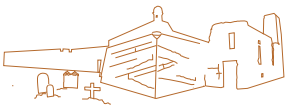


INGREDIENTS OF A FLORIDA FORT: PART I - COQUINA STONE

Students learn how coquina stone is formed and how it changed Florida history.

ACADEMIC OUTCOMES/LESSON OBJECTIVES:

- Students read selections introducing them to the science of coquina formation and the ways this stone has influenced history in Florida.

SUNSHINE STATE STANDARDS ASSESSED:

SOCIAL STUDIES 4TH-5TH
- (SS.A.6.2.2) Understands the influence of geography on the history of Florida.

SCIENCE 4TH
- (SC.4.E.6.3) Recognize that humans need resources found on Earth and that these are either renewable or nonrenewable.
- (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.E.6.6) Identify resources available in Florida (water, phosphate, oil, limestone, silicon, wind, and solar energy).
- (SC.4.N.3.1) Explain that models can be three dimensional, two dimensional, an explanation in your mind, or a computer model.

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.
- (SC.5.P.9.1) Investigate and describe that many physical and chemical changes are affected by temperature.

RESOURCES:

Florida Public Archaeology Network. 28 February 2008 <http://www.flpublicarchaeology.org>.
"Quarry Historical Site." Florida State Parks. 28 February 2008 <http://www.floridastateparks.org/anastasia/Quarry.cfm>.
"Castillo de San Marcos." National Park Service. 28 February 2008 <http://www.nps.gov/casa/>.

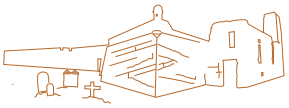
MATERIALS LIST FOR EXPERIMENT I:

Chewy granola bars (1 per student team), table sugar, spoons (one per student team), glasses of water (1 per student team), limestone (1 small piece per student team), bowls (1 per student team), 2-liter bottle of Sprite

MATERIALS LIST FOR EXPERIMENT II:

Thick slabs of Styrofoam (1 per student team), Hammers (1 per student team)

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.



INGREDIENTS OF A FLORIDA FORT: PART I - COQUINA STONE

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ANSWER KEY FOR EXPERIMENT I:

The sugar should dissolve in pure water and become invisible. The warmer the water, the quicker the sugar will dissolve because heat catalyzes (speeds) the reaction. Limestone (calcium carbonate) will not dissolve in pure water. However, it will dissolve in acidic liquids, like Sprite. The fizzing chemical reaction occurs when the calcium carbonate (CaCO3) releases CO2 into the liquid. Note: The chunk of limestone will not dissolve completely. The chewy granola bar should soften in the sun's heat. Just as heat makes the sugar in the glass of water dissolve more quickly, the sun's heat melts the sugary paste inside the granola bar. This is a model of how acid rain can speed the breakdown of the natural cement that holds coquina stone together (just as acidic sprite dissolves the limestone).

ANSWER KEY FOR EXPERIMENT II:

The Styrofoam is similar to coquina because both have plenty of airspaces inside to absorb shock. The hammer strike should dent the Styrofoam, but not crack it or break through. Hint: Try different size hammers to mimic the strikes of different sizes of cannonballs.

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

STUDENT ARTICLES & ACTIVITIES:

1. What is coquina?
2. EXPERIMENT 1: What is the paste inside coquina?
3. What's a fort really for?
4. EXPERIMENT 2: How do coquina forts stand up to cannon fire?
5. How is coquina being used today?

VOCABULARY: Absorb, Acidic, Calcium, Cement, Coast, Coquina Stone, Coquina Shell, Defenses, Dissolve, Impact, Particles, Process, Sea Level, Structures, Support

ASSESMENT OPTIONS:

WRITING PROMPT #1: Many old forts, like the Castillo de San Marcos, are no longer needed to protect our modern cities. Think about the different ways you might be able to make one of these huge stony buildings useful again. Write to explain what you would do with an old Florida fort if you had plenty of money to work with.

WRITING PROMPT #2: Some Floridians believe that coquina stone should only be used to repair important old buildings while others wish to crush coquina stone for use in road-making. Think about whether the government should save this natural stone for forts or allow it to be crushed and used to in road construction. Write to explain how you feel coquina should be used in our state.

ASSESSMENT #1: Review the article titled, "What is Coquina?" Describe the process of coquina formation.

ASSESSMENT #2: Review the article titled, "Try this Experiment – Standing Up to Cannon Fire." Explain why early Floridians preferred to build some structures with coquina stone and other structures with brick.

ASSESSMENT #3: Review the article titled, "Try this Experiment – What is the Paste Inside Coquina?" Explain why a granola bar is a good model for a block of coquina stone

INGREDIENTS OF A FLORIDA FORT: PART I - COQUINA STONE

Students learn how coquina stone is formed and how it changed Florida history.

WHY ARE WE STUDYING ABOUT COQUINA?

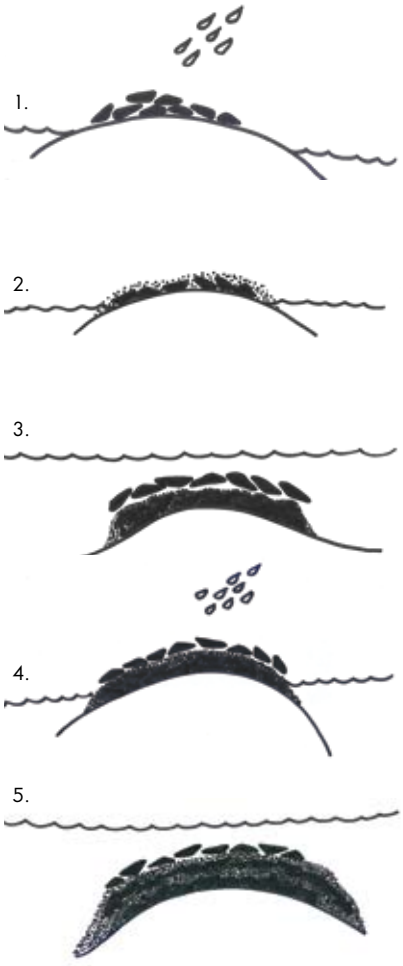
We're studying coquina because this stone played an important role in Florida history. Some coquina stone was used to make forts. These powerful buildings prevented battles between European nations. In other cases, coquina stone was used to build homes, businesses, canals, and even beautiful tombstones. Without our coquina resources, Florida's history might have been very different. Our official language might be Spanish or French instead of English. Florida's early Indians might have triumphed over the Europeans, so that Florida would be a native nation today. Because coquina buildings played a huge role in shaping our state's history, it's important for Florida kids to know about this unusual kind of stone.

WHAT IS COQUINA?

Donax Shells

People don't make coquina stone. Nature does, and it takes thousands of years for coquina to form! Coquina is a mixture of shell and sand, and this unusual stone is found in only a few places around the world. The shells come from tiny clams called Donax. (Some people call these tiny clams coquina shells.) The shells are made from a material called "calcium carbonate" (*kal-see-um car-bun-nut*). After the shell animals die, waves crush them up and wash the tiny shell bits onto sandy beaches. Each day, waves carry the sand and shell pieces up and down the coast, mixing them together.

How does this mixture of sand and shell change into stone? The coquina process depends on two things: changes in sea level and plenty of rain. At times during our planet's history, the ocean level was 400 feet lower than it is now. This means that parts of the ocean bottom were high and dry. At other times, the ocean's surface was 100 feet higher than it is today. This means the entire state of Florida was under water! When dry land changes into deep ocean, coquina can start to form.



How? Diagram 1. When the shells and sand are high and dry, rainwater begins to change them. Rain is naturally a little acidic (*uh-sid-ik*). This means it dissolves the tiny bits of shell.

Diagram 2. The dissolved material settles to the bottom. It sticks to the remaining shells and sand. There, it serves as a natural paste or cement. Over time, coquina stone is formed!

Diagram 3. When sea levels change again, the new coquina stone will be covered by seawater. Waves will dump more shells and sand on top of the coquina.

Diagram 4. As sea levels drop again, rainwater dissolves the new shells. The cementing process starts all over again.

Diagram 5. This means that coquina stone is often found sandwiched between layers of shelly sand.

INGREDIENTS OF A FLORIDA FORT: PART I - COQUINA STONE

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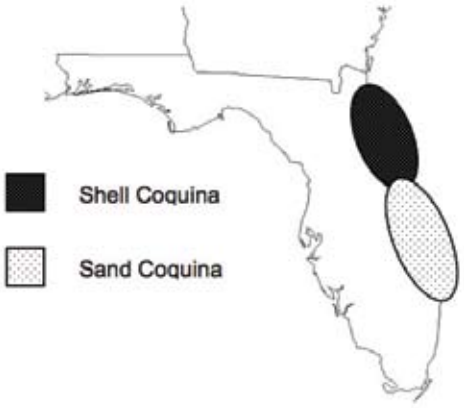
In some places, coquina stone is made of mostly shell with just a little sand mixed in. This is very common in north Florida, from St. Augustine all the way down to Cape Canaveral. Other coquina stone is made of mostly sand with just a little shell mixed in. This kind of coquina is common in central and southern Florida, from Cape Canaveral down to West Palm Beach.



Coquina Stone

INGREDIENTS OF A FLORIDA FORT: PART I - COQUINA STONE

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TRY THIS EXPERIMENT - WHAT IS THE PASTE INSIDE COQUINA?

BACKGROUND: Look at this picture of coquina stone. Did you ever wonder what sticks all those tiny shells and bits of sand together? The paste is not easy to spot. Even if you examine a chunk of coquina under a magnifying glass, you mainly see sand and broken shell. But the paste is there. It's a natural paste, called calcium carbonate. This calcium carbonate comes from the ocean and is made up of old, dissolved seashells.

Coquina Stone

Wait a minute. We just said the natural paste is called Calcium Carbonate. Weren't oyster shells made of "Calcium Carbonate" too? Absolutely. The waves and ocean chemicals break down seashells into tiny microscopic bits. And these bits dissolve in the seawater.

You can try this at home with sugar. If you look closely at a spoonful of sugar, you can see the tiny sugar grains. (In our comparison, the sugar grains are similar to the seashells in the ocean.) After you've examined the sugar, dump it into a big glass of water and stir. The sugar will dissolve and disappear. But it's still there! In fact, if you take a sip of the water, you can taste its sweetness. The sugar is definitely there, but you can't see it anymore. (The same thing happens to seashells when they dissolve in seawater. The dissolved shells are still there, even though we can't see them! And it's these dissolved shells that make the paste inside coquina.)

How can we learn more about this natural paste? Try looking at a chewy granola bar. Do you see a combination of seeds and nuts? Just like in coquina, these materials are cemented together by a natural paste. The natural paste in a granola bar is made of butter and sugar. If you leave a granola bar outside on a hot day, the sun's energy will melt this sugary paste. Once melted, the granola bar is easy to squash or break. If you tried this with a chunk of coquina, you'd see that heat does not damage the "calcium carbonate" paste in coquina. However, other environmental forces, like rainwater, do damage coquina. Naturally acidic rains can dissolve the calcium carbonate along the edges of coquina stones. That's why coquina has a rough, bumpy surface. The smooth natural paste has eroded away.

EXPERIMENT: Place a piece of limestone in a bowl. (Limestone is another form of calcium carbonate). Pour a weak acid (like Sprite) over it. What happens? Does it fizz? If the answer is "yes," then your limestone is giving off carbon dioxide gas. This gassy reaction proves that the acids in Sprite are breaking down the limestone. But don't worry. Since Sprite is much more acidic (and much more destructive) than rainwater, the Castillo isn't in danger of dissolving any time soon. Still, Florida's archaeologists are always looking ahead, studying ways to protect the Fort from future dangers.

Granola Bar

INGREDIENTS OF A FLORIDA FORT: PART I - COQUINA STONE

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COOL FACT:

Modern concrete blocks have pointed corners. So why do the blocks we see in old coquina forts have rounded corners? They didn't start out that way. Look at the photo below. It shows newly replaced yellow coquina blocks next to the old rounded gray blocks at the Castillo de San Marcos. In the beginning, the gray blocks had pointed corners too. So what happened? Over time, the acidic properties of rain eroded away the edges. This makes the old blocks look rounded.

Repointed Wall at the Castillo

WHAT'S A FORT REALLY FOR?

A fort is a heavy-duty building with only one job. It keeps the peace. That's right. Forts are designed to STOP attacks, never to start them. Over the years, the Spanish built nine wooden forts at St. Augustine. Whenever the French or the English or marauding pirates burned down one wooden fort, the Spanish built a new one. Finally, in the 1670s, the Spanish discovered coquina stone. This sturdy natural stone could not be burned down. This made the new coquina fort a very good peacekeeper.

How? The Spanish soldiers mounted many cannons on the top of the Castillo de San Marcos. They fired these cannons at enemy ships to stop them from getting too close. Meanwhile, inside the coquina Fort, these Spanish soldiers were safe from any cannonballs the ships might fire back at them. It worked so well that no enemy ship ever got close enough to attack the town of St. Augustine. In fact, the Castillo was NEVER captured in battle. When English soldiers attacked from land instead of from sea, the Castillo's tall coquina walls kept them out. During each of these attacks, the people of St. Augustine hid inside the Fort until the attacking soldiers gave up and left. That's how the Castillo kept the peace. But it did have one weakness.

In the year 1740, Spanish leaders noticed that the Castillo's cannons couldn't shoot very far to the south. If English ships sailed up from that direction, the Spanish soldiers would need a backup plan for protecting the city of St. Augustine. They decided to build another smaller coquina fort (Ft. Matanzas) south of town. When the English general, Oglethorpe, attacked from the south, the Spanish were ready. The cannons at Ft. Matanzas drove the English ships away! Both coquina forts, the Castillo and Ft. Matanzas, protected St. Augustine's people. After all, that's what forts do. They help to keep the PEACE.

INGREDIENTS OF A FLORIDA FORT: PART I - COQUINA STONE

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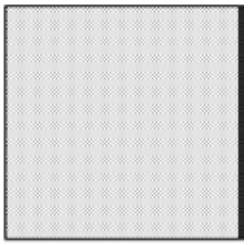
TRY THIS EXPERIMENT - STANDING UP TO CANNON FIRE

QUESTION: Ever wonder why coquina forts are so strong? Cannonballs fired at the Castillo de San Marcos NEVER broke through the walls. They never even cracked the coquina stone. Instead, cannonballs hit the fort walls and rolled down to the ground. If the fort had been made of brick, cannonballs would have torn it apart. Why? Let's find out!

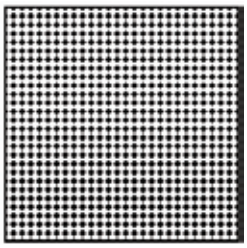
BACKGROUND: How are brick and coquina different?

1. Brick is made from a fire-hardened mixture of clay and water. During the brick-making process, all of the air is squeezed out of the wet clay. (See how close together the clay particles are in the drawing?) At this point, the clay bricks are very soft. They must sit and dry for seven weeks, and then be heated in a very hot fire for six days. The heating process makes these bricks sturdy enough to support the weight of a whole building.



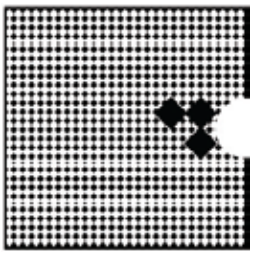
Brick Wall

2. People make bricks, but only nature can make coquina stone. The actions of wind and water paste together sand and bits of shell over thousands of years. When it is still wet, coquina stone is soft. Sometimes it is soft enough to crush in your hand.
Heating the wet stone doesn't make it any harder. Instead, the stones must be allowed to dry for one to three YEARS until they are sturdy enough to support the weight of a whole building. And you thought it took a long time to make bricks!



Coquina Wall

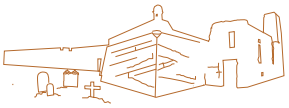
3. We know that in bricks, the clay particles are pressed close together. Coquina stone is very different. Nature has squeezed the shell bits as close together as possible, but there are still tiny air spaces between them. These air spaces are the secret to coquina's strength. When a cannonball hits a coquina wall, the force presses the shell bits inward. Since these shells are pressing against air spaces, the air absorbs (or soaks up) most of the cannonball's force. In fact, the air stops the dangerous force, so it doesn't cause further damage. A cannonball may leave a dent, but it won't tear through the coquina wall or even crack it.



Coquina Wall

4. Brick walls are a totally different story. Why? The brick particles have no air spaces between them for soaking up destructive forces. When a cannonball hits a brick wall, the clay particles get crushed against one another. Under that kind of pressure, the bricks just crack! Bricks are great for building quick houses, but they're a poor choice for the walls of a fort!

Brick Wall



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STANDING UP TO CANNON FIRE, CONTINUED

EXPERIMENT: Set a piece of thick Styrofoam (from a packing box) on the sidewalk. Styrofoam has lots of air spaces inside it. Does this make it more like a brick or more like a coquina block? In this experiment, we'll use the force of a hammer to represent the force of a cannonball. (No, we won't throw the hammer. We'll just use it to hit the Styrofoam.) What do you think will happen when a hammer hits a piece of Styrofoam?

Write a hypothesis stating your idea. _____

_____

_____

Next, use the hammer to give the Styrofoam a direct hit. Observe what happens, and record your observations here.

_____

_____

_____

What have you learned from your experiment? Is Styrofoam more like a brick or more like a coquina block? Write your conclusions here.

_____

_____

_____

_____

COOL FACT:

Cannonballs were made in many different sizes. A small cannonball (the size of a baseball) weighed about 8 pounds. Let's think about how heavy that actually is. A gallon of water weighs just over eight pounds. Imagine somebody firing a gallon jug of water at you from a cannon! That would HURT! And that's the weight of a SMALL cannonball. Some cannonballs weighed 40 pounds!

HOW IS COQUINA STONE USED TODAY?

Today, construction companies use coquina to build new roads. They dig up coquina stone, grind it into pieces, and then spread the coquina crumbles across the ground – right where the new road will go. This crushed coquina makes the dirt hard and flat, so it's ready for the new road to be built.

Some citizens are concerned that Florida may be running out of coquina stone. They believe that all of the remaining coquina should be protected. Other people think it should only be used to fix the old forts when these important buildings begin to fall apart. Still others believe that anyone should be able to use this beautiful stone in their homes and yards. What do you think?