



How do ge archaeologists use remote sensing to interpret landscapes?



Investigation Overview

In this investigation students learn the seven elements ge archaeologists and specialists in remote sensing use to detect significant human and physical features. They apply these elements to analyze an image to learn more about ancient Egypt.

Time required: Two 45-minute sessions

Materials/Resources

Logs (one of each per student)

Log 1: What features do ge archaeologists look for on an image?

Log 2: How do interpretive elements help us determine what the image is showing?

Log 3: In conclusion

World map

White paper

Colored pencils

Content Preview

Traditional techniques of finding archaeological evidence include: locating and studying surface structures, studying aerial photographs, researching documents, and digging. Ge archaeologists now use remote sensing techniques to look for information not yet detected using traditional techniques. They analyze images to discern where cultural evidence has been covered by sand, by vegetation, or by subsequent human occupation.

Classroom Procedures

Beginning the Investigation

1. Explain to students that remote sensing is the science of identifying, observing, and measuring an object without coming into direct contact with it. The process involves the detection and measurement of radiation of different wavelengths reflected or emitted by distant objects or materials. This data helps a remote sensor to identify substances and to categorize them by class, type, and spatial distribution. A primary use of remote-sensing data is to classify the variety of features in a scene, usually presented as an image. The image can then be used to create a thematic map, such as a land use map, a vegetation

Geography Standards

Standard 1: The World in Spatial Terms

How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

- Describe the essential characteristics and functions of maps and geographic representations, tools, and technologies.

Geography Skills

Skill Set 4: Analyze Geographic Information

- Interpret information obtained from maps, aerial photographs, satellite-produced images, and geographic information systems.

map, or a rainfall map. A farmer might use thematic maps to monitor the health of his crops without going into his fields. A biologist might want to study the variety of plants in a large area. And a geoarchaeologist may use remotely sensed images to discover evidence of past human occupation in a region.

2. Identify and discuss how geoarchaeologists find locations of ancient cultures. Discuss new techniques.
3. Introduce the following terms: ground (eye) level view, oblique view, aerial view, tone, shape, size, pattern, texture, shadow, and association. Explain that these terms are used by geoarchaeologists as they examine remotely sensed images to discover information about the past.

Developing the Investigation

4. Distribute **Log 1**. Lead the class through the Log. As you look at the remotely sensed images for the interpretive elements, display the first image (Tone) in color. Have students discuss the questions before writing answers. Continue with each interpretive element in a similar manner.
5. Have students form into groups of three to four to work on **Log 2: Part I**. Display (or distribute) the image for Part I. Assign each group one of the interpretive elements. Have students study the image and complete the chart
6. Have students discuss the information they put on the chart and add additional details and information to help them better understand the image.
7. Have students continue working to complete the statements in **Log 2: Part II**. Review map-reading and map-making skills before students draw a sketch map of the remotely sensed image. Discuss responses to the questions and share the different ways students interpreted the image into a sketch map.

Concluding the Investigation

8. Have students individually complete **Log 3: In conclusion**.

Background

Geoarchaeologists look for information about the past by searching for and researching historic sites. They research the landforms, climate, and aspects of the ecosystem. Finally, they try to determine why environments change. Other geoarchaeologists specialize in human history by focusing on ancient cultures, colonial history, or the industrial era. They look for evidence that helps them put together a story of what life was like. Earth is too big to look randomly for sites. Geoarchaeologists use clues from writings or oral histories to select regions for further investigation.

Traditional techniques of finding archaeological evidence include:

- locating and studying surface structures, such as the pyramids, Anasazi ruins, Stonehenge;
- studying remotely sensed images and aerial photographs for traces which indicate human occupation, such as plow scars or old drainage or irrigation systems;
- researching documents for information that tells about the culture, such as a ship's logs and diaries; and
- digging to uncover artifacts left behind, such as in dry wells or garbage pits.

Geoarchaeologists now use sophisticated remote sensing techniques to discern where cultural evidence has been covered by sand, by vegetation, or by subsequent human occupation. Log 1 provides background on the seven interpretive elements used to analyze images. In addition, global positioning systems (GPS) pinpoint the locations of buildings and other cultural evidence. Geographic information systems (GIS) are used to map the data.

Evaluation

Log 1

Tone: tans, some blue and red, yellow

Brightest: yellow

Showing: roads

Shape: rectangle, square

Showing: buildings, reservoirs

Size: two-lane unpaved road

Connecting line: driveway

Pattern: water/rivers

Rectangular pattern: fields

Texture: trees (rain forest)

Vegetation: crops

Shadow: pyramids

Shape: square

Sides: 4

Shape: triangular

Tallest: Great Pyramid of Khufu

Association: water (a reservoir)

Other: water (canals)

Features: human made

Use: transportation; to store water

Log 2

Chart: Answers will vary. Some suggested answers are:

Tone: magenta and green dominate the image; a white streak runs across the image, and thin red streaks are visible

Shape: round, bumpy-looking features in magenta area; white streak has a fan-shape at one end

Size: red streaks are much smaller than the white streak; the bumpy features are all about the same size

Pattern: red lines converge into middle of image; white streak travels across the image; distinctive break between the magenta and green colors

Texture: magenta—bumpy; green—uneven, disrupted

Shadow: little to none; some shading in the green and on one side of the bumpy features in the magenta may be shadows

Association: red and white streaks are not the same feature, but may be related as red leads to center of the white streak

Questions

1. Tone: a
2. Shape: a
3. Size: c
4. Pattern: a
5. Texture: a
6. Shadow: c
7. Association: b
8. c

Log 3

1. Different interpretive elements on the images help geoarchaeologists determine features. Color is not always a good indicator of what a feature is because water may not be blue and plants may not be green. The interpretive elements are: **Tone**, which shows colors; **Shadows**, caused by the angle of the Sun and helps determine size of features; **Association**, what is around the specific features of interest; **Texture**, how the tone appears, for example, blotchy or smooth; **Shape**, which might help to determine whether the feature is natural or human made; **Size**, objects in relation to each other, using shadows to determine; **Pattern**, regularity of a texture or feature
2. Reading an image is similar to reading a map because you use similar skills and apply the same processes. You need to orient the remotely sensed image (know where the direction of north is) and have a sense of scale (for size of the region shown, as well as measuring distances). You might use a reference system to locate the image, and it is important to understand what the colors represent.

Additional Resources

Aerial photographs and satellite images (booklet)
USGS. 1997 September.

Archeological remote sensing

http://www.ghcc.msfc.nasa.gov/archeology/remote_sensing.html

Archeological remote sensing electromagnetic spectrum <http://www.ghcc.msfc.nasa.gov>

Putting NASA's earth science to work: Remote sensing applications (booklet) Upper Marlboro, Maryland: Raytheon Systems Company. n.d.

The technical page: Nuts & bolts of aerial archaeology <http://www.nmia.com/~jaybird>

Tom Sever: Off-planet archeology

<http://www.omninag.com/archives/interviews/sever.html>

Understanding the biosphere from the top down
http://geo.arc.nasa.gov/sge/jskiles/top-down/intro_product/Investigations-by-module.html



Module 4, Investigation 2: Log 1

What features do archaeologists look for on an image?

What are the seven elements used by ge archaeologists to analyze and interpret remotely sensed images?

Geoarchaeologists face several issues when using remotely sensed images. They must determine the location on Earth, the height of objects, the scale of the image (based on the distance and the angle from which the image was sensed), and what the images show from the size and resolution of the image. These skills are similar to those used in reading a map. Perhaps the most important skill is analyzing the colors and patterns on a remotely sensed image.

Identifying Detail on Remotely Sensed Images

Seven interpretive elements help ge archaeologists analyze an image:

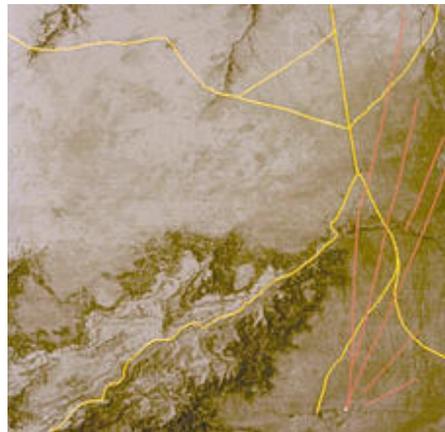
- tone
- shape
- size
- pattern
- texture
- shadow
- association

Below are descriptions and examples of each element, followed by several questions to help you focus on what you see.

TONE

is the brightness or the color of objects in an image. It is a very important element in distinguishing target objects.* Different types of imaging (radar, infrared, photographic) record different types of energy reflected or emitted by the target. Whether true color, as on a photograph, or false color imaging, a target stands out.

*A target object is the geographic feature the ge archaeologist is looking for, like a road or a building.



Chaco Canyon
http://www.ghcc.msfc.nasa.gov/archeology/chaco_compare.html

List the tones (colors) on this image. _____

Which tone is the brightest? _____

What do you think this bright color is showing? _____



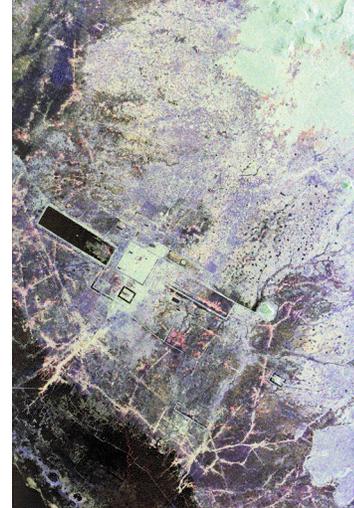
Module 4, Investigation 2: Log 1

What features do archaeologists look for on an image?

SHAPE

is the general form or outline of an object in an image. Shape helps distinguish an object. Most human-made objects have regular geometric shapes and edges, such as roads, buildings, and agricultural fields. Natural features typically have an irregular shape, such as a forest or a natural lake, although some natural features such as glacially formed lakes have fairly regular shorelines.

List geometric shapes in this image:



Angkor, Cambodia
<http://www.jpl.nasa.gov/radar/sirsxsar/angkor.html>

What do you think is being shown by the shapes?

SIZE

of a target object relates to scale. Object size can be compared and measured using shadow length of known features. Size of objects is related to the distance from which the image is sensed and the type of sensor used.

The lines crossing the aureole (circle) are automobile tracks.

Using this information, determine the width of the road that crosses the photo from left to right. Circle which size tracks that you think that they are:

- automobile tracks
- two-lane unpaved road
- four-lane highway

What is the line connecting the homestead (in the upper right corner) with the road?



Aureole of Chacoan Culture
<http://www.nmia.com/~jaybird/AANewsletter/ChacoPage2.html> Used with permission T. Baker



Module 4, Investigation 2: Log 1

What features do archaeologists look for on an image?

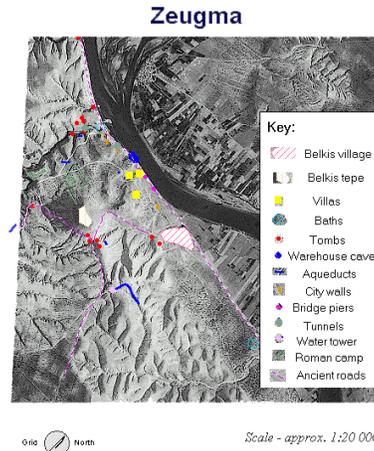
PATTERN

is the spatial arrangement of objects in an image. An arrangement of lines or objects regularly spaced, such as streets in a city, is a pattern.

The Euphrates River is the dark thick line which flows through the center of this photograph. On the left side of the river, the drainage branches form a pattern known as dendritic. Look carefully to notice that the "little branches" all flow into another branch which eventually flows into the Euphrates River.

This pattern is associated with what type of physical geographic feature?

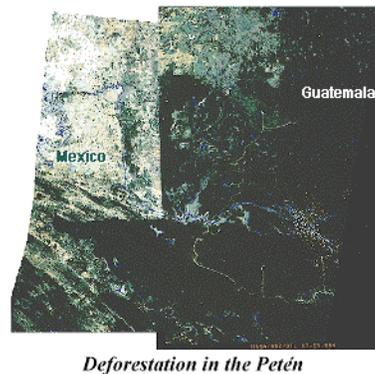
On the right side of the Euphrates River is a more rectangular pattern. What do you think this pattern shows?



Euphrates River and Zeugma, Turkey
<http://www.ist.lu/ele/html/departement/zeugma/html/maps/gis1.html>

TEXTURE

refers to the pattern and tones in an image. Rough textures reflect energy and produce irregular, uneven images. This might be the top of a rain forest where trees are not the same height, a mountainous region, or soil with different amounts of water content. Smooth textures have surfaces with similar objects evenly mixed, such as a field of wheat, a parking lot, or grasslands. Texture is one of the most important elements in analyzing radar imagery.



Deforestation in the Petén, Guatemala
<http://www.ghcc.msfc.nasa.gov/archeology/peten.html>

This image of the Petén has a very straight edge on it. In Guatemala, the Petén is a protected rain forest. In Mexico, land has been cleared of rain forest.

What vegetation does the darker texture show: rain forest or cleared land? _____

What vegetation does the lighter texture show? _____

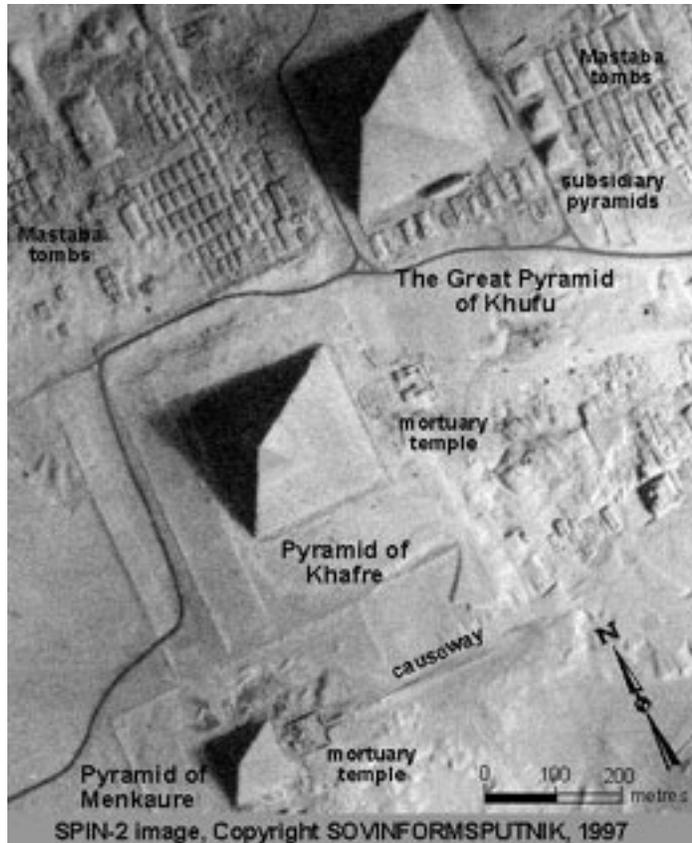


Module 4, Investigation 2: Log 1

What features do archaeologists look for on an image?

SHADOW

is produced by the angle of the Sun and the angle of the equipment recording the image. A slightly oblique (side) view of a site often produces a shadow. Shadows are used to determine heights of objects.



Pyramids at Giza, Egypt
http://ourworld.compuserve.com/homepages/mjff/giza_kv.htm

This photograph was taken at an oblique angle. The shadows on the target objects clearly show that they are _____.

If you looked at the pyramids from directly above they would appear as what shape? _____

Because this photograph is taken at a slightly oblique view, you clearly see that these three main pyramids have _____ sides, each with a _____ shape.

Using the shadow as a guide, which pyramid is the tallest?



Module 4, Investigation 2: Log 1

What features do archaeologists look for on an image?

ASSOCIATION

is the relationship between recognizable objects and unrecognizable objects. Making an association allows the identification of objects which, by themselves, would not be recognized in an image. For example, many schools have playgrounds or ball fields. If the school building is recognizable, then the patch of ground near it can be identified. The reverse is also true—ball fields and parking lots may be used to identify a school building.

The dark area in the southwest corner is Tonle Sap, a lake in Cambodia. If we know that this smooth textured dark color is water, we may identify other water bodies on this image. Look carefully at the left center of the image. There is a large dark rectangle. We now associate this texture and tone with the lake.



Angkor, Cambodia
<http://jpl.nasa.gov/radar/sircxsar/angkor.html>

The large dark rectangle is _____
 Near this rectangle are two more similar thick lines of similar tone and texture. One looks like an L; the other is a dark line around a light-colored square.

These are also _____

Are these three features natural or human made? _____
 (Remember that natural features are usually irregular and that human-made features often have a regular geometric shape.)

What might these features have been used for? _____

References

Angkor, Cambodia
<http://jpl.nasa.gov/radar/sircxsar/angkor.html>
 Chaco Canyon
<http://www.nmia.com/~jaybird/AANewsletter/ChacoPage2.html>
http://www.ghcc.msfc.nasa.gov/archeology/chaco_compare.html

Giza, the Great Pyramids, Egypt
http://ourworld.compuserve.com/homepages/mjff/giza_kv.htm
 The Petén
<http://www.ghcc.msfc.nasa.gov/archeology/peten.html>
 Project Zeugma
<http://www.ist.lu/ele/html/departement/zeugma/html/maps/gis1.html>



Module 4, Investigation 2: Log 2

How do interpretive elements help us determine what the image is showing?

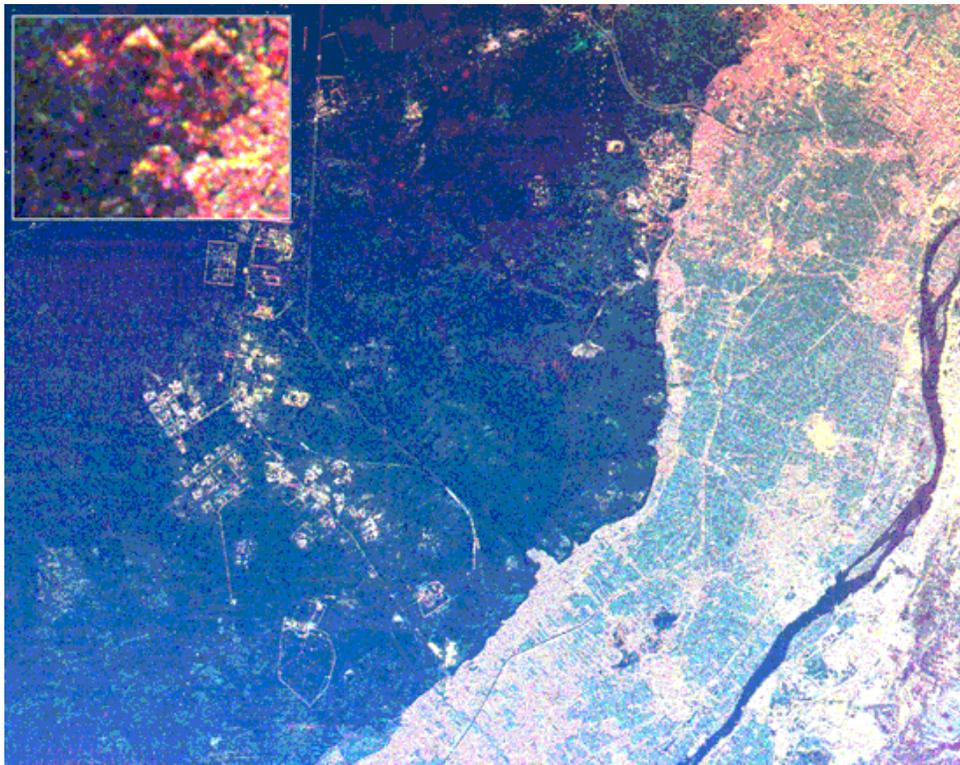
Objective

In this lesson you use interpretive elements to analyze a remotely sensed image.

Part I

In groups, study the image carefully.

This is an image of a very famous archaeological site of an ancient river valley culture. In this image it is easy to recognize the river (dark line in lower right of image). It is located in a very dry region of the world.





Module 4, Investigation 2: Log 2

How do interpretive elements help us determine what the image is showing?

Use the interpretive elements to identify what you are seeing. Record your observations for each category. Refer to the definitions and examples in Log 1 if you need help.

Tone	
Shape	
Size	
Pattern	
Texture	
Shadow	
Association	



Module 4, Investigation 2: Log 2

How do interpretive elements help us determine what the image is showing?

Part II

Make decisions based on your analysis of the image. Circle the answer that completes the statement.

- 1. Tone:** Don't be fooled by what's light and what's dark on this image. Very light Earth colors look very dark in this image. Because this is a dry region, the river would have been used for many purposes.
The lighter region along the river is

 - agricultural land.
 - desert.
 - urban development.
- 2. Shape:** Along the top edge of the image just to the left of the light region are three shapes. There is an inset image in the upper left-hand corner which shows an enlarged image of these three objects.
The shape of these objects indicates they

 - were used for a similar purpose.
 - all had different uses.
 - have no connection to each other.
- 3. Size:** The light area to the left of the river is approximately 10 times as wide as the river. The dark area is much greater than this. The light area represents

 - open space.
 - desert.
 - the river valley.
- 4. Pattern:** Within the light tones and the dark tones, there are visible lines.
These lines

 - connect places and are roads.
 - are tributaries to the river.
 - connect places and are canals for transportation.
- 5. Texture:** Whether light or dark, the texture is not smooth. It has a rough appearance. The differences between the shades of gray on any part of the image might be

 - vegetation.
 - water in the soil.
 - houses.
- 6. Shadow:** Concentrate on the enlarged inset image. If you look carefully at the three shapes, there is a shadow on each one. The shadows help us determine that the bases of these objects are

 - rectangular.
 - triangular.
 - square.
 - circular.
- 7. Association:** Your ground-truthing team reports that these three objects are actually tombs. You can conclude that these objects are

 - Hammurabi's Hanging Gardens.
 - the Great Pyramids.
 - Roman ruins.
 - ziggurats in Mesopotamia.
- 8. You identify this image of an ancient river valley as part of the**

 - Indus River Valley.
 - Euphrates and Tigris River Valley of Mesopotamia.
 - Egyptian Nile River Valley.
 - Huang He River Valley.
- 9. Can you determine what the image shows?**



Module 4, Investigation 2: Log 3

In conclusion

1. How does remote sensing help geoarchaeologists read the landscape? Be sure to include information about the interpretive elements.

2. How is reading a remotely sensed image like reading a map? Be sure to include all of the map-reading skills.
