Archaeo-Tech: Geophysics

Cultural Resources Education

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Grade Levels

3rd, 8th & High School Earth Science

Estimated Time

1 hour

Goal

Students will learn how archaeologists use survey techniques to locate archaeological sites and determine where to excavate. After watching the *Archaeo-Tech: Geophysics* short film, students will learn how archaeologists can "see" beneath the Earth's surface using three different techniques: ground penetrating radar, electrical resistance survey, and magnetic gradiometry. These three techniques give archaeologists different information about what is beneath the ground's surface. Students will compare these geophysical survey methods to each other and to traditional archaeological survey techniques.

Objectives

After viewing the *Archaeo-Tech: Geophysics* short film and completing the activity, students will be able to:

1. *Define* archaeology and *list* various surveying techniques archaeologists use to find archaeological sites.
2. *Explain* the methodology behind archaeological survey methods like shovel testing, as well as geophysical survey techniques like ground penetrating radar, resistance surveys, and gradiometer surveys.
3. Broadly *identify* what geophysicists are looking for when they conduct geophysical surveys.
4. *Create* a map of an archaeological site using various symbols and colors to represent artifacts and features.
5. *Model* archaeological survey techniques in class using construction paper and tracing paper.
6. *Compare* and *contrast* conventional survey techniques to geophysical survey techniques.
7. *Relate* key scientific concepts, like electromagnetic waves, magneticity, and electricity to geophysical survey methods.
8. *Investigate* and *discuss* why geophysics is an appealing alternative to conventional shovel testing.

South Carolina Academic Standards

Science

3.S.1 The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

3.E.4B Earth's surface has changed over time by natural processes and by human activities. Humans can take steps to reduce the impact of these changes.

- **3.E.4B.3** Obtain and communicate information to explain how natural events (such as fires, landslides, earthquakes, volcanic eruptions, or floods) and human activities (such as farming, mining, or building) impact the environment.

8.S.1 The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.

- **8.P.3A.3** Analyze and interpret data to describe the behavior of waves (including refraction, reflection, transmission, and absorption) as they interact with various materials.
- **8.P.3A.6** Obtain and communicate information about how various instruments are used to extend human senses by transmitting and detecting waves (such as radio, television, cell phones, and wireless computer networks) to exemplify how technological advancements designs meet human needs.

H.E.1 The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

H.E.3 The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere

- **H.E.3A.1** Analyze and interpret data to explain the differentiation of Earth's internal structure using (1) the production of internal heat from the radioactive decay of unstable isotopes, (2) gravitational energy, (3) data from seismic waves, and (4) Earth's magnetic field.
- **H.E.3A.8** Analyze and interpret data of soil from different locations to compare the major physical components of soil (such as the amounts of sand, silt, clay, and humus) as evidence of Earth processes in that region producing each type of soil.

Activity Type: In-Class

This lesson is to be completed as an in-class activity. The teacher will provide the required materials and necessary instructions.

Materials

- Construction Paper (three sheets per student)
- Markers, crayons, or colored pencils
- Tracing Paper or Tissue Paper (one sheet per student)
- Ruler (one per student)
- Scotch Tape
- Hole Punch or Wooden Skewer (one per student)

Geophysics Background Information

- How do archaeologists know where to dig? Archaeologists do not randomly dig holes and excavation units in hopes of finding artifacts. Instead, sites need to be methodically surveyed first before full excavations can take place.
- Traditionally, archaeologists surveyed a site by digging uniformly spaced shovel width holes called "**shovel test pits**". In a shovel test, the dirt is screened, and artifacts are collected and recorded. On a map, archaeologists make note of which shovel tests contained artifacts (positive) and which did not (negative). Areas with artifact clusters indicate the location of an archaeological site and might be examined further with large scale excavations.
- In the past, the only way for archaeologists to know what was beneath the ground would be through excavation. Excavation is, by its very nature, a destructive process. Because of this, archaeologists are very meticulous in data collection when they excavate a site.
- **Geophysics** has become an important part of modern archaeology because it allows archaeologists to "see" what is beneath the ground without digging it up.
- Like shovel testing, geophysical survey data is collected along established grid lines. This is so scientists uniformly cover the survey area and have an accurate underground map of the site. Data is collected by a variety of instruments, which is then processed by a computer and analyzed by a trained geophysicist. Geophysical experts are looking for anomalies in the collected data, which indicates an unnatural change in the surrounding subsurface.
- Three commonly used geophysical techniques are ground penetrating radar, electrical resistivity, and magnetometry.
    - **Ground Penetrating Radar (GPR)**: In GPR, a radar signal is sent into the ground. When the radar pulse encounters a physical change in the subsurface, it bounces back to a receiver at different strengths and time intervals.
    - **Resistance Survey**: In a resistance survey, an electrical current is passed through the ground at regular points on the survey grid. Electrical resistance (measured in ohms) in the soil varies and patterns of resistance are recorded, plotted, and interpreted.
    - **Magnetic Gradiometry**: In a gradiometer survey, a device is used to detect changes in the local magnetic field, which indicates past human activity. The data collected is used to map magnetized features and objects beneath the ground's surface.

- While geophysical data is a great tool for archaeologists, it has its limitations. Certain soil conditions can make it difficult to get accurate readings from the instruments, and tall grass or difficult walking conditions makes it difficult to create a reliable site map. Furthermore, anomalies in the data that might appear to be man-made, may in fact be natural rock or soil formations. The only way to confirm the results from a geophysical survey is start digging, or “ground-truthing”.

Pockoy Background Information

- **Pockoy Island** is a remote South Carolina barrier island, part of the Department of Natural Resource’s Botany Bay Heritage Preserve / Wildlife Management Area. The property is located on the northeast corner of Edisto Island in Charleston County.
- Botany Bay is one of the largest relatively undeveloped wetland ecosystems on the Atlantic Coast, providing a critical habitat for a number of wildlife species.
- The **cultural resources** of Botany Bay are equally important, with sites dating from approximately 4,000 years ago to the nineteenth century. Several sites are listed on the National Register of Historic Places, including the outbuildings from Bleak Hall Plantation, granite markers from the 1850 Alexander Bache U.S. Coast Survey, and the Fig Island Shell Rings.
- The shell ring on Pockoy Island was first identified in early 2017 by analysts studying Hurricane Matthew’s effect on South Carolina’s coastline. When studying maps produced by aerial light detection and ranging, or **LiDAR**, the analysts noticed strange circular features on the coast of Pockoy Island, indicating the presence of a shell ring. **Shovel testing** began in the summer of 2017, which confirmed the ring’s existence. **Radiocarbon dating** conducted on recovered animal bone revealed that the site was approximately 4,300 years old, making it the oldest known shell ring in South Carolina.
- Testing continued in late 2017, with large scale **excavations** taking place in May and December of 2018.
- **Shell rings** are mysterious structures found along the coasts of South Carolina, Georgia, Florida, and Mississippi. These sites date to the **Late Archaic** period (roughly 5,000 – to 3,000 years ago) and are the earliest significant examples of people living on the southeastern U.S. coast. Dates suggests that the shell ring on Pockoy Island was built over a relatively short period of time, around 20 – 30 years.
- As the name indicates, shell rings are large circular or semi-circular structures made from piled shell. Some are C-shaped and U-shaped, while others are irregularly shaped or made up of multiple shapes. Pockoy is doughnut shaped. Shell rings are primarily composed of oyster shell, but cockles, periwinkles, clams, and whelk shells are also commonly found. They range in size from 30 to 250 meters and are between 1 and 6 meters high. Pockoy’s shell ring is approximately 60 meters in diameter.

- Another key feature of a shell ring is a central area called a **plaza**, which is devoid of shell. Archaeologists speculate that this area was maintained for ceremonial purposes or contained some sort of structure.
- Archaeologists have been studying shell rings for decades but there is still a lot we do not know.
- Archaeologists are unsure if shell rings were intentionally built or not. Some argue that shell rings were inadvertently created from piles of discarded shell following meals over a long period of time. Others believe shell rings were planned structures built from leftover shells of feasts and other quarried shell.
- Archaeologists are also unsure what shell rings were used for. Some believe shell rings were sites of general human occupation, while others theorize shell rings were ceremonial structures only used for specific purposes at specific times.
- Archaeologists have recovered thousands of **artifacts** from Pockoy and other shell rings. The most common artifacts are pottery, shell, and animal bone.
    - The pottery found at Pockoy belongs to the earliest types of ceramics found in South Carolina. Many of the potsherds found at Pockoy are decorated with punctations, incised lines, or stamped designs. The people who created this pottery used shells, reeds, and other natural materials to produce these effects.
    - Shells were not only used to build the ring, they were also used as tools and for decoration. The ancient inhabitants of Pockoy modified whelks and other shells to create hammers, awls, adzes, hoes, and other necessary tools for everyday life. They also turned shells into jewelry by shaping them into beads.
    - Animal bone is normally not well preserved because of the acidity of South Carolina's soil. However, bone is plentiful at Pockoy because the calcium from the shell raises the soil's pH level, preserving the bone. Worked bone is frequently found and at Pockoy archaeologists have recovered numerous finely decorated bone pins.
- What archaeologists do not find at a site can also tell them a lot about the people that lived there. Very little stone has been found at Pockoy, telling archaeologists that the people that once lived there did not rely on stone tools. Some archaeologists interpret this as evidence that the shell ring was not a site of human occupation, but others propose that this is reflective on the environment – good stone is hard to find on the coast so the people living there adapted by making their tools out of shell and bone.
- Due to Pockoy's location along the coast, the site is vulnerable to coastal erosion and rising sea levels. With a rate of 9.5 meters of coastline lost per year, Pockoy is expected to be completely engulfed by the ocean by 2024.
- Climate change, or "heritage at risk", poses a serious challenge to archaeologists, and Pockoy is not the only site facing destruction. According to a report by DINAA (The Digital Index of North American Archaeology), a one-meter rise in

sea level would result in the loss of 13,583 archaeological sites across the Southeastern United States. It is imperative to salvage, protect, and study these vulnerable sites before they are gone.

Vocabulary

- **Archaeological Site:** A place where human activity occurred, and material remains were deposited.
- **Archaeologist:** An anthropologist (social scientist) who studies the material remains of past human activity.
- **Archaeology:** The scientific study of past human cultures by analyzing the material remains (sites and artifacts) that people left behind.
- **Artifact:** Any object made, modified, or used by people.
- **Cultural Resources:** Evidence of past human activity. They include archaeological sites, historic homes, battlefields, burial grounds, shipwrecks, historic and prehistoric artifacts.
- **Excavation:** The systematic digging and recording of an archaeological site.
- **Feature:** Material remains that cannot be removed from a site such as roasting pits, fire hearths, house floors or post molds.
- **Geophysical Survey:** a number of non-invasive remote sensing techniques used in archaeological investigations to determine the presence of cultural resources.
- **Ground Penetrating Radar (GPR):** A geophysical method that uses radar pulses to collect and record information about what is below the surface of the ground (only near-surface).
- **Magnetometry:** A geophysical technique that measures and maps patterns of magnetism in the soil.
- **Resistivity:** A geophysical technique where an electrical current is passed through the ground at regular points to measure and map the electrical resistance of the soil.
- **Shovel Test Pit:** A pit or hole dug to determine site depth, stratigraphic sequences, and so forth, prior to excavation.
- **Stratigraphy:** The layering of deposits in archaeological sites. Cultural remains and natural sediments become buried over time, forming strata. General principle is that more recent artifacts are on the top, and the oldest artifacts are on the bottom.
- **Survey:** The close examination of an area prior to land alteration activities in order to see if there are any sites present that might be damaged or destroyed.

Lesson

1. Optional. Before starting the lesson, have your students read this article from the *South Carolina Wildlife* magazine about the archaeological excavations at Pockoy Island, a small barrier island off the coast of Edisto Island.
    - http://www.scwildlife.com/articles/septoct2018/TheShellRingsofPockoy.html
2. Begin the lesson by discussing the field of archaeology. Explore basic questions, like what is archaeology, what do archaeologists do, and how do archaeologists study the past? Students can use examples from the article to answer these questions.
3. As a class, brainstorm how archaeologists find archaeological sites. How do archaeologists know where to dig? There are many ways archaeologists find sites. Some are found by referencing historical documents, like old maps, while others are found by accident. Many sites are found when archaeologists visit a potential site and conduct what is called an archaeological survey.
4. Explain that in an archaeological survey, archaeologists have a map of the area they are surveying with a grid laid over it. Archaeologists use this map to uniformly plot “shovel test pits”, shovel width holes dug straight into the ground. The dirt from these shovel test pits (STPs) is sifted and artifacts are recorded and collected. Archaeologists make note of which STPs yielded artifacts (positive) and which did not (negative), and they plot the results on the map. Areas with artifact clusters indicate the location of an archaeological site and might be examined further with large scale excavations.
5. Distribute the construction paper, tape, markers, and hole punchers. Each student needs three pages of construction paper. Tell your students that they will be simulating an archaeological survey.
    - Wooden skewers can be used in place of hole punchers, but holes made by the skewers will be significantly smaller than holes made by a hole puncher. Wooden skewers may not be appropriate for younger students since they are sharp, and students could accidentally hurt themselves.
6. On one piece of construction paper, have your students draw an archaeological site (see example at the end of the lesson plan). Students should use uniform symbols and different colors to indicate artifacts and features. On a second page of construction paper, have your students draw a grid using 1-inch or 2-inch units of measurement. A gridded piece of paper may be prepared beforehand to save class time.
7. Using a hole punch or wooden skewer, have your students punch holes where the grid lines intersect. These holes represent “shovel test pits”. Leave the third page of construction paper blank. This page will represent the ground surface.
    - Students need to draw their sites from a top-down perspective. Note that the students’ archaeological sites do not need to be accurate to real-life archaeological sites and encourage students to use their imagination when creating their maps.

8. Layer the three pages on top of each other so the hole punched gridded page is on top, the blank page is in the middle, and the archaeological site is on the bottom. Use tape to secure the top page to the bottom page by taping the upper left and right corners together but leave the middle page loose. Then, have your students trade their “sites” with each other. The idea is that students should not know what the site looks like prior to “surveying”.
9. Students should gently hold the site down on their desks, and slowly slide the blank middle page out from the stack, revealing the archaeological site. Have your students make observations about the site. Explain that large scale excavations are time consuming and expensive, and they only have time to excavate ten units. Based off the information from their “shovel test pits”, what units should they excavate?
10. Have your students look at their archaeological sites. Discuss the pros and cons of the shovel test pit survey method. What information did the survey tell you about the site? What did it miss? How effective was it in showing you the full picture of the site or where to excavate? What are some other ways archaeologists might survey a site? Brainstorm ways archaeologists could survey a site without digging shovel test pits.
11. Show your class the *Archaeo-Tech: Geophysics* short film and answer any questions students might have.
12. Using what your students learned in the film, discuss what geophysics is and how it applies to archaeology. Discuss the advantages geophysical surveying has over conventional surveying techniques. Also discuss the disadvantages of geophysical surveying compared to conventional surveying methods.
13. Identify the underlying science behind the three geophysical survey methods seen in the film. Radar / electromagnetic waves for ground penetrating radar, electricity for resistance surveys, and magnetic fields for magnetometry. Have your students recall their knowledge of these concepts from previous science classes and apply it to archaeological surveying.
14. Distribute sheets of tracing paper (tissue paper cut to the size of the construction paper may also work). Have your students lay the tracing paper over their archaeological sites. Explain that the tracing paper represents geophysical survey techniques. Tell your students that geophysical surveys do not show individual artifacts, but they do show changes in soil composition and buried features. Using a different marker color, have your students trace what would show up in a geophysical survey of their archaeological sites on the tracing paper. Have your students compare this result to the results from the conventional shovel test survey.
15. When students are finished with the activity, ask them which survey method is less destructive. Explore why being able to “see” a site before excavating is important to archaeologists.
16. Optional. Students can research the science and application of different geophysical survey techniques for an in-class presentation, either individually or as a group.

Resources

Archaeological geophysics: ground penetrating radar. (n.d.). *Landscape and Geophysical Services.* Retrieved from http://www.lgs.ie/ground-penetrating-radar.shtml.

Archaeological geophysics: magnetic gradiometry. (n.d.). *Landscape and Geophysical Services*. Retrieved from http://www.lgs.ie/magnetic-gradiometry.shtml.

Brock, T. (2010). Archaeology 101: Shovel Test Pit Survey. Retrieved from http://campusarch.msu.edu/?p=463.

Catling, C. (2017). *A practical handbook of archaeology: A beginner's guide to unearthing the past*. London, United Kingdom: Anness Publishing.

Geophysics. (n.d.). *Past Perfect: The Virtual Archaeology of Durham and Northumberland*. Retrieved from http://www.pastperfect.org.uk/archaeology/geophys.html.

Time Team America: Geophysics 101 (n.d.). *Public Broadcasting Service (PBS)*. Retrieved from http://www.pbs.org/time-team/experience-archaeology/geophysics/.

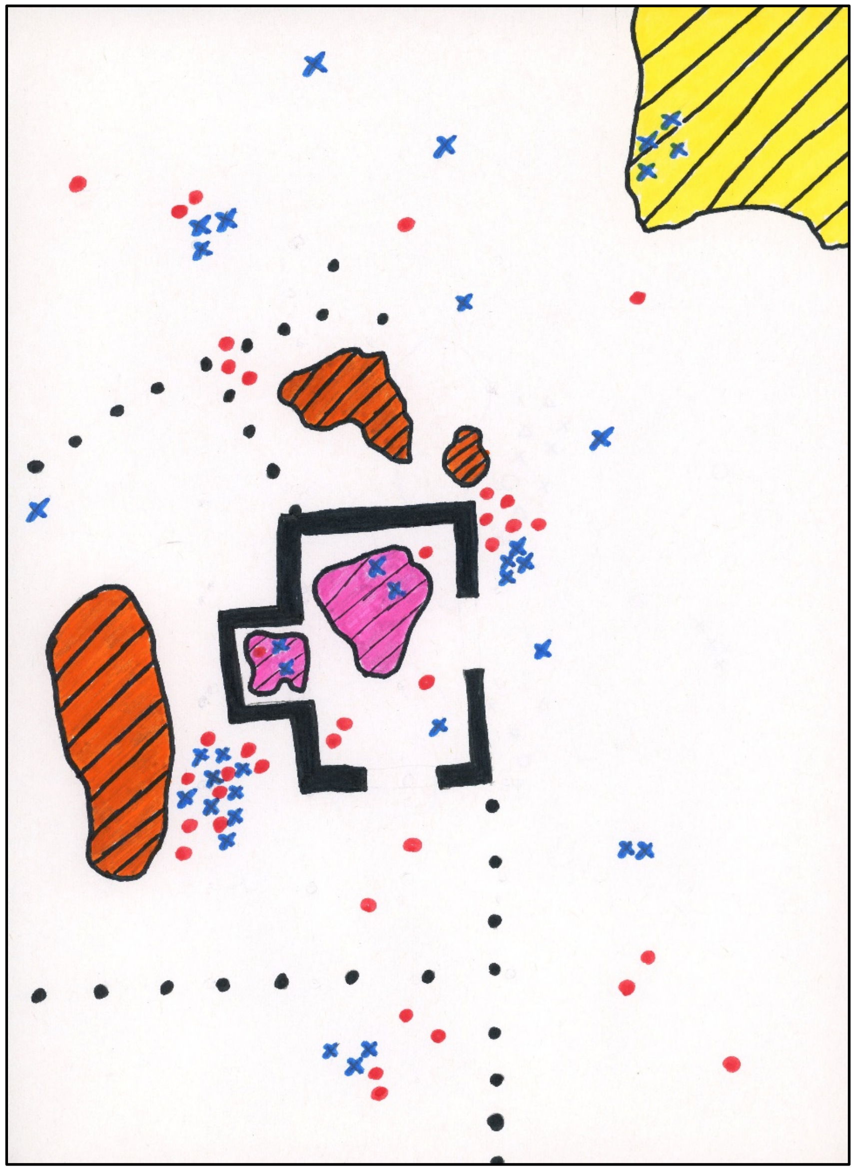
Time Team America: Ground-Penetrating Radar (GPR). (n.d.). *Public Broadcasting Service (PBS)*. Retrieved from http://www.pbs.org/time-team/experience-archaeology/ground-penetrating-radar/.

Time Team America: Magnetometry (n.d.). *Public Broadcasting Service (PBS)*. Retrieved from http://www.pbs.org/time-team/experience-archaeology/magnetometry/.

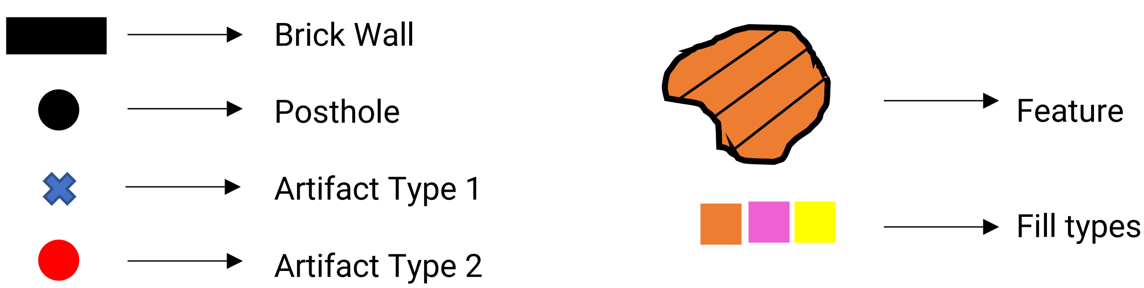
Time Team America: Resistance (n.d.). *Public Broadcasting Service (PBS)*. Retrieved from http://www.pbs.org/time-team/experience-archaeology/resistivity/.

White, J. R. (2005). *Hands-on archaeology: Real-life activities for kids*. Waco, Texas: Prufrock Press.

Archaeological Site Map Example



Map Key



Note that students' site maps do not need to resemble this example, nor is this example an accurate depiction of a real archaeological site.