use as a mortar, since it causes damage to the historical resource (in this case, the popsicle sticks). The wooden frame affixed using glue stick mortar holds fast under light stress, but separates under extreme stress. This makes glue sticks an appropriate mortar for a structure made from popsicle sticks.

AUTHOR: Kelley Weitzel, http://www.KelleyWeitzel.com

STUDENT ARTICLES & ACTIVITIES:

1. What does a coquina conservator do?
2. Fighting Chemical Attacks
3. Fighting Biological Attacks
4. Fighting Human Attacks
5. EXPERIMENT: Choosing the Right Mortar

VOCABULARY: Absorb, Archaeology, Biological, Conservation, Conservator, Contract, Coquina, Erode, Excavate, Expand, Fern, Flex, Foundation, Herbicide, Lichen, Limewash, Mortar, Moss, Repointing, Resource, Species, Structure, Tabby, Vandalism, Vine

ASSESMENT OPTIONS:

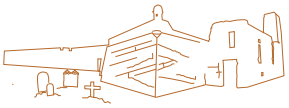
WRITING PROMPT #1: Scientists must determine the true cause of a problem before they try to fix it. Think of a time you needed to solve a problem. Write to explain your problem and the process you used to discover the best solution.

WRITING PROMPT #2: Sometimes, natural parts of the environment, like weather and plants, can damage old coquina buildings. Think about the reasons it is important to protect old forts and buildings from this kind of damage. Write to persuade your city planners to hire a conservator who will find ways to protect local coquina buildings.

ASSESSMENT #1: Based on your reading of the conservation articles, define three different things that damage old coquina structures. Use details and information from the articles to support your answer.

ASSESSMENT #2: Plants often cause damage to old coquina buildings. Explain why coquina stone is so easily damaged by tiny plants like mosses, ferns, and weeds.

This project has been financed in part with historic preservation grant assistance provided by the Bureau of Historic Preservation, Division of Historical Resources, Florida Department of State, assisted by the Florida Historical Commission.



COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

WHY ARE WE STUDYING ABOUT COQUINA CONSERVATION?

Coquina is a very sturdy stone, but after hundreds of years, even the strongest materials need some protection. Conservators must find ways to repair problems caused by acid rain, plant roots, and human actions - before our state's historical buildings disappear forever.

WHAT DOES A COQUINA CONSERVATOR DO?

When people hear the word "conservation," they usually think about natural resources, like water, trees, or clean air. But conservation is important in archaeology too. Some archaeologists work to protect things like old coquina buildings. These men and women are called "Conservators." Their goal is to keep these important coquina buildings in good shape - so that people can visit them well into the future.

In archaeology, there are many different kinds of conservators. Some focus on caring for coquina or brick structures. Others are more interested in creating educational displays for cool archaeology sites. Still others spend their time working with artifacts like arrow points or pottery pieces.

We'll focus on the conservators who work with coquina. What exactly do they do? First, they deal with the problem of chemical attacks. For example, acid rains cause damage to old coquina buildings. So, some conservators work to protect coquina buildings from acid rain.

Next, these conservators deal with biological attacks. A biological attack is an attack by a plant or animal. When plants grow on coquina buildings, their roots damage the coquina shell stone. The mortar that holds the old coquina blocks together also begins to crumble and fall apart. Conservators look for ways to prevent and repair this damage.

Coquina conservators also deal with human attacks. Some human attacks are intentional, like graffiti and vandalism. Other human attacks are accidental. People like to touch old stone objects, like tombstones or forts, because it helps them feel like they are really back in the past. While one or two touches doesn't do much damage, several million touches can start to wear away the coquina surface. Accidental attacks also occur when people try to fix old coquina structures. Sometimes they use the wrong materials (like Portland cement). This can end up causing more problems than it fixes. Conservators search for ways to protect coquina buildings from 1. people who are actually trying to cause damage, 2. people who just want to touch the past, and 3. people who really just want to help.

FIGHTING CHEMICAL ATTACKS

What is a chemical attack? A chemical attack occurs when a chemical (like acid) dissolves coquina stone. This breaks the coquina down into other natural materials. Rain is normally a little bit acidic, so the chemical "acids" in rain actually break down coquina stone.

Why does this happen? Coquina is made up of a chemical called Calcium Carbonate. Problems arise because acid rain can rip calcium carbonate apart. In fact, it rips the coquina into three parts:

Part 1: Calcium. This chemical dissolves in the rainwater and washes away.
Part 2: Water. This just runs off the coquina stone, mixed with bits of calcium.
Part 3: Carbon dioxide. This gas just floats off into the surrounding air.

What started out as a piece of coquina stone ends up as a mixture of gas and mineral water. This kind of chemical attack wears the edges off large coquina blocks. It can also eat away the mortar (or paste) between the blocks.

Calcium Carbonate + Acid Rain ⟶ Calcium + Water + Carbon Dioxide

COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

Look at the photo below. During recent repairs at the Castillo de San Marcos, some new yellow coquina blocks were added to the fort. See how they're cut in perfect rectangles? Now look at the older, gray coquina blocks nearby. Their edges are rounded, but they didn't always look like that. Naturally acidic rains have been falling on the Castillo for 300 years. The acids in these rains have broken down the edges of the stone blocks, destroying the crisp rectangular corners they once had. Why did the National Park Service replace some of the old gray coquina blocks? They didn't do it to make the Castillo look nicer. They did it because these blocks were crumbling badly. The National Park Service only does repairs to make sure that the Castillo's structure will be strong and secure.

Conservation Work Showing New Coquina Blocks Added at the Castillo

Now, check out this photo. The mortar between these coquina blocks has been eroded away. Without mortar to hold the stones in place, the weight of these huge stones will force the walls of the Castillo to crack and lean.

How do conservators fix this problem? It's called "repointing." They must find exactly the right lime mortar to replace the missing paste between the blocks. This mortar must be the right color, matching the mortar that the original builders used. Conservators at the *Mala Compra* site mixed up 21 different mortars to find just the right one. They mixed their mortars with local sands – just like the original Spanish builders did. This helped them find the perfect match.

Repointed Coquina Wall

Replacement mortars must always be made of materials that will expand and flex. What does that mean? Well, as the weather changes, coquina stone will expand (get bigger) and contract (get smaller). These tiny changes pull on the mortar (paste) holding the blocks together. If the mortar will not stretch and bend a little, it will eventually crack due to the changes brought on by harsh weather.

COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

In addition to the color and flexibility of new mortars, conservators must also think about the mortar's strength. Anytime they are working on repointing a structure, the mortar they choose must be WEAKER than the coquina stones. That's right; it has to be weaker. Doesn't make sense, does it? If you're trying to fix a wall, you want the wall to be as strong as possible, right? The answer is…sort of. You want the wall to last, but if the mortar is stronger than the coquina, when this natural stone expands and contracts, it's not the mortar that will crack. It's the coquina stones! Now you've really got a problem! That's why conservators work so hard to find just the right mortar, including color, flexibility, and strength.

How can conservators PREVENT chemical attacks on coquina structures? One way is to protect the coquina with a limewash, just like the original builders did. Since this white limewash will wear away, it must be reapplied every five years. That gets expensive, so it is NOT often chosen as a solution. Another way to protect the coquina is to build a roof over the entire archaeological site, so rain can't fall on it. At *Mala Compra*, conservators have done just that. Check out this roof that protects the newly repointed sections of floor and wall.

View of Mala Compra Site During Conservation Efforts

This photo shows some repointing work done at the *Mala Compra* site. When this photo was taken in late 2007, conservators were in the process of building a sturdy roof to protect this cotton plantation's coquina foundations. Since then, they have installed wooden walkways and educational signs. The walkways allow people to get up close to the coquina foundations without actually stomping on them. The educational signs help people learn about our coquina history. Helping people visit and learn about these old structures is a big part of a conservator's job.

COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

FIGHTING BIOLOGICAL ATTACKS

"Biological attacks" are attacks by living things. In the case of old coquina buildings, most biological attacks are caused by plants and lichens (pronounced lie-kens). However, animals like pigeons that build nests in old forts and poop all over the place also cause problems.

Why are plants usually the biggest issue? Coquina walls absorb (soak up) huge amounts of water. This makes the walls constantly damp, so plants grow there easily. Flat, crusty lichens and squishy, green mosses are the first things that grow on a coquina surface. Some lichens put out acids that react with the coquina stone. They cause the same problems as acid rains. The green mosses absorb extra rainwater and also trap windblown dirt against the coquina stone. This creates an excellent habitat where larger plants can grow.

This coquina block is part of the border around the Robertson graves in the Huguenot Cemetery.

The light green, crusty material on the left is lichen.

The spongy, dark green material on the right is a kind of moss.

Both lichens and mosses are forms of biological attack on this coquina grave marker.

Example of Biological Attack

Cemeteries aren't the only spots that suffer from biological attacks. The coquina foundation in New Smyrna's Old Fort Park is covered with weeds, ferns, vines, and even larger plants like palm trees. Here's a list of the most common plants growing on the coquina stone.

10 KINDS OF WEEDS AND WILDFLOWERS: Artillery Plant, Eyebane, Miterwort, Ragweed, Shepherd's Needle, Virginia Ground Cherry, Wild Geranium, Wood Sorrel, Yellow Aster, Yellow Clover

3 KINDS OF MOSSES, FERNS, AND VINES: Twisted Moss, Ladder Brake Fern, and Virginia Creeper

COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

Many other plants are growing on the old tabby floors underneath this foundation, including sabal palm trees, matrimony vine, peppergrass, nightshade, and spiny sow thistle. The roots of these plants burrow into the tabby floors, the coquina stone, and the mortar that holds coquina stones together. This root action weakens coquina and tabby, which may cause the walls and floors to shift, crack, or fall in the future.

This is a photo of the New Smyrna coquina foundation, left over from the Turnbull Colony. Can you see all of the plants growing in it?

This is a close-up of a coquina well at the Turnbull foundation. Many plants are growing right on the coquina blocks.

The Castillo de San Marcos has even more plants growing on its coquina walls, 56 different species! In 2005, the National Park Service hired conservators to study this problem. The conservators identified all of the different plant species. Then they worked together to come up with ways to remove the plants. In some cases, the plants were carefully removed by hand. That took a LOT of work! Unfortunately, most of the plants grew back right away. In other areas of the Castillo walls, conservators carefully applied herbicide (weed killer). One kind of herbicide killed the leaves and stems, but the plants grew right back from the roots. Other kinds of herbicides worked better. However, using those herbicides for long periods of time could damage the coquina just like acid rain. The conservators came to one conclusion. Fighting biological attacks at the Castillo would take a lot of time, money, and effort.

COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

Image 1: Plants on Castillo Wall

Image 2: View of Castillo Scupper

The photo on the left shows plants growing all the way down the Castillo wall beneath a scupper (drainage pipe). The photo above shows a close-up of a drainage scupper.

Many plants grow under the Castillo's scuppers. When rainwater falls on the top gun deck, it drains off through these pipes, then drips down the outside of the fort. The coquina stones absorb these drips, creating an excellent habitat for weeds and ferns.

Why don't conservators just remove the scuppers? If they did, rainwater would form pools up on the gun deck. These pools would create slip-dangers for visitors and cause cracks in the floor of the gun deck. The cracks would allow rainwater to leak down into the rooms below. That's an even worse problem! Conservators will have to find another way to stop plants from damaging the coquina underneath the scuppers.

The scuppers aren't the only places where weeds and ferns grow on the Castillo's coquina walls. Many plants grow near the bottom of each wall. Why? The coquina stones closest to the ground absorb plenty of water from the soggy soil in the moat. This creates an excellent habitat for weeds and ferns. It is impossible to keep the moat completely dry because it rains so often in Florida. In the future, conservators will have to invent new ways to prevent heavy plant growth on the Castillo's coquina walls.

Image 3: Weeds and Ferns

COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

FIGHTING HUMAN ATTACKS

Some human attacks on archaeology sites are acts of vandalism. People carve their initials into stone structures, and this damages the historical buildings forever.

How do conservators prevent this kind of damage? They try to make it hard for people to get close enough to damage the coquina.

Look at the walkways installed at the *Mala Compra* site. These walkways serve two important purposes. One: They keep people who want to cause trouble AWAY from the coquina structure. Two: The walkways also help interested learners get CLOSE to the coquina foundations. Conservators find it challenging to do both jobs at the same time, but if they want to protect our coquina buildings, they have to try.

Walkways at Mala Compra

Human mistakes are another problem that conservators must solve. One example is the old Ximenez-Fatio House. Over the years, the natural limewash that protected this coquina building had eroded away. In the early 1900s, people decided to protect this old coquina building by covering it with a layer of Portland cement. The cement did stop rain from eroding the coquina blocks, but it caused another major problem.

Portlant Cement Fix at Ximenez-Fatio House

You see, this building's coquina walls were still absorbing water from the earth, and that water had to go somewhere. Normally, it would evaporate into the outside air. However, in this case, the Portland cement stopped the evaporation process. The moisture couldn't move out into the air, so instead, it soaked deeper inside the old hotel's walls. This caused the indoor plaster and paint to crack, peel, and mold. That's a problem. The caretakers of the Ximenez-Fatio House hired conservators to solve this problem. The conservators decided to 1. remove every bit of Portland cement from the outside of the house and 2. to cover the coquina with natural limewash instead. This process took A LOT of time, money, and effort. Conservation work is never quick and easy. It takes thought, planning, and patience. Conservators knew they couldn't start repairing the damage inside the house until they had solved the actual CAUSE of the problem. Look at this photo. Most of the peeling paint and plaster has been removed. Thanks to the conservators, the caretakers of the Ximenez-Fatio House can now start repairing the walls inside.

COQUINA CONSERVATION – TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

THE CASTILLO DE SAN MARCOS: The Castillo experienced another form of "accidental" human attack. In 1938, the Fort's caretakers believed that the moat around the fort had originally been filled with water. They wanted to make the Fort more realistic, so they flooded the moat with seawater. In 1996, the National Park Service discovered two important facts. ONE: The Spanish did NOT keep the moat full of water. They only flooded it if the fort was under attack. TWO: The water now in the moat was actually damaging the coquina stones in the old Fort's walls.

In fact, HUGE cracks had formed in the corners of the Fort. Before conservators could try to repair the cracks, they needed to find out WHY the coquina was cracking in the first place.

View of Castillo Wall

They studied the problem for several years, and their research produced the following information. The corners of the Fort (the bastions) were not built of solid coquina stone. The outer walls were made of coquina blocks, but the inside area was filled with sand and small coquina chunks. This fill material was very sturdy. It helped support the weight of the heavy cannons that sat on top of the bastions. So, what was the problem?

Well, when that fill sand became soaked with water, it got REALLY heavy. The extra weight pushed against the bastion's outer walls, making the coquina stones and mortars crack. And it was still happening. The cracks were getting bigger every year!

Where was this water coming from? Archaeologists discovered that some of it had come from the moat. The stones at the bottom of the coquina walls were soaking up seawater from the moat. Then, the sand inside the bastions soaked up the seawater too. One CAUSE of the Castillo's cracks turned out to be the moat itself, so in 1996, conservators drained the moat and allowed grass to grow there.

Archaeologists also excavated the gun deck (the roof of the fort). They found that cracks in the gun deck were allowing rain to seep down into the bastions. The sand inside soaked up rainwater and got even heavier. So the problem actually had two CAUSES. In 2007, conservators installed a new concrete roof with a waterproof layer to prevent leaks.

After years of careful study, the conservators were ready to fix the cracks in the Castillo's walls. The sand inside the bastions was now much drier and lighter. It would not be pushing on the cracks to make them worse. So, conservators began repointing the cracks, filling them with a mortar that had the correct color, flexibility, and strength. By making sure they had solved each CAUSE behind the Castillo's cracks, the conservators were able to make long-term repairs to Florida's oldest coquina fort.

Crack in Castillo Wall

COQUINA CONSERVATION - TAKING CARE OF OUR HISTORY

Students learn how archaeologists study and care for Florida's coquina ruins.

TRY THIS EXPERIMENT - CHOOSING THE RIGHT MORTAR

BACKGROUND: Before repointing (replacing the mortar on) an old coquina building, conservators need to choose the correct replacement mortar. If the mortar is too weak, it may not hold the coquina blocks together. If the mortar is too strong, forces that push or pull on the repaired wall might actually crack the coquina blocks. The best mortar will stick together under light force BUT ALSO separate under extreme force. This will protect the coquina blocks from cracking under stress.

EXPERIMENT: Students will test three different sticky substances to determine which one forms the best mortar.

MATERIALS: We will use popsicle sticks as a building material to create our model. We will be testing three mortars, including jelly, Elmer's glue, and glue sticks. Use plastic spoons or knives to apply the jelly mortar.

BUILDING PROCEDURE:

- Each team of student conservators should place two popsicle sticks on a table. The popsicle sticks should be about one stick's length apart. Apply Elmer's glue to the ends of each stick. Next, lay down two more sticks to form a square. The top popsicle sticks should cover your mortar (Elmer's glue). Allow your popsicle structure to dry overnight.

- Repeat this procedure using jelly as a mortar.

- Repeat this procedure using a glue stick to apply your mortar.

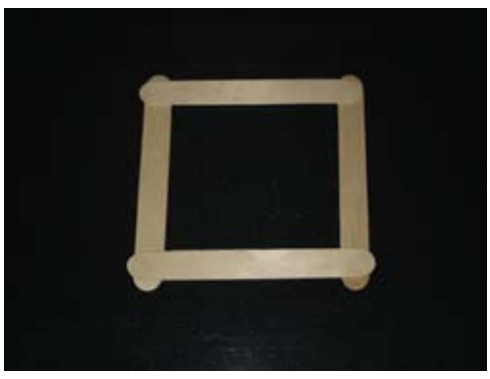
TESTING PROCEDURE: On Day 2, choose one person on each team to test the strength of your mortars.

- Start with the jelly mortar. Twist the sticks a little. Does the jelly hold the sticks together under light force? If the answer is "yes," twist the sticks as hard as you can. What happens?

- Next, test the Elmer's Glue mortar. Twist the sticks a little. Does the Elmer's Glue hold the sticks together under light force? If the answer is "yes," twist the sticks as hard as you can. What happens? Do the popsicle sticks crack?

- Finally, test the glue stick mortar. Twist the sticks a little. Does the glue stick mortar hold the sticks together under light force? If the answer is "yes," twist the sticks as hard as you can. What happens? Does the glue stick mortar separate under extreme force, leaving the popsicle sticks whole?

CONCLUSION: Based on your experiment, which mortar is the best for building structures with popsicle sticks? Jelly, Elmer's Glue, or Glue stick glue? Use evidence from your experiment to support your answer.



Example of Popsicle Structure