Settlement

Exploration: Then and Now

Essential Question

How do an area's location, soil, and weather affect settlement?

Lesson Overview

This lesson compares the location, soil, and weather of early Jamestown to the Moon as each site is considered for settlement. Students use maps and graphs to look for patterns and then make inferences about ways that location and weather affect settlements. Students also conduct experiments to gather data about space radiation shielding and Moon regolith formation and then compare their findings to Earth's weather and soil.

Background Information

Settlement is affected by location, soil, weather, and access to natural resources.

From the 17th century to the 21st century, all explorers begin with one basic need: a suitable place to live.

Grade Level: 6–8

Connections to Curriculum:

Science and Geography

Teacher Preparation Time:

20 Minutes

Lesson Duration:

Five 50-Minute Class Periods

(See Pacing Chart for Options)

National Science Education Standards

Science as Inquiry

Physical Science

Earth Science

Science and Technology

National Geography Standards

The World in Spatial Terms

Human Systems

The Uses of Geography

Instructional Objectives

Students will:

- look for patterns in the location of New World colonies;
- plot the Apollo landings on the Moon and identify lunar surface features of each landing site;
- make correlations between rainfall and mortality in Jamestown from 1604 through 1615;
- interpret and make inferences about rainfall based upon tree rings;
- gather data on space radiation shielding by observing a flashlight beam as it shines through different materials;
- investigate the effects of micrometeoroid bombardment on regolith formation;
- make inferences about properties of regolith based upon observations;
- compare samples of the Earth's soil with simulated lunar regolith; and
- compare the differences in challenges faced by 17th-century and 21st-century explorers.

Materials

(Students will need journals and class charts in order to organize information throughout this lesson.)

Engage

Per class:

- Overhead transparency of "Map of Original 13 Colonies"
- Atlases and United States maps
- Overhead projector

Per student:

- "Map of the Moon"
- "Apollo Landing Sites Chart"

Explore

Activity One: Weather

Per class:

- Overhead transparency of "Jamestown Rainfall Index and Mortality Rate"
- Overhead projector
- Cross sections of tree limbs or trunks (optional)

Per student:

- "Tree-Ring Cross Section Drawing"

Activity Two: Space Weather

Per group:

- Flashlight
- Metric ruler
- Materials to test (all materials should be the same color and about the same size)

    *several sheets of unlined copy paper
    *several sheets of tissue paper
    *several sheets of construction paper
    *several sheets of card stock paper

Explain

Per student:

- "NASA and Jamestown Settlement Chart: Location"
- "NASA and Jamestown Settlement Chart: Weather"
- "NASA and Jamestown Settlement Chart: Soil"

Extend

Per group:

- Microscope or magnifier
- Box lid (shoe-box size)
- Larger box or lid (must be able to fit shoe-box-size lid inside this box or lid)
- Cinnamon sugar graham crackers (enough to line the bottom of the small shoe-box lid)
- Three to four white-powdered sugar and cake mini-donuts (day-old works best)
- Three index cards

- Clear packing tape
- Two different-sized wire strainers (colander, tea strainer, etc.) or two pieces of different-sized wire screens
- One pair of scissors
- Four containers for holding sifted regolith
- One-hole punch
- Marker
- Earth's soil samples

Vocabulary

abiotic: not living

basalt: dark gray to black, dense igneous rock

bay: an inlet of the ocean partly surrounded by land

biotic: living

dendrochronology: the science of dating events by comparative study of growth rings in trees

drought: a long period of dry weather

geologic terrains: physical features of a piece of land

highland: elevated land on the Moon

impact craters: craters caused by asteroids and meteorites

isthmus: a narrow strip of land connecting two larger land areas

magnetosphere: that region of space around Earth affected by Earth's magnetic field such that charged particles are trapped in it

maria: mostly flat, dark areas on the surface of the Moon

mortality: the rate of death in a given population

ozone: the layer of Earth's atmosphere at about 32 to 48 kilometers (20 to 30 miles) that helps block most solar ultraviolet radiation from entering the lower atmosphere

peninsula: a portion of land surrounded by water on three sides

rainfall index: the amount of rainfall from a series of observations; used as an indicator or measure

rays: the material that is scattered on the Moon's surface when craters are created

regolith: a mixture of fine dust and rocks that covers the Moon's surface

rilles: long, narrow valleys on the Moon that formed as underground lava channels collapsed once the hot lava flowed away

solar wind: streams of particles from the Sun

topography: the physical or natural features of the land's surface

ultraviolet rays: electromagnetic radiation that has a wavelength shorter than wavelengths of visible light and longer than x-rays; rays that have more energy than visible light and can cause chemical reactions

wetlands: land or area, such as a tidal flat or swamp, containing much moisture

Suggested Pacing:

	Engage	Explore	Explain	Extend	Evaluate	Total
50-minute class period	1 class period	2 class periods	1 class period	1 class period	Completed throughout the lesson	5 class periods

Instructional Procedure

Teaching Suggestion: *Prior to beginning this lesson, create a chart that will be displayed throughout the lesson to help organize student learning. Ask the students to create similar charts in their journals. The charts may be formatted as follows, but must be large enough to organize information.*

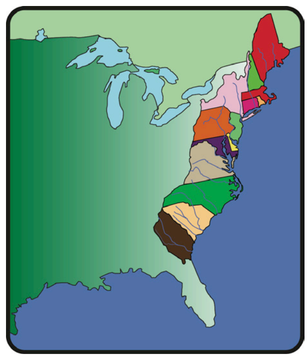
How do location, weather, and soil affect settlement?

	JAMESTOWN	MOON
LOCATION		
WEATHER		
SOIL		

Engage

1. Discuss the following questions as a class or ask students to write their thoughts in their journals:
    - How does the place where you live affect:
        - the clothes you wear?
        - the materials you use to build your homes?
        - the types of food you can grow?
        - your leisure activities?

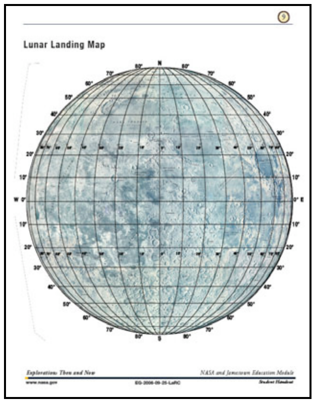
2. A settlement's location affects the quality of life for that settlement. Remind students that the first settlers traveled by ship to the New World. Make an overhead transparency of the "Map of the Original 13 Colonies". Ask students to locate the Chesapeake Bay and the Massachusetts Bay. Review with students the definition of a bay. (*A bay is an inlet of the ocean partly surrounded by land.)*



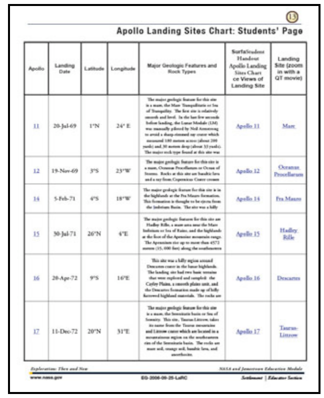
Map of the Original 13 Colonies

3. Explain that colonial towns were built close to the water because access to a port was important. Discuss why ports were important to the development of a colonial town. *(Major towns and cities needed access to ships bringing people and goods to and from Europe.)*
4. Ask students to use maps and atlases to locate the following colonial cities:
    - Boston, MA
    - Plymouth, MA
    - Philadelphia, PA
    - Baltimore, MD
    - Williamsburg, VA
    - Jamestown, VA
5. Discuss the following questions as a class or ask students to write their thoughts in their journals:
    - What is similar about the locations of all of these colonial cities?
    - How does location affect settlement?
6. Review the terms *longitude* and *latitude*. Discuss how these coordinates help to locate exact positions on Earth. Longitude and latitude coordinates for the Moon start at a point near the crater Bruce (0 degrees latitude, 0 degrees longitude). Give students a "Map of the Moon" handout and ask them to locate and label this point.
7. Twelve astronauts in six Apollo missions landed on and explored the nearside (Earth-facing side) of the Moon between 1969 and 1972. The six landing sites

were chosen to explore different geologic terrains. Give each student a copy of the “Apollo Landing Sites Chart.” Ask the students to locate the Apollo landing sites on their map of the Moon and to mark these sites with the number of the Apollo mission. Ask students to identify the topography of the site using information in the chart and from the map.



Map of the Moon



Apollo Landing Sites Chart

Technology Insertion Point: *Sections of the Apollo Landing Sites Chart are linked to images and QuickTime movies. To maintain active links, students must access this chart on the computer. If the instructor uses paper copies of the chart, information on the links should be printed.*

8. Discuss the following questions as a class or ask students to write their thoughts in their journals:
   - How would you describe the lunar landing sites?
   - Identify similar terrain on the map.
   - Why do you think these six sites were chosen?
   - If you were to choose the next lunar landing site, what site would you choose? Why?
   - How does a site’s location, on the Moon or on Earth, affect settlement?

9. Ask students to add information to the charts they created earlier in their journals. Return to the class chart and add information learned during these activities.

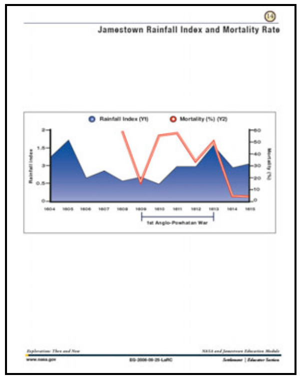
Teaching Suggestion: *The Apollo Landing Sites activity was modified from Exploring the Moon: a Teacher’s Guide with Activities. Additional activities may be found in this document,* http://lunar.arc.nasa.gov/education/lesson.htm

Explore

Activity One: Weather

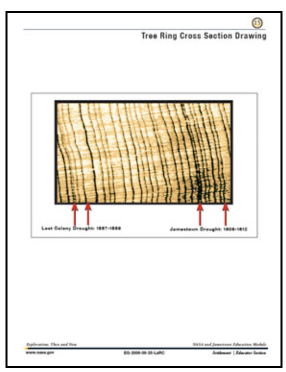
1. Make an overhead transparency of the “Jamestown Rainfall Index and Mortality Rate” graph. Discuss the following questions as a class, based upon the graph:
   - When was the rainfall index the highest?
   - When did a drought occur in Jamestown?

- What is the correlation between low rainfall and mortality? Explain this correlation.



Jamestown Rainfall Index and Mortality Rate

2. Introduce students to the study of dendrochronology, or tree-ring dating. Each year that a tree grows, a ring can be seen in a cross section of the tree's trunk or large branches. These rings can be used to help reconstruct patterns of drought and climate change. During years of plentiful rain, the rings are wider; years of little rainfall or drought produce narrower rings. Tree-ring samples from ancient bald cypress trees in southeastern Virginia and northeastern North Carolina give researchers over 800 years of information on rainfall in this region. Rainfall records between 1606 and 1612 (early Jamestown) distinguish these years as having one of the worst droughts during the 800-year period.
3. Give each student a copy of the "Tree-Ring Cross Section Drawing" and ask the students to highlight the rings that indicate the Jamestown drought. Ask students to measure the distance between tree rings to compare years of plentiful rain to years of drought. Is there evidence of another drought? *(Note: The Lost Colony drought is indicated in this drawing. Students may want to find out more about this failed colony by visiting this National Park Service Web site, http://www.nps.gov/archive/fora/roanokerev.htm)*



Tree-Ring Cross Section Drawing

4. Ask students to compare the rainfall index/mortality rate graph to the tree-ring drawing. Discuss the effect that a drought would have had on the Jamestown

settlers. Consider factors such as availability of food, fresh water, willingness of the Powhatan Indians to trade food to the settlers, and disease.

Teaching Suggestion: *Before beginning this activity, cut cross sections of tree limbs or trunks to bring to class so students may analyze "real" tree rings.*

Activity Two: Space Weather
The Moon has basically no atmosphere. With no atmosphere, there can be no weather similar to that on Earth and no ozone to protect humans from the Sun's ultraviolet rays. Although Jamestown's weather was harsh, Earth's atmosphere protected the Jamestown settlers from ultraviolet rays. The Earth's magnetosphere and atmosphere also protected the settlers from solar particles and other forms of what is known as "space weather."

Space weather is made of many components including solar particles, magnetic storms, and radiation from outside our solar system. Solar storms are one source of space weather. Space is filled with solar wind, debris from comets, and particles of dust. Space radiation comes from the Sun and from other stars from outside our solar system.

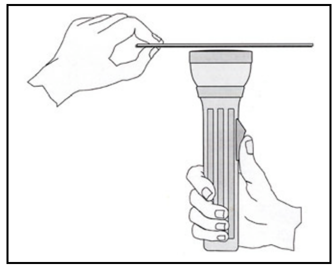
Because the Moon has no protective atmosphere or magnetosphere, it is not protected from space weather. When astronauts live and work in space, away from Earth's protective atmosphere, they are exposed to more radiation than the average person is exposed to on Earth. Current spacecraft materials cannot block all of the radiation in space weather.

For long-duration missions, especially those taking astronauts far away from low-Earth orbit, more protection from space radiation will be needed. NASA is already working on how to make spacecraft safer by using different materials to provide protection.

1. Follow this procedure to help students test and compare different materials as they are used to block simulated space radiation. Materials to be tested include: unlined copy paper, tissue paper, construction paper, and card-stock paper. Students may suggest other paper products to test, if time permits. The light from a flashlight will represent space radiation.

    a. Before testing the materials, ask the students to predict how many pieces of that material it will take to completely block the light. Ask students to record their predictions in their science journals.

    b. Ask one student in each group to hold the flashlight. He or she should steady the flashlight on the tabletop so it points up at the ceiling, turn it on, and keep holding it. <u>Caution: Remind students NOT to look directly into the flashlight beam.</u>



c. Ask another member of the group to stack paper on top of the flashlight, one sheet at a time, to block the light. As each piece of paper is added, the transmitted light should become weaker. Instruct students to continue adding sheets until the light is completely blocked, and then record this number in their journals.

d. Repeat steps a–c with another material until all materials have been tested.

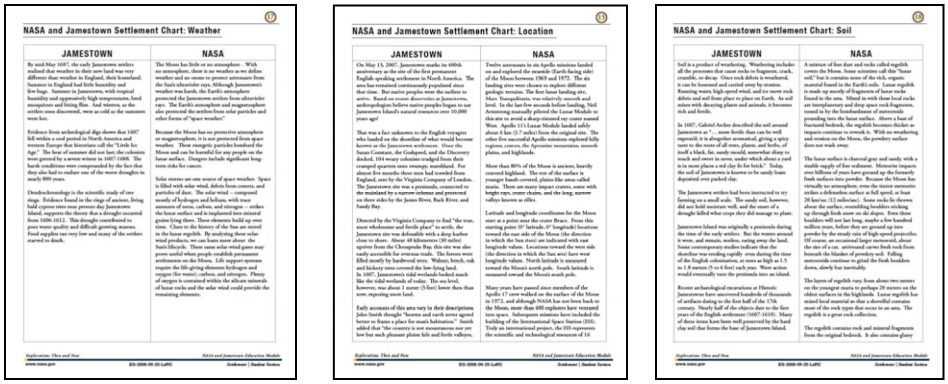
2. Discuss the following questions as a class or ask students to write their thoughts in their journals:
   - Which material provided the best shielding from the simulated space radiation? Explain your choice.
   - Compare the mass of the materials. How does the mass of the material that was the best shield compare to the mass of the other materials?
   - Why would mass be important in choosing materials for spacecraft and shelters? (*Mass is a consideration for NASA due to fuel, space, and cost issues*.
3. Ask students to add any new information to the class/student charts they created earlier.

Teaching Suggestion: *You may want to show the 30-second NASA KSNN™ (Kids Science News Network) video, "What would you hear in a weather report from Mars?" found at* http://ksnn.larc.nasa.gov/21Century/p11.html*. You will also find an expanded version of this activity and more explanations about space weather on this site.*

Explain

A living community depends upon the nonliving, or abiotic, factors in its environment. Abiotic factors include water, topography, landforms, climate, soils, sunlight, and air quality.

1. Ask students to read the three "NASA and Jamestown Settlement Charts" to find out more about the abiotic factors of location, soil, and weather; how they affected the early Jamestown settlement; and how they would affect possible lunar settlements.



NASA and Jamestown Settlement Charts

2. Help students add this information to both the class chart and their own charts.

Extend

1. Earth's soil is very different from the Moon's soil, or regolith. Help students find out more about regolith formation by completing the NASA KSNN™ activity "Making Regolith," found at *http://ksnn.larc.nasa.gov/21Century/pdf/p10_educator.pdf*.
2. Ask students to bring in soil samples to compare Earth's soil with the simulated lunar regolith.
3. Discuss the following questions as a class or ask students to write their thoughts in their journals:
    - In your opinion, what topography and location would be best suited for a settlement?
    - How might life in Jamestown have been different if Jamestown's soil was more like the soil in your area?
    - How might regolith be used as a resource to build shelters on the Moon?
    - How could shelters protect astronauts from space weather?

4. Ask students to develop a multimedia presentation that shows the parallels between exploration of the past and exploration for the future. They may choose to focus on the theme of settlement or include other themes of exploration, such as transportation, human needs, and the hunt for water.
5. Complete other lessons from "Exploration: Then and Now."

Evaluate

Choose one or more of the following activities to assess student understanding of how an area's location, soil, and weather affect settlement.

1. Evaluate the students' charts. Look for an increase in understanding of how an area's location, soil, and weather affect settlement.
2. Ask students to apply what they have learned to other settlements. How do location, weather, and soil affect *any* settlement?
3. Assess student journal responses.

4. Work with students to create a rubric to evaluate the multimedia presentations created to characterize past and to predict future exploration.

Additional NASA Resources

Sections of this lesson were adapted from existing NASA educational products. These additional NASA resources may extend student understanding about how an area’s topography, weather, and soil affect settlement.

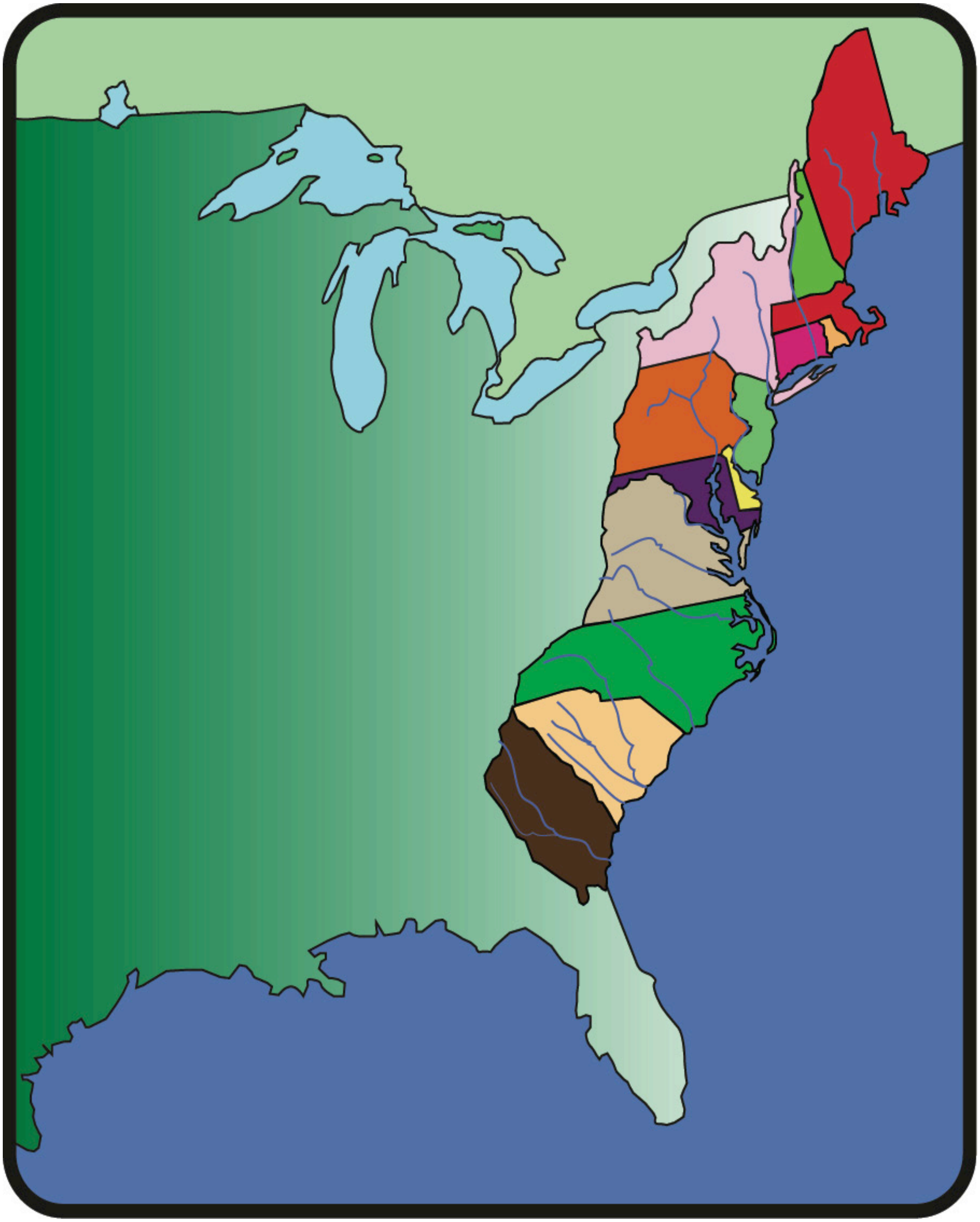
Topography
NASA CONNECT™ Landscape Archaeology: Hidden Treasures
Use a coordinate plane system to create a topographic map of a mystery planet landscape.
http://connect.larc.nasa.gov/programs/2004-2005/treasures/index.html

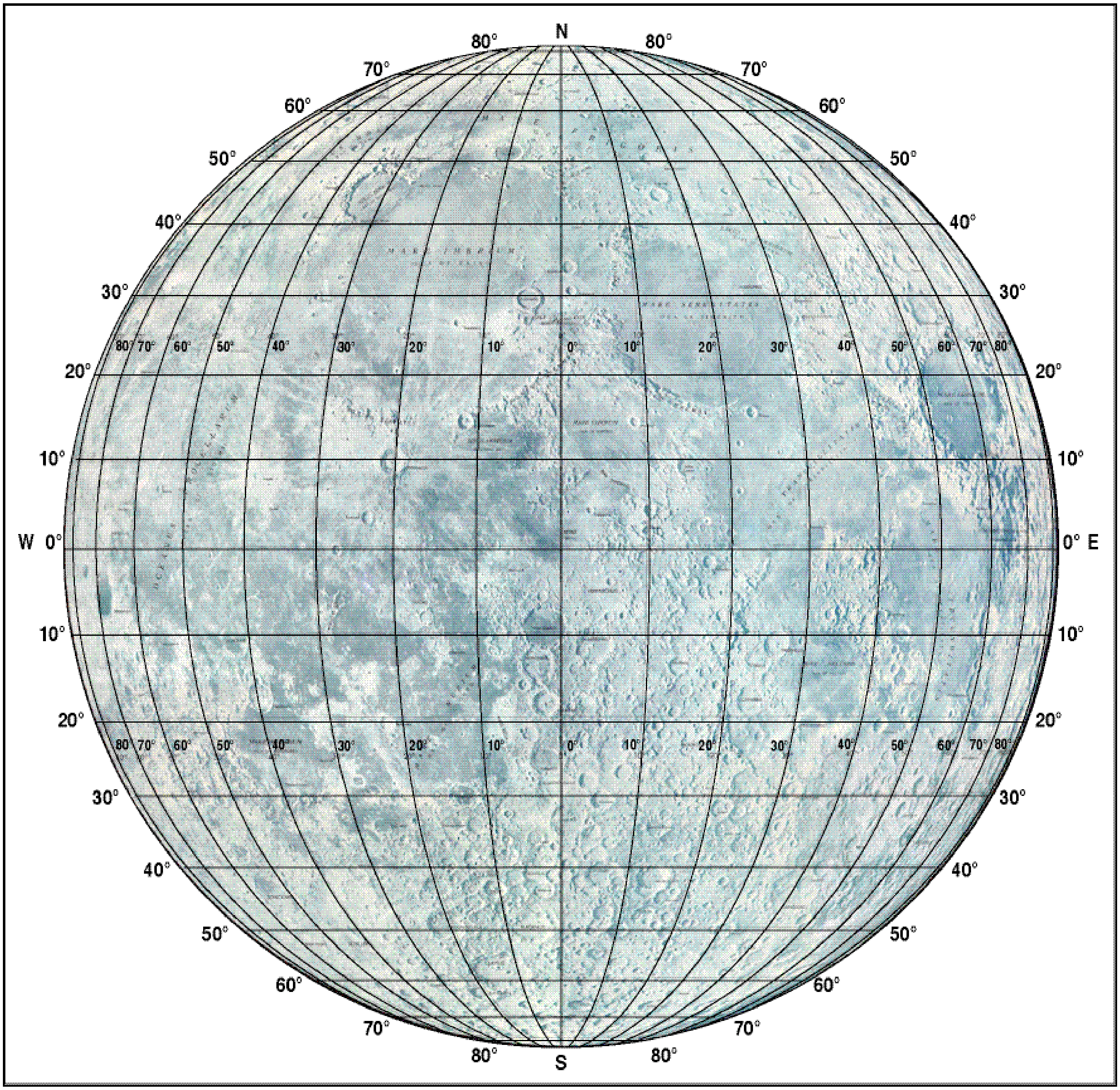
Weather
Modeling Solar Wind Collection
Model how different materials collect different solar wind particles.
http://solarsystem.nasa.gov/educ/docs/ModelSolarWindColTG.pdf

Space Weather
Sun-Earth Connection Education Forum
This site provides additional resources to learn more about space weather.
http://sunearth.gsfc.nasa.gov/

Soil
Clay Lava Flows
Simulate surface lava flows in this experiment to understand some of the geological processes and structures that form as lava flows across the Moon's landscape.
http://ares.jsc.nasa.gov/Education/Activities/ExpMoon/LavaFlows.pdf

Map of Original 13 Colonies



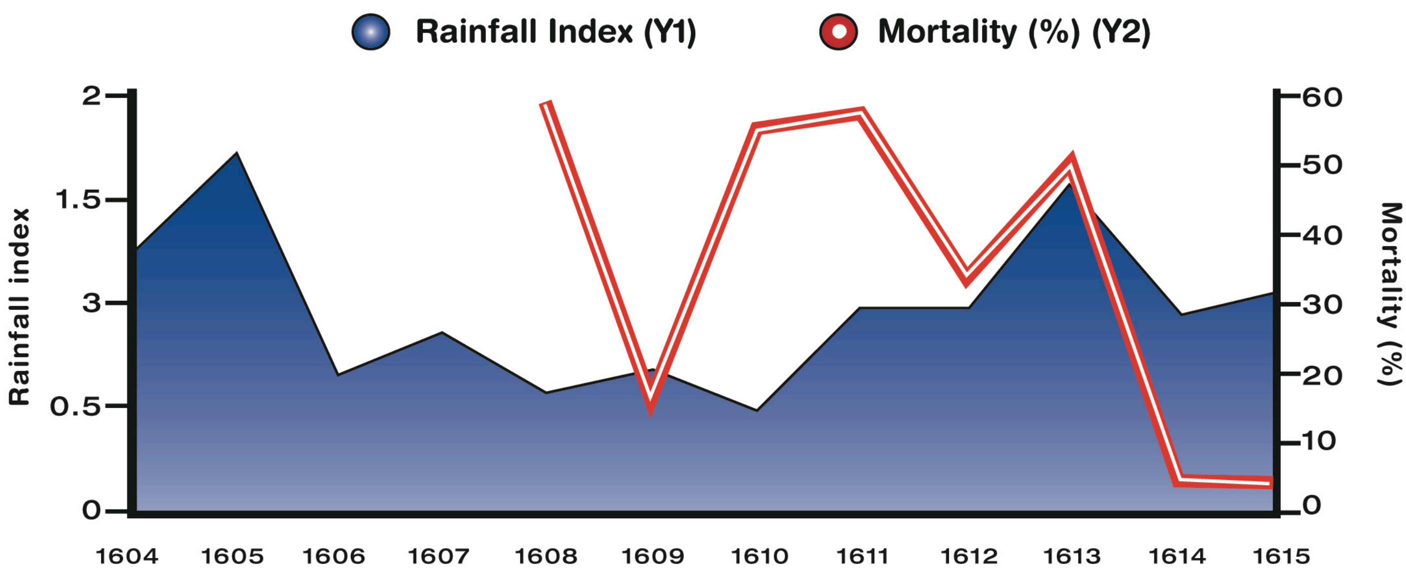


Credit: NASA/GSFC

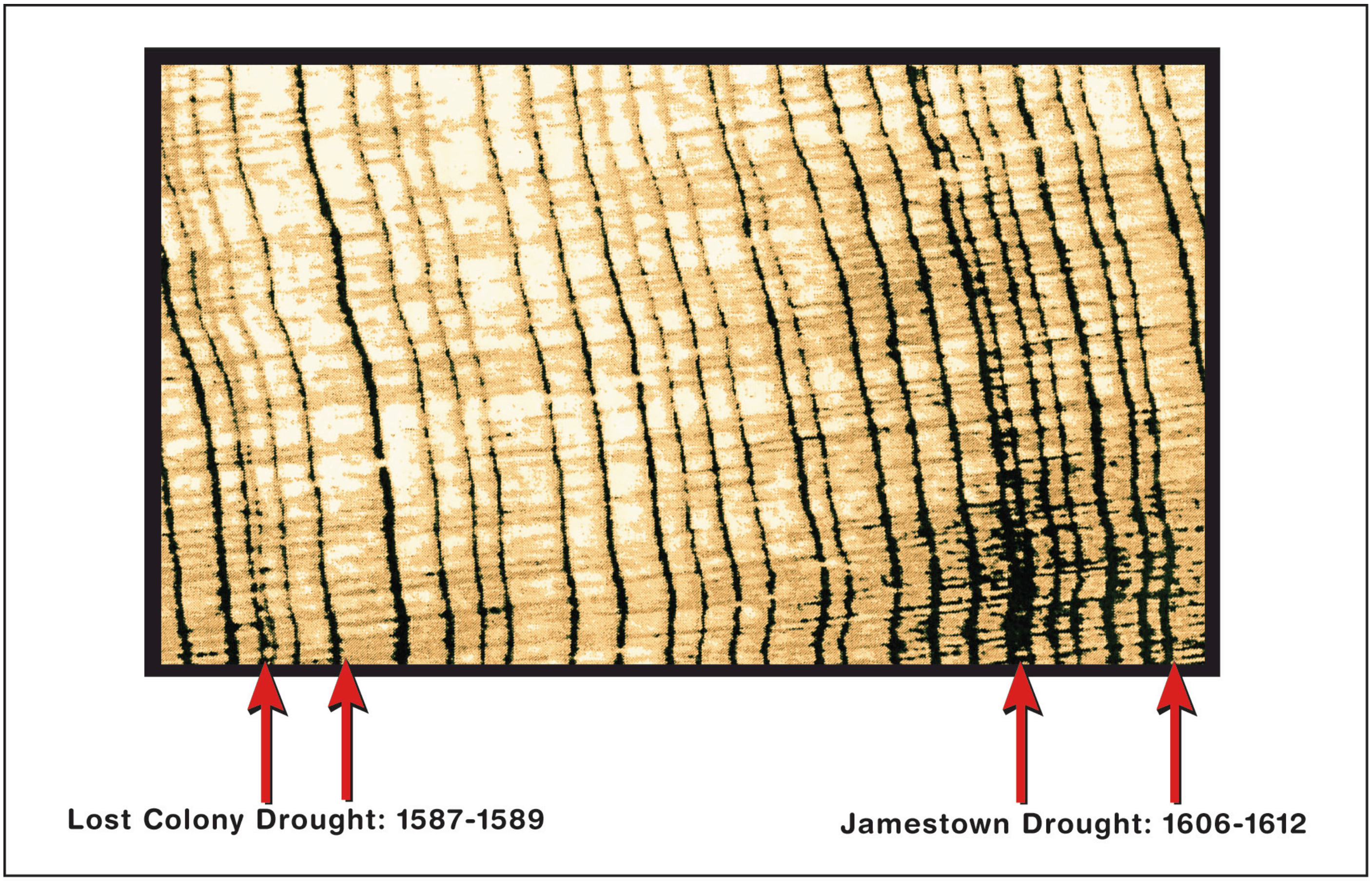
Apollo Landing Sites Chart Student Handout

Apollo Mission	Landing Date	Latitude	Longitude	Major Geologic Features and Rock Types	Surface Views of Landing Site	Landing Site (zoom in with a QT movie)
11	July 20, 1969	1°N	23° E	The major geologic feature for this site is a mare, the Mare Tranquilitatis or Sea of Tranquility. The first site is relatively smooth and level. In the last few seconds before landing, the Lunar Module (LM) was manually piloted by Neil Armstrong to avoid a sharp-rimmed ray crater which measured 180 meters across (about 200 yards) and 30 meters deep (about 33 yards). The major rock type found at this site was basaltic lava.	Apollo 11	Mare Tranquilitatis
12	November 19, 1969	3°S	23°W	The major geologic feature for this site is a mare, Oceanus Procellarum or Ocean of Storms. Rocks at this site are basaltic lava and a ray from Copernicus Crater crosses the site.	Apollo 12	Oceanus Procellarum
14	February 3, 1971	4°S	18°W	The major geologic feature for this site is in the highlands at the Fra Mauro formation. This formation is thought to be ejecta from the Imbrium Basin. The site is a hilly region about 49.3 km (30.6 miles) north of the Fra Mauro crater.	Apollo 14	Fra Mauro
15	July 30, 1971	26°N	4°E	The major geologic features for this site are Hadley Rille, a mare area near the Mare Imbrium or Sea of Rains, and the highlands at the foot of the Apennine mountain range. The Apennines rise up to more than 4572 meters (15, 000 feet) along the southeastern edge of Mare Imbrium (Sea of Rains). The rocks at this site are breccia and basalt.	Apollo 15	Hadley Rille
16	April 20, 1972	9°S	16°E	This site was a hilly region around Descartes crater in the lunar highlands. The landing site had two basic terrains that were explored and sampled: the Cayley Plains, a smooth plains unit, and the Descartes formation made up of hilly furrowed highland materials. The rocks are anorthosite and highlands soil.	Apollo 16	Descartes
17	December 11, 1972	20°N	31°E	The major geologic feature for this site is a mare, the Serenitatis basin or Sea of Serenity. This site, Taurus-Littrow, takes its name from the Taurus mountains and Littrow crater which are located in a mountainous region on the southeastern rim of the Serenitatis basin. The rocks are mare soil, orange soil, basaltic lava, and anorthosite.	Apollo 17	Taurus-Littrow

Jamestown Rainfall Index and Mortality Rate



Courtesy of Colonial National Historical Park



Courtesy of Colonial National Historical Park

JAMESTOWN	NASA
On May 13, 2007, Jamestown marks its 400th anniversary as the site of the first permanent English-speaking settlement in North America. The area has remained continuously populated since that time, but Native Americans were the first known inhabitants. Based on recent discoveries at Jamestown, anthropologists believe native peoples began to use Jamestown Island's natural resources over 10,000 years ago! That was a fact unknown to the English voyagers who landed on the shoreline of what would become known as the Jamestown settlement. Once the boats the *Susan Constant*, the *Godspeed*, and the *Discovery* docked, 104 weary colonists trudged from their cramped quarters onto swampy, marshland. These men had been at sea for nearly 5 months, sent by the Virginia Company of London, England. The Jamestown site was a peninsula, connected to the mainland by a narrow isthmus and protected on three sides by the James River, the Back River, and Sandy Bay. The men were directed by the Virginia Company to find "the true, most wholesome and fertile place" to settle, and the Jamestown site was defensible since it had a deep harbor close to shore. About 48 kilometers (30 miles) upriver from the Chesapeake Bay, this site was also easily accessible for overseas trade. The forests were filled mostly with hardwood trees. Walnut, beech, oak and hickory trees covered the low-lying land.	Twelve astronauts in six Apollo missions landed on and explored the nearside (Earth-facing side) of the Moon between 1969 and 1972. The six landing sites were chosen to explore different geologic terrains. The first lunar landing site, Mare Tranquilitatis, was relatively smooth and level. However, in the last few seconds before landing, Neil Armstrong needed to manually pilot the Lunar Module to this site to avoid a sharp-rimmed ray crater named West. Apollo 11's Lunar Module landed safely about 6 kilometers (3.7 miles) from the original site. The other five successful Apollo missions explored hilly regions, craters, the Apennine mountains, smooth plains, and highlands. More than 80 percent of the Moon is ancient, heavily cratered highland. The rest of the surface is made up of younger, basalt-covered, plains-like areas called maria. There are many impact craters, some with bright rays; crater chains; and the long, narrow valleys known as rilles. Latitude and longitude coordinates for the Moon start at a point near the crater Bruce. From this starting point (0° latitude, 0° longitude) locations toward the east side of the Moon (the direction in which the Sun rises) are indicated with east longitude values. Locations toward the west side (the direction in which the Sun sets) have west longitude values. North latitude is measured toward the Moon's north pole. South latitude is measured toward the Moon's south pole.

In 1607, Jamestown's tidal wetlands looked much like the tidal wetlands of today. The sea level, however, was about 1 meter (3 feet) lower then than now, exposing more land. Early accounts of this area vary in their descriptions. John Smith thought "heaven and earth never agreed better to frame a place for man's habitation." Smith added that "the country is not mountanous[sic] nor yet low but such pleasant plaine hils[sic] and fertle valleyes[sic], one prettily crossing an other[sic], and watered so conveniently with their sweet brookes[sic] and christall[sic] springs, as if art itselfe[sic] had devised them." Gabriel Archer described the area this way. "This land lieth[sic] low at the mouth of the river and is sandy ground, all over beset with fair pine trees. It is generally replenish'd[sic] with wood of all kinds and that the fairest, yea, and the best that ever any of us (traveler or workman) ever saw, being fit for any use whatsoever, as ships, houses, planks, pales, boards, masts, wainscot, clapboard—for pikes or elsewhat[sic]." On first impression, the area appeared to be exactly what the settlers needed to build their new homes. Chief Powhatan was the leader of the Powhatan Indians, a powerful tribe who lived near Tidewater Virginia, where the Englishmen had chosen to build their new settlement. Both Chief Powhatan and his daughter Pocahontas became important to the Jamestown settlers. Chief Powhatan's description of the area was based on more than first impressions. Calling the area around Jamestown "waste ground," the Powhatan Indians knew it was difficult to find fresh water there. None of their villages were built in the tidal wetlands.	Many years have passed since members of the Apollo 17 crew walked on the surface of the Moon in 1972. Although NASA has not been back to the Moon, more than 400 explorers have ventured into space. Subsequent missions have included the building of the International Space Station (ISS). Since October 31, 2000, at least one person from Earth's population has lived on the ISS, working to improve life on Earth and marking the permanent presence of mankind in space. NASA plans to return to the Moon and eventually build a base there. Before humans return to the Moon, NASA will conduct robotic missions to learn more about the lunar surface. These missions will help determine potential lunar landing sites and explore whether resources, such as oxygen, hydrogen, and minerals, are available. The missions will include searches for water ice in permanently-shadowed craters at the lunar south pole.

NASA and Jamestown Settlement Chart: WEATHER Student Handout

JAMESTOWN	NASA
By mid-May 1607, the early Jamestown settlers realized that the weather in their new land was very different than the weather in England, their homeland. Summer in England had little humidity and few insects. Summer in Jamestown, with tropical humidity and oppressively high temperatures, bred mosquitoes and biting flies. And winters, as the settlers soon discovered, were as cold as the summers were hot. Evidence from archeological digs shows that 1607 fell within a cool period in North America and western Europe that historians call the "Little Ice Age." The heat of summer did not last; the colonists were greeted by a severe winter in 1607–1608. The harsh conditions were compounded by the fact that they also had to endure one of the worst droughts in nearly 800 years. Dendrochronology is the scientific study of tree rings. Evidence found in the rings of ancient, living bald cypress trees near present-day Jamestown Island, supports the theory that a drought occurred from 1606 through 1612. This drought contributed to poor water quality and difficult growing seasons. Food supplies ran very low and many of the settlers starved to death.	The Moon has little or no atmosphere. With no atmosphere, there is no weather as we recognize it on Earth and no ozone to protect astronauts from the Sun's ultraviolet rays. Although Jamestown's weather was harsh, Earth's atmosphere protected the settlers from ultraviolet rays. Earth's atmosphere and magnetosphere also protected the settlers from solar particles and other potentially harmful energetic particles known as "space weather." Because the Moon has no protective atmosphere or magnetosphere, it is not protected from space weather. Space weather affects the Moon and can be harmful for any people on the lunar surface. Dangers include significant, long-term risk of cancer. Solar storms are one source of space weather. Space is filled with solar wind, debris from comets, and particles of dust. The solar wind is composed mostly of hydrogen and helium, with trace amounts of neon, carbon, and nitrogen. It strikes the lunar surface and is implanted into mineral grains lying there. These elements build up over time. Clues to the history of the Sun are stored in the lunar regolith. By analyzing these solar-wind products, we can learn more about the Sun's lifecycle. These same solar-wind gases may prove useful if people establish permanent settlements on the Moon. Life-support systems require the life-giving elements hydrogen and oxygen (for water), carbon, and nitrogen. Plenty of oxygen is contained within the silicate minerals of lunar rocks, and the solar wind could provide the remaining elements.

JAMESTOWN	NASA
Soil is a product of weathering. Weathering includes all the processes that cause rocks to fragment, crack, crumble, or decay. Once rock debris is weathered, it can be loosened and carried away by erosion. Running water, high-speed wind, and ice move rock debris and soil from place to place on Earth. As soil mixes with decaying plants and animals, it becomes rich and fertile. In 1607, Gabriel Archer described the soil around Jamestown as "… more fertile than can be well express'd[sic]; it is altogether aromatical[sic], giving a spicy taste to the roots of all trees, plants, and herbs, of itself a black, fat, sandy mould[sic], somewhat slimy to touch and sweet in savor, under which about a yard is in most places a red clay fit for brick." Today, the soil of Jamestown is known to be sandy loam deposited over packed clay. The Jamestown settlers had been instructed to try farming on a small scale. The sandy soil, however, did not hold moisture well, and the onset of a drought killed what crops they did manage to plant. Jamestown Island was originally a peninsula during the time of the early settlers. But the waters around it were, and remain, restless, eating away the land. Some contemporary studies indicate that the shoreline was eroding rapidly, even during the time of the English colonization, at rates as high as 1.5 to 1.8 meters (5 to 6 feet) each year. Wave action would eventually turn the peninsula into an island.	A mixture of fine dust and rocks called regolith covers the Moon. Some scientists call this "lunar soil," but it contains none of the rich, organic material found in Earth's soils. Lunar regolith is made up mostly of fragments of lunar rocks found in the area. Mixed in with these local rocks are interplanetary and deep-space rock fragments, tossed in by the bombardment of meteoroids pounding into the lunar surface. Above a base of fractured bedrock, the regolith becomes thicker as impacts continue to rework it. With no weathering and erosion on the Moon, the powdery surface does not wash away. The lunar surface is charcoal gray and sandy, with a sizable supply of fine sediment. Meteorite impacts over billions of years have ground up the formerly fresh surfaces into powder. Because the Moon has virtually no atmosphere, even the tiniest meteorite strikes a defenseless surface at full speed, at least 20 kilometers/second (12 miles/second). Some rocks lie thrown about the surface, resembling boulders sticking up through fresh snow on ski slopes. Even these boulders will not last long, maybe a few hundred million years, before they are ground up into powder by the steady rain of high-speed projectiles. Of course, an occasional larger meteoroid, about the size of a car, arrives and carves fresh rock from beneath the blanket of powdery soil. Falling meteoroids continue to grind the fresh boulders down, slowly but inevitably. The layers of regolith vary, from about 2 meters on the youngest maria to

Recent archaeological excavations at Historic Jamestowne have uncovered hundreds of thousands of artifacts dating to the first half of the 17th century. Nearly half of the objects date to the first years of the English settlement (1607–1610). Many of these items have been well preserved by the hard clay soil that forms the base of Jamestown Island. Most people had believed that the site of the original fort had washed into the James River as the shoreline receded. Archaeologists, however, have uncovered large sections of the Jamestown triangular fort, built soon after the first colonists landed. As the artifacts are cleaned and studied, new information about Jamestown and the people who settled there is being discovered.	perhaps 20 meters on the oldest surfaces in the highlands. Lunar regolith has mixed local material so that a shovelful contains most of the rock types that occur in an area. The regolith is a great rock collection. The regolith contains rock and mineral fragments from the original bedrock. It also contains glassy particles formed by the impacts. In many lunar regoliths, half of the particles are composed of mineral fragments that are bound together by impact glass. The chemical composition of the regolith is similar to the composition of the bedrock. Regolith in the highlands is rich in aluminum, as are the highland rocks. Regolith in the maria is rich in iron and magnesium, which are elements also found in basalt.