Mapping a Maya Settlement

Focus
Archaeological surveying

Grade Level
9-12 (Mathematics/Earth Science)

Focus Question
How do archaeologists map the ancient Maya seaport site at Vista Alegre?

Learning Objectives
- Students will discuss the maritime cultural landscape approach, describe some of the interactions between human activities and ecological resources, and explain how artifacts may provide clues about these interactions.
- Students will plot Total Station data to construct a simplified version of the Vista Alegre site.
- Students will make inferences about how local hydrology might be related to anthropogenic features at the Vista Alegre site.
- Students will discuss how features of the Vista Alegre site may reflect the influence of maritime trading activities.

Materials
- Copies of Vista Alegre Base Map and Vista Alegre Survey Data; one copy for each student group

Audio-Visual Materials
- Interactive white board or other technology to display Figures 1 and 2

Teaching Time
One or two 45-minute class periods

Seating Arrangement
Groups of two to four students

Maximum Number of Students
30
Background Information

NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

Vista Alegre is the site of a Maya settlement on a small mangrove-shrouded island on the southern coast of the Yalahau Lagoon at the northeastern tip of the Yucatán Peninsula. The lagoon connects to the Gulf of Mexico, and most of Vista Alegre is surrounded by lagoons or estuaries. The lagoon connects to the Gulf of Mexico, and most of Vista Alegre is surrounded by lagoons or estuaries. This community was part of the great Mesoamerican civilization that developed true writing, sophisticated mathematics and astronomy, and trade networks that spanned thousands of miles. Archaeologists first visited the site in 1954, and subsequent research has recovered pottery remains that suggest Maya peoples have inhabited Vista Alegre for about 3,000 years. The site has not been continuously occupied, however; and archaeological evidence suggests that there have been four distinct periods of occupancy:

Vista Alegre I (800/700 BC to 450/400 BC)
Vista Alegre II (100/150 AD to 650 AD)
Vista Alegre III (850/900 AD to 1100 AD)
Vista Alegre IV (1100 AD to 1521 AD)

For more information about these periods and their relationship to the overall chronology of the Maya civilization, please see the Expedition Purpose for the Exploring the Hidden World of the Maritime Maya 2011 Expedition, http://oceanexplorer.noaa.gov/explorations/11maya/background/edu/purpose.html.

The Yucatán Peninsula rests on a foundation of limestone bedrock. Limestone is gradually dissolved by acidic water (normal rainwater is slightly acidic). This process creates underground caves, and makes the Yucatán limestone highly porous. In many places, underground limestone caves collapse and form sinkholes. Yucatán’s sinkholes are called cenotes (pronounced “seh-NO-tehs”), and are very important in Maya history. Besides being a major source of fresh water, cenotes had religious significance and were sometimes sites of human sacrifice.
Yucatán’s limestone bedrock slopes gradually downward from south to north. The peninsula is often described as being divided into northern and southern lowlands with a boundary at about 19° N. The southern lowlands include numerous rivers, streams, and wetlands; although water is scarce in the central interior area. The northern lowlands have almost no surface streams, and fresh water is found only in cenotes and a few small lakes. At the northern tip of the Yucatán, however, an area known as the Yalahau region includes a series of north-south oriented freshwater wetlands that receive higher-than-average rainfall, possibly because of sea breezes that converge over this area.

Environmental conditions in the vicinity of Vista Alegre are very different from those around other Maya settlements. Fresh water is scarce; the complex coastal ecology is not suitable for the types of agriculture practiced by Maya in other regions; and the coastal environment offers food resources and transportation opportunities that are not available to inland inhabitants. Maya living at Vista Alegre must have developed specialized ways to live with these conditions, and these different lifeways may have caused Vista Alegre Maya to become culturally distinct from Maya living elsewhere. In fact, records from early European contacts state that the coastal Maya saw themselves as more “refined” than inland peoples. These considerations cause archaeologists to ask whether physical evidence at Vista Alegre demonstrates that its inhabitants had a distinct coastal identity that was significantly different from that of Maya living inland.

In this lesson students will plot survey data from the Vista Alegre site, and infer how features at the site may be related to local hydrology and maritime trading activities.

**Learning Procedure**


2. Introduce Exploring the Hidden World of the Maritime Maya 2011 Expedition, and briefly describe the Maya civilization. See the resources listed below and the Expedition Purpose for the Exploring the Hidden World of the Maritime Maya 2011 Expedition ([http://oceanexplorer.noaa.gov/explorations/11maya/background/edu/purpose.html](http://oceanexplorer.noaa.gov/explorations/11maya/background/edu/purpose.html)) for more information. Describe the maritime cultural landscape approach, and emphasize that this concept is based on recognizing that artifacts and structures that form the archaeological record are the result of complex interactions between human activities and geographical and ecological features and events that provided the context for these activities. Point out that
archaeologists often excavate trash pits (also called middens) to find objects that give clues about these interactions, ecological features, and events. Tell students that when this type of archaeological study is applied to modern cultures it is sometimes called “garbology.”

3. Provide each student group with a copy of *Vista Alegre Base Map* and *Vista Alegre Survey Data*. Each group should have access to a protractor, dividers, straightedge, and a sharp pencil. Tell students that these data were part of a survey of the Vista Alegre site, and that the data were collected with an instrument called a Total Station. This instrument makes very accurate measurements of horizontal and vertical angles, as well as distance. In use, the surveyor aims the Total Station at a reflector which is usually mounted on a long pole held by an assistant at the location the surveyor wants to mark. The Total Station measures the distance to the reflector and the angle relative to some reference direction (in this case north). Be sure students understand that the horizontal angles listed in the survey data are relative to north; so an angle of 90° is exactly east of the Total Station position, an angle of 180° is exactly south of the Total Station position, and so forth.

You may also want to point out that the measured distance between the Total Station and reflector is affected by any difference in height between these two instruments. If one is higher than the other, the measured distance will be greater than the horizontal distance that would be measured if they were at the same height. In actual surveys, these effects are eliminated by Total Station data processing software based on vertical angle measurements and information about the height of the Total Station and reflector. For this exercise, students may assume that the Total Station and reflector were exactly horizontal relative to each other.

Have students plot the location of the sacbe, andador, and the three structures, and calculate the height of the pyramid as directed on the Survey Data sheet. You may want to plot the data for one structure as a class exercise if students are unsure about the plotting procedure.

4. Have each student group present their results, then show Figure 1 (see page 5). Discuss any discrepancies between students’ plots and this figure. Students should have used the Pythagorean Theorem to calculate the height of the Pyramid:

\[
(250 \text{ m})^2 = (249.758 \text{ m})^2 + (\text{height})^2
\]

\[
62,500 \text{ m}^2 = 62,379 \text{ m}^2 + (\text{height})^2
\]

\[
62,500 \text{ m}^2 - 62,379 \text{ m}^2 = (\text{height})^2
\]

\[
121 \text{ m}^2 = (\text{height})^2
\]

\[
\text{height} = 11 \text{ m}
\]
Figure 1. Structures and Features from Table 1 Plotted on Base Map
After this discussion, tell students that modern Total Stations contain microprocessors that make these calculations, and with appropriate software can generate display plots of the survey data. It is normal, however, for beginning surveyors to make these plots themselves from angle and distance data so they understand how the Total Station achieves its results.

5. Tell students that limestone landscapes frequently are fractured in various directions, and the junctions of two or more fractures are often the sources of freshwater discharge. In the Yucatán Peninsula as a whole, fracture intersections are known to be the site of many of the largest freshwater springs, particularly along the Caribbean coast, and these locations also were the sites of major Maya trading ports.

Show students Figure 2, which diagrams the location of limestone fractures in the vicinity of Vista Alegre, and ask what features on their data plots correspond to potential locations of freshwater discharge. Students should recognize that both ends of the sacbe coincide with fracture junctions. The presence of freshwater springs at these locations may have been an important consideration for the location of the sacbe. It is very likely that an important use of the sacbe was for exchanging cargo with trading canoes. With freshwater springs at each end, the sacbe also could have been used to bring fresh water to the Vista Alegre settlement. Having freshwater springs at these locations would also have made it convenient bring freshwater aboard the canoes.

Tell students that a similar junction has been located farther inland at the end of the andador where another structure known as the Templo Perdido is located. Ask students why these fracture junctions might not be sources of fresh water today. Students should infer that rising sea level could have caused saltwater and sediments to intrude into these junctions. In addition, diminished rainfall could reduce the availability of fresh water at these locations.

The BRIDGE Connection
www.vims.edu/bridge/archeology.html

The “Me” Connection
Have students write a brief essay about how knowledge of ancient Maya settlements might be of personal importance or benefit.

Connections to Other Subjects
English/Language Arts, Geography

Assessment
Students’ data plots and class discussions provide opportunities for assessment.
Figure 2. Location of Limestone Fractures in the Vicinity of Vista Alegre

- Mangrove
- Island
- Water
- Structure
- Fracture
Extensions
2. For more activities about the Maya civilization, see Other Resources, below.

Other Relevant Lesson Plans from NOAA’s Ocean Exploration Program

The Puzzle of the Ice Age Americans
(from the Exploring the Submerged New World 2009 Expedition)
http://oceanexplorer.noaa.gov/explorations/09newworld/background/edu/media/puzzle.pdf

Focus: Origin of the first humans in the Americas (Anthropology, Earth Science)

Students will describe alternative theories for how the first humans came to the Americas and explain the evidence that supports or contradicts these theories, explain how exploration of a submerged portion of the North American west coast may provide additional insights about the origin of the first Americans, and describe the role of skepticism in scientific inquiry.

By Land or By Sea or Both?
(from the Exploring the Submerged New World 2009 Expedition)
http://oceanexplorer.noaa.gov/explorations/09newworld/background/edu/media/landsea.pdf

Focus: Watercraft in Paleoamerican Migrations

Students will describe evidence that supports the idea that the initial settlement of North and South America involved watercraft, discuss types of watercraft that might have been involved in new world settlement, and explain at least three advantages and three disadvantages of coastal settlements compared to inland settlements.

Other Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page’s publication, but the linking sites may become outdated or non-operational over time.

http://oceanexplorer.noaa.gov/explorations/11maya/welcome.html
– Web site for the Exploring the Hidden World of the Maritime Maya 2011 Expedition

http://www.smm.org/sln/ma/ – Maya Adventure, from the Science Museum of Minnesota; includes science activities and information related to ancient and modern Maya culture

http://teacher.scholastic.com/lessonrepro/lessonplans/profbooks/ss970818d.htm – Peoples of Mexico - The Maya from Scholastic.com

http://www.pbs.org/wgbh/nova/teachers/programs/2804_maya.html – Teacher’s Guide to accompany the NOVA production, Lost King of the Maya; includes an activity using the Maya calendar


Correlations

Framework for K-12 Science Education

B. Crosscutting Concepts

2. Cause and effect: Mechanism and explanation

7. Stability and change

C. Disciplinary Core Ideas

Life Sciences

Core Idea LS2: Ecosystems: Interactions, Energy, and Dynamics

LS2.A: Interdependent Relationships in Ecosystems

LS2.C: Ecosystems Dynamics, Functioning, and Resilience
LS2.D: Social Interactions and Group Behavior
Core Idea LS4: Biological Evolution: Unity and Diversity
LS4.D: Biodiversity and Humans
Earth and Space Sciences
Core Idea ESS3: Earth and Human Activity
ESS3.C: Human Impacts on Earth Systems
Core Idea ETS2: Links Among Engineering, Technology, Science, and Society
ETS2.B: Influence of Engineering, Technology and Science on Society and the Natural World

Ocean Literacy Essential Principles and Fundamental Concepts

**Essential Principle 2.**
The ocean and life in the ocean shape the features of the Earth.

*Fundamental Concept c.* Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.

**Essential Principle 5.**
The ocean supports a great diversity of life and ecosystems.

*Fundamental Concept i.* Estuaries provide important and productive nursery areas for many marine and aquatic species.

**Essential Principle 6.**
The ocean and humans are inextricably interconnected.

*Fundamental Concept b.* From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation’s economy, serves as a highway for transportation of goods and people, and plays a role in national security.

*Fundamental Concept c.* The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

*Fundamental Concept f.* Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).
Send Us Your Feedback
In addition to consultation with expedition scientists, the development of lesson plans and other education products is guided by comments and suggestions from educators and others who use these materials. Please send questions and comments about these materials to:

oceanexeducation@noaa.gov.

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Credit
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Vista Alegre Survey Data

Archaeologists, surveyors and others who need to make precise measurements of the location of various objects often use an instrument called a Total Station. This instrument combines a digital version of a theodolite (an instrument for measuring horizontal and vertical angles) with an electronic distance measuring device (EDM). To survey the Vista Alegre site diagrammed on the Base Map, archaeologists located their Total Station at the spot indicated by the red X. Table 1 shows the distance from this point to the locations of various structures on the site, as well as the angle of these locations relative to north. All of these structures are approximately rectangular, and the data in Table 1 locate the four corners of each structure. Structure 12 is a pyramid that may have been used as a lookout or signalling station when Vista Alegra was occupied. Note that a sacbe is a road, and an andador is a raised walkway.

To plot a location from Table 1 onto the Base Map:
1. To plot angles between 0° and 180°, position your protractor so that the vertex is directly over the red X, and 0° on the protractor corresponds to the direction of the north arrow (this means that the base of your protractor will be vertical with 0° at the top). To plot angles between 180° and 359°, position your protractor so that the vertex is directly over the red X, and 180° on the protractor corresponds to the direction of the north arrow (now the base of your protractor will be vertical with 0° at the bottom).

2. With a sharp pencil, make a small dot at the point on the outer ring of the protractor that corresponds to the angle for a selected location listed in Table 1. If the angle is greater than 180°, subtract 180° from the angle measurement and plot the result. So, if the angle you want to plot is 225°, plot 45° (remember, if the angle to plot is greater than 180°, your protractor must be positioned with zero degrees at the bottom).

3. Now draw a light line from the red X to the point plotted in Step 2.

4. Use the scale at the top of Figure 1 to set your dividers so that the space between the divider points corresponds to the distance for the selected location shown in Table 1.

5. Place one of the divider points at the center of the red X, and the other point on the line that you drew in Step 3. This is the location of the selected point listed in Table 1.
Total Stations usually measure elevation angles relative to vertical, so an
elevation angle of 90° means that the Total Station was pointed exactly
horizontally.

The distance to the apex of the Pyramid at Vista Alegre was 250.000 m from the
Total Station, and the distance to a point directly beneath the apex at the base
of the Pyramid was 249.758 m. Assuming the elevation angle was 90.0°, how
high was the Pyramid?

Table 1. Distance and Angle from Total Station Location to Locations of
Various Structures at Vista Alegre

<table>
<thead>
<tr>
<th>Survey Line Number</th>
<th>Point Description</th>
<th>Distance (meters)</th>
<th>Angle (degrees from north)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-1</td>
<td>West end of Andador</td>
<td>355</td>
<td>183</td>
</tr>
<tr>
<td>S-2</td>
<td>East end of Andador</td>
<td>409</td>
<td>181</td>
</tr>
<tr>
<td>S-3</td>
<td>West end of Sacbe</td>
<td>334</td>
<td>257</td>
</tr>
<tr>
<td>S-4</td>
<td>East end of Sacbe</td>
<td>110</td>
<td>46</td>
</tr>
<tr>
<td>S-5</td>
<td>Intermediate point #1 on Sacbe</td>
<td>220</td>
<td>244</td>
</tr>
<tr>
<td>S-6</td>
<td>Intermediate point #2 on Sacbe</td>
<td>139</td>
<td>227</td>
</tr>
<tr>
<td>S-7</td>
<td>Intermediate point #3 on Sacbe</td>
<td>48</td>
<td>115</td>
</tr>
<tr>
<td>S-8</td>
<td>South corner Structure 21</td>
<td>94</td>
<td>298</td>
</tr>
<tr>
<td>S-9</td>
<td>East corner Structure 21</td>
<td>99</td>
<td>309</td>
</tr>
<tr>
<td>S-10</td>
<td>North corner Structure 21</td>
<td>130</td>
<td>305</td>
</tr>
<tr>
<td>S-11</td>
<td>West corner Structure 21</td>
<td>125</td>
<td>295</td>
</tr>
<tr>
<td>S-12</td>
<td>Northeast corner Pyramid base</td>
<td>243</td>
<td>288</td>
</tr>
<tr>
<td>S-13</td>
<td>Northwest corner Pyramid base</td>
<td>265</td>
<td>285</td>
</tr>
<tr>
<td>S-14</td>
<td>Southeast corner Pyramid base</td>
<td>235</td>
<td>282</td>
</tr>
<tr>
<td>S-15</td>
<td>Southwest corner Pyramid base</td>
<td>256</td>
<td>280</td>
</tr>
<tr>
<td>S-16</td>
<td>Northeast corner Structure 14</td>
<td>319</td>
<td>302</td>
</tr>
<tr>
<td>S-17</td>
<td>Southeast corner Structure 14</td>
<td>310</td>
<td>300</td>
</tr>
<tr>
<td>S-18</td>
<td>Northwest corner Structure 14</td>
<td>347</td>
<td>298</td>
</tr>
<tr>
<td>S-19</td>
<td>Southwest corner Structure 14</td>
<td>334</td>
<td>297</td>
</tr>
</tbody>
</table>
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Vista Alegre Base Map

- Mangrove
- Island
- Water

0 25 50 100 200 300 400 meters

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