

Astronomy/Space 5E STEM Unit Plan

Unit Title: Out of this World Geology!

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Topic: Earth's Systems and Earth's Place in the Universe

Targeted Grade Level: 5th Grade

Time Needed: 10-12 days (1 hour lesson/day)

Justification: This series of lessons is designed to teach students about important geologic processes through the lens of space in order to build students' interest in geology as well as astronomy. According to Ampartzaki and Kalogiannakis (2016), it is important to incorporate astronomy concepts early in a child's education because it supports appreciation for Earth and Space and builds scientific thinking¹.

Big Idea and Enduring Understandings: The "big idea" this unit is designed around is the essential question, "What can we learn about the history of an area through an analysis of rocks and the land?", while the enduring understandings it strives to develop are the following: an understanding of the different types of rocks, how rocks are formed, and how geologists analyze rocks to discover changes over time. These enduring understandings were developed from the following standards.

Standards: The standards this unit is designed around are the Highlands School 5th Grade Science Standards which are adaptations of the Next Generation Science Standards. *Where applicable, the correlating NGSS are marked in parentheses. The correlating Science and Engineering Practices, Disciplinary Core Ideas, and Cross-cutting Concepts of the NGSS have also been provided.* Additionally, the unit is designed to include some of the Highlands School 5th Grade Technology Standards, which are based on the Alabama Course of Study Digital Literacy and Computer Science Standards (2018).

¹ Ampartzaki, M., & Kalogiannakis, M. (2016). Astronomy in Early Childhood Education: A Concept-Based Approach. *Early Childhood Education Journal*, 44(2), 169-179. doi:10.1007/s10643-015-0706-5

Performance Expectations

Students who demonstrate understanding can:

Plan and carry out investigations that demonstrate the chemical and physical processes that form rocks and cycle Earth's materials (e.g., processes of crystallization, heating and cooling, weathering, deformation, and sedimentation). (MS-ESS2-1)

Construct explanations by citing evidence found in patterns of rock formations and fossils in rock layers that Earth changes over time through both slow and rapid processes (e.g., rock layers containing shell fossils appearing above rock layers containing plant fossils and no shells indicating a change from land to water over time, a canyon with different rock layers in the walls and a river in the bottom indicating that over time a river cut through the rock). (4-ESS1-1)

Analyze and interpret data (e.g., angle of slope in downhill movement of water, volume of water flow, cycles of freezing and thawing of water, cycles of heating and cooling of water, speed of wind, relative rate of soil deposition, amount of vegetation) to determine effects of weathering and rate of erosion by water, ice, wind, and vegetation using one single form of weathering or erosion at a time. (4-ESS2-1)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
<p>Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 3– 5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. Identify the evidence that supports particular points in an explanation. (4-ESS1-1)</p>	<p>ESS2.A: Earth’s Materials and Systems</p> <p>All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms. (MS-ESS2-1)</p> <p>ESS1.C: The History of Planet Earth</p> <p>Local, regional, and global patterns of rock formations reveal changes over time due to</p>	<p>Patterns: Patterns can be used as evidence to support an explanation. (4-ESS1-1)</p>

	earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4-ESS1-1)	
Highlands School 5th Grade Technology Standards		
<p><i>Students who demonstrate understanding can:</i></p> <p>Create a working program in a block-based visual programming environment using arithmetic operators, conditionals, and repetition in programs, in collaboration with others</p> <p>Connect data from a simulation to real-life events.</p>		

Measurable Student Learning Objectives:

- Students will be able to recognize processes of crystallization, heating/cooling, weathering, and sedimentation by analyzing rocks.
- Students will be able to explain the rock cycle by synthesizing the information in a creative writing piece.
- Students will be able to construct an explanation of how land changes over time by referring to patterns identified in rock layers and fossils.
- Students will be able to determine the effects of weathering and erosion by carrying out an investigation and analyzing data.

Engaging Context/Phenomena: The engaging context for this unit is the landing of the Perseverance rover and the geologic investigations it is conducting on Mars.

Data Integration: NASA data that is being integrated is in the form of Google Mars (*a Google application that was developed using NASA data*), the Astromaterials 3D Explorer site (*a site developed by NASA to make information about*

space rock samples accessible), as well as Infiniscope (*a site with interactive, educational materials designed from NASA data*).

Course Resources: Resources from the Astronomy & Space Science course through NASA Endeavor that are being incorporated include the following: the NASA Perseverance website, Infiniscopes: Stories In Rock, and NASA JPL STEM Lessons for Educators. These resources will better help my students achieve the goals of this unit in many ways. Perseverance, for example, will act as the anchoring phenomenon for the unit, driving the students' inquiry into geologic processes. And the Infiniscope and NASA JPL STEM Lessons provide resources that directly build the students' understanding of the standards.

Differentiation of Instruction: In order for all students to be able to participate, these lessons have been designed to accommodate students learning in a virtual setting. They have also been designed to meet the needs of different learners by incorporating a diverse array of activities that support auditory, visual, kinesthetic, and social learning styles.

Real-life Connection: By designing this unit around a recent, historic event - the landing of the Mars rover - students can immediately see the real-life importance of understanding geologic processes and the work of geologists as it directly impacts our search for life on other planets.

Possible Misconceptions: Possible misconceptions students may have are that other planets are not composed of elements found on Earth and are not geologically active like Earth. To help with this, it would be best to have this unit follow a study of space/our solar system so students have a basic understanding of the inner planets, moons, asteroids, and other rocky bodies in space.

Teacher Background: To effectively teach this unit the teacher should have an understanding of the geologic processes that shape our Earth and other planets. For example, it will be necessary to understand how rocks can be weathered into sediment and eroded away, how sediment can be cemented and compacted into sedimentary rock, how heat and pressure create metamorphic rocks, and how igneous rocks are created through the cooling of magma. An understanding of ways geologists analyze rocks and categorize them in geologic time would also be helpful, as would a basic understanding of the Mars rovers and space exploration. The British Geological Survey (<https://www.bgs.ac.uk/discovering-geology/geological-processes/>) and the Encyclopedia Britannica (<https://www.britannica.com/science/geology>) are useful sites for building background knowledge.

Lesson Procedures:

Lesson	5E Objectives
<p>Lesson 1: Perseverance Time: 1-2 Days</p>	<p>Procedure: <i>This lesson is a modification of the NASA JPL Classroom Activity “Mars Rover Driver Board Game”.</i></p> <p>Engage: To engage the students, first share footage of the Perseverance rover landing on Mars. Ask the students to think about what they know about Mars and the Mars rovers. For example, ask, “What do we know about the rovers on Mars and what they do?”. Then, give the students time to learn more about how Perseverance is designed and what it is doing on Mars by exploring the Perseverance website. As a class, have the students share their observations. Next, ask the students how rovers know where to drive. Share with them the “Mars-in-a-Minute: How Do Rovers Drive on Mars?” video.</p> <p>Explore: Inform students that they will get to simulate commanding a Mars Rover like real NASA scientists and engineers! Have them play the "Mars Rover Game" via NASA's Space Place.</p> <p>Explain: After the students have gotten to experience the game and what it is like to write command sequences for the rover to collect rock samples, have the students answer a set of debriefing questions to voice what they learned from the activity. Questions to consider include having them analyze what was easy and difficult about the game, and whether their command sequences always went as planned. Then, have them share their thoughts aloud.</p> <p>Elaborate: To elaborate on their learning, have the students access Google Mars (a visual designed using real NASA data) to learn more about the Martian surface and what the NASA rovers might encounter.</p> <p>Evaluate: The students’ learning is being evaluated formatively throughout the lesson - through an assessment of their prior knowledge in the beginning, an assessment of the coherence of their command sequences (coding) during the game, and through an assessment of the students’ responses during the debrief.</p>

	<p>Resources:</p> <p>Perseverance Lesson Slides: https://docs.google.com/presentation/d/e/2PACX-1vQeAWDazuJj3ziPbZ6EF11Vefi_3yuGSEoHUVwj8F1gc7RPDPvgv9iRwbe4mRXPwddR8ulg7fe239VI/pub?start=false&loop=false&delayms=3000</p> <p>Mars Rover Driver Board Game Classroom Activity: https://www.jpl.nasa.gov/edu/teach/activity/mars-rover-driver-board-game/</p> <p>Perseverance Landing Video Clip: https://youtu.be/4czjS9h4Fpg</p> <p>NASA Space Place: https://spaceplace.nasa.gov/</p> <p>Mars 2020 Perseverance website: https://mars.nasa.gov/mars2020/</p> <p>Mars-in-a-Minute: How Do Rovers Drive on Mars?: https://youtu.be/e6vzjNkDB5k</p> <p>Google Debrief Form https://forms.gle/E6dQBrdr3knsZ9Ay8</p> <p>Google Mars: https://www.google.com/mars/</p>
<p>Lesson 2: Space Rocks! Time: 1 Day</p>	<p>Procedure: <i>This lesson incorporates the NASA JPL Project “Describe Rocks Like a NASA Scientist”.</i></p> <p>Engage: Begin with an image of the Perseverance rover holding out it’s robotic arm, and state that it acts like a human geologist. Have students recall the activity they did yesterday and ask</p>

them, what they think a geologist does. Then, share with them that they will be exploring this idea as they investigate the essential question, “What can we learn about the history of an area through an analysis of rocks and the land?”.

Explore: Inform the students that they will once again be acting as NASA scientists, but this time their mission is to analyze rock samples that have been collected by the Mars rovers and other NASA missions! *Direct students to the NASA JPL website to conduct the project, “Describe Rocks Like a NASA Scientist.”* Read Steps 1 and 2 aloud to the students. Then, have the students do a “turn-and-talk” to compare the image from Mars with the image from Earth. Have a few students share their observations. Then, instruct the students to complete steps 3-5 of the online activity.

Explain: Afterwards, have students share what they learned. Ask guiding questions such as, “What are ways scientists describe rock samples?” and “What did this teach you about the work of geologists?”.

Elaborate: To elaborate on their learning, have students visit the NASA Astromaterials 3D website and click on the, “Antarctic Meteorite Collection”. Let them explore the different samples and try to describe some of their properties. If time allows, students can share samples they find interesting.

Evaluate: To evaluate the students' understanding, have them complete an exit slip to explain (1) what a geologist does and some of the terminology they use to describe rocks, and (2) something interesting they learned.

Resources:

Lesson Slides (*last two slides of presentation*):

https://docs.google.com/presentation/d/e/2PACX-1vQeAWDazuJj3ziPbZ6EF11Vefi_3yuGSEoHUVwj8F1gc7RPDPvgv9iRwbe4mRXPwddR8ulg7fe239VI/pub?start=false&loop=false&delayms=3000

Describe Rocks Like a NASA Scientist:

<https://www.jpl.nasa.gov/edu/learn/project/describe-rocks-like-a-nasa-scientist/>

	<p>Astromaterials 3D: https://ares.jsc.nasa.gov/astromaterials3d/</p> <p>Space Rocks! Exit Ticket: https://forms.gle/1EeBGHU7QPfynQhp7</p>
<p>Lesson 3: Rock Classifications Time: 3 Days</p>	<p>Procedure: <i>This lesson incorporates the Annenberg Learner Rock Cycle Interactive.</i></p> <p>Engage: To engage the students, have 9 rocks on display (3 from each rock classification). Remind students that yesterday they learned about different properties of rocks and got to practice examining some. Share with them that today they will be taking a closer look at some rock samples and trying to identify similarities between them. Ask for volunteers to share similarities that they notice between the samples and group them according to their responses.</p> <p>Explore: Then, tell students that one strategy geologists use to analyze rocks is classifying them by how they are formed. Group students in groups of 3-4 students and distribute a variety of rock samples from the three classifications to each group. <i>(If students are learning virtually this activity can be modified by using images of rocks that the students can sort digitally through an application such as Jamboard).</i> Then, have the groups sort their samples into three categories. Allow each group to share how they sorted their rocks, and make sure they include their reasoning behind how they sorted them. <i>Save the sorted rocks for later in the lesson.</i></p> <p>Explain: To learn about the ways geologists classify rocks the students will complete the Annenberg Learner Rock Cycle Interactive. This online interactive introduces students to the three rock types and explains how they are formed through the rock cycle in a fun way. It also includes a test the students can take at the end, the results of which can be printed and shared with the teacher. After the students have had time to complete the interactive, pull up the rock cycle diagram and ask students to explain it, based on what they learned. You should also review other concepts the interactive introduced like the properties that describe the different rocks. <i>(Students can take notes in their science journals about the properties that describe the different rock types and on the rock cycle.)</i> Then, have the students revisit the rocks they sorted at the beginning of the lesson and instruct them to analyze them to see if there are any rocks they</p>

	<p>would change to classify them as igneous, metamorphic, and sedimentary. <i>Use this as an opportunity to walk around and assess students' learning. If there is a group that is struggling to classify their rocks correctly, offer assistance and refer them back to the information learned through the interactive if need be.</i></p> <p>Elaborate: To elaborate on their learning, give the students an opportunity to write a fictional story with a rock as the main character that travels through each step of the rock cycle. When they are done, the students should be given time to share their work with their classmates.</p> <p>Evaluate: The students' learning is being evaluated throughout this lesson, from an assessment of their prior knowledge at the beginning of the lesson with how they originally sorted the rocks, to how they sorted them after having the rock types explained, through the test on the Annenberg Interactive, and through the fictional story at the end which can be used to assess their understanding of the rock cycle.</p> <p>Resources:</p> <p>Annenberg Learner Rock Cycle Interactive: https://www.learner.org/series/interactive-rock-cycle/</p> <p>Rock Cycle Story Assignment Page and Rubric: https://docs.google.com/document/d/1Vlls6mANUXMqvi3AIY0V35zkam0JPwQR4iEf1XsqsyYM/edit?usp=sharing</p>
<p>Lesson 4: <i>Hidden History!</i> <i>Time: 2 Days</i></p>	<p>Procedure: <i>This lesson incorporates an Infiniscopes Lesson: Stories in Rock.</i></p> <p>Engage: To begin, remind students of the essential question, “What can we learn about the history of an area through an analysis of rocks and the land?”, and ask students, based on what they have learned so far from their investigations of rocks from space, rocks from Earth, and the rock cycle, what they think? Then, show the students a picture of the “Red Mountain Cut” (<i>The Red Mountain Cut is a National Natural Landmark in Birmingham, Alabama many students should be familiar with</i>) and ask them what they see. Share with them a bit about the history of</p>

the “Red Mountain Cut” from the Trek Birmingham website [It is a cut exposing 190 million years of geologic strata dating back over 500 million years and containing rare trilobite fossils!]. How could an ancient underwater creature have been buried here in Birmingham?! Discuss and lead students into wondering what else scientists can learn from geologic strata and how they study them.

Explore: Tell students that not only does studying geologic strata tell us about our own history, but that it can also help us understand the history of other planets and whether or not life existed. Inform students that they are going to get to explore how geologists study strata by completing an interactive, online activity. Direct students to the Infiniscopes: Stories in Rock website and have them work their way through the site. (*Through this activity, the students will learn about the different types of fossils and how geologists interpret the rock layers and date them.*)

Explain: After the students have completed the exploration, lead a class discussion so students can explain what they learned. (*Optional - students can take notes in their science journals to record their learning.*)

Elaborate: To elaborate on the study of rock strata and to support students’ understanding of geologic time, show students the video, “A Brief History of Geologic Time” by PBS Eons. Give students time afterwards to share their thoughts.

Evaluate: To evaluate their understanding, have students respond to an exit slip question or record in their journals an answer to the following: “What are some ways geologists analyze rocks, and what is an example of information they could learn about life long ago?”

Resources:

Trek Birmingham, The Story of Red Mountain Cut:
<https://trekbirmingham.com/articles/the-story-of-red-mountain-cut/>

Infiniscope, Stories in Rock:
<https://infiniscope.org/>

	<p>A Brief History of Geologic Time: https://youtu.be/rWp5ZpJAIAE</p> <p>Hidden History! Exit Ticket: https://forms.gle/zAivrJbEG1HfK6FX7</p>
<p>Lesson 5: Changing Rocks Time: 2-3 Days</p>	<p>Procedure: <i>This lesson incorporates NASA imagery, A Scholastic Study Jam about weathering and erosion, and information on Martian weathering from Windows to the Universe developed by the National Earth Science Teachers Association.</i></p> <p>Engage: Review with students, how yesterday they witnessed how Earth has changed a lot over time, and inform them that the land and rocks are constantly changing bit by bit. Then, show them a picture of the selfie the Mars Rover, Curiosity, took at Mont Mercou. Ask students to share their observations. <i>(How would you describe the land in this image? Does anything look like it has been changed over time?)</i></p> <p>Explore: Next, tell the students they are going to be experimenting with forces that can change the rocks and land. Each student will need a bowl of either sand or soil, a straw (optional), and a glass of water. First, have students use the straw (if they have one) to blow lightly across the surface of their sand or soil. Then, on a sticky note have the students write what happened when they blew and whether or not they noticed any patterns. <i>(If in person, have students place their sticky notes on the board. Create a table that has sand and soil across the top and wind and water along the side to create four quadrants. The students should place their sticky note in the corresponding quadrant.)</i> Then, review the results afterward with the class, sharing how the sand and soil were different. Repeat the experiment, but this time instead of using the straw to blow on the sand/soil, use the straw to drop droplets of water from the glass of water onto the sand/soil. Have students experiment with dropping small drops of water and then large bursts of water. Once more, have the students write their observations on sticky notes, and go over their observations as a class.</p> <p>Explain: Inform the students that water and wind are two forces that cause weathering and erosion. To learn what weathering and erosion are and how they are different, have the students</p>

watch the Scholastic Study Jam: Weathering and Erosion. (*Optional - students can take notes in their science journals to record their learning.*)

Elaborate: To elaborate on their learning, the students should return their attention to the “Selfie” picture shared at the beginning of class. Ask students if they can identify ways the martian surface has been weathered. (*Students should mention physical weathering by wind because of the patterns visible in the ground and the rock formation, as well as by chemical means as seen in the rust.*) Then, share with students the “Windows to the Universe” webpage about the weathering processes on Mars and have them read through the information and hyperlinked pages.

Optional Further Elaboration: For further elaboration, consider discussing how asteroids/meteors are objects that can also physically change the land and rocks. Observe pictures of the heavily cratered dark-side of the moon to get students thoughts going, then introduce the NASA JPL Classroom Activity: Whip-Up a Moon Like Crater.

Evaluate: Students' learning can be evaluated through the observations they shared during the hands-on lab as well as through the discussion afterward on examples of weathering they see in the Mars selfie picture.

Resources:

Curiosity's Selfie at Mont Mercou:

<https://mars.nasa.gov/resources/25757/curiositys-selfie-at-mont-mercou/>

Scholastic Study Jam, Weathering & Erosion:

<https://studyjams.scholastic.com/studyjams/jams/science/rocks-minerals-landforms/weathering-and-erosion.htm>

Windows to the Universe, Weathering Processes on Mars:

https://www.windows2universe.org/mars/exploring/MPF_weathering.html#:~:text=Unlike%20the%20rocks%20of%20Earth,Mars%3A%20wind%20and%20acid%20fog.&text=Wind%20erosion%20of%20Mars%20was.wind%20tails

	Whip-Up a Moon Like Crater Classroom Activity: https://www.jpl.nasa.gov/edu/teach/activity/make-a-crater/
<p>Lesson 6: <i>Pulling It all Together</i> <i>Time: 30 min.</i></p>	<p>Procedure: <i>This lesson incorporates the NASA biography of Sarah Noble, a planetary geologist.</i></p> <p>Engage: To engage the students, have a blank web on a piece of chart paper (or a digital whiteboard if teaching remote learners) with “Ways Geologists Learn About the History of an Area Through It’s Rocks” at the center. Have the students create their own web in their science journals and fill it in based on what they know now. Then, have the students share items from their own webs to create the class copy. (Items that could be included might be that they use rovers to collect rock samples, they describe the properties of rocks and apply knowledge of the rock cycle, they date rocks according to their layers, they chemically date igneous rocks, they search for fossil remains, they look for signs of weathering and erosion, and they compare samples from various places.) Congratulate the students on their thoughts! Then, inform them that today we will be learning about someone who is a real planetary geologist!</p> <p>Explore: Have students read the profile of Sarah Noble, a planetary geologist who works for NASA.</p> <p>Explain: At their tables, or independently if remote, have the students share something that stood out to them about her biography and something they would like to know more about (either about her or planetary geology in general).</p> <p>Elaborate: Then, have students write a reflection about why the work of planetary geologists and geologists are important - why bother studying the history recorded in rocks? <i>Optional - students can be assigned study materials to help them prepare for the summative assessment over the material they have learned.</i></p> <p>Evaluate: After the students have been given time to prepare, the students will take a summative assessment over the material they learned. It is an assessment that places the students in the role of a NASA planetary geologist. The students will be expected to explain the following: They will need to determine a rock type based on its properties. They will also need to analyze the</p>

	<p>Martian landscape and explain how it has been weathered. Finally, the students must explain ways geologists learn about the history of an area through its rocks and why the work of planetary geologists is important.</p> <p>Resources:</p> <p>NASA bio, Sarah Noble: https://solarsystem.nasa.gov/people/1740/sarah-noble/</p> <p>Summative Assessment: https://forms.gle/HdhECCyYGp2saX4A8</p>
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