03. Ecological Relationships Lesson #2: GEOLOGY SHAPES THE LANDSCAPE

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Overview: This lesson assesses youths’ prior knowledge of geological processes and introduces the development of the ecosystem over time. Additionally, it examines the natural succession of plant communities and subsequent ecosystem changes.

Learner Outcomes
Youth will:
1. Understand the fundamental geological concepts and processes of Yellowstone.

Hint: This is a difficult lesson to teach if you get caught up in geological facts. The goal of this lesson is that they understand the geological time scale, not the details of every geological process.

Getting Ready
Materials: Youth need a journal, pencil, colored pencils, water bottles, an outcropping of large rocks and some small rocks, different colors of sand and soil, twigs, and leaf litter; staff need handouts.

Preparation: Review this lesson thoroughly.

Location: Preferably an area close to water that has the materials described easily exposed.

Background
The following material is supplemental information. Adapted from Yellowstone Resources and Issues Handbook: 2012, p. 43.

Yellowstone’s geological story provides examples of how geologic processes work on a planetary scale. The foundation to understanding this story begins with the structure of Earth and how it gives rise to forces that shape the planet’s surface.

Earth is frequently depicted as a ball with a central core surrounded by concentric layers that culminate in the crust or surface layer. The distance from Earth’s surface to its core is approximately 4,000 miles. The mostly iron and nickel inner core (about 750 miles in diameter) is extremely hot but solid due to immense pressure. The iron and nickel outer core (1,400 miles thick) is hot and molten. The mantle (1,800 miles thick) is a dense, hot, semi-solid layer of rock. Above this layer is the relatively thin crust, three to forty-eight miles thick, on which the continents and ocean floors are found.

Earth’s lithosphere (crust and upper mantle) is divided into many plates, which are in constant motion. Where plate edges meet, one plate may slide past another or one plate may be driven beneath (subduction). Upwelling volcanic material pushes plates apart at mid-ocean ridges. Continental plates are made of less dense rocks (granites) that are thicker than oceanic plates (basalts) and thus “ride” higher than oceanic plates. Evidence supports a theory of crustal plate movement that suggests convection currents in the partially molten asthenosphere (the zone of mantle beneath the lithosphere) move the rigid crustal plates above. The volcanism that has so greatly shaped today’s Yellowstone is a product of plate movement combined with upwellings of molten rock.
Lesson at a Glance

Concept Maps: Assessment of Prior Knowledge (15 minutes)
Concept maps reflect youth’s current knowledge and perhaps their misconceptions of the geological landscape of Yellowstone National Park.

Building Yellowstone’s Geologic Landscape (35 minutes)
Youth create miniature Yellowstone geologic landscapes to understand that the vegetation of Yellowstone today is shaped by its geologic past. It is key that the location (an area close to water) has the material described for the lesson.

Concluding the Lesson: Revisit Concept Maps (10 minutes)
Youth examine their knowledge of the geologic landscape of Yellowstone National Park.

Suggested Procedure

Concept Maps: Assessment of Prior Knowledge (15 minutes) (D1)
Youth will reflect on their current knowledge and misconceptions of the geological landscape of YNP.

1. Explain that they will be learning about the development of the Yellowstone ecosystem over a period of geologic time. Before getting started, have youth think back to the geological concepts that they are already familiar with using a concept map.
2. Demonstrate how to complete a concept map (refer to staff notes). Start with an unrelated key concept in the middle of the page, to provide plenty of room and complete the example as a group on the dry erases board.
3. Give “geology” as the central concept with the following instructions:
   a. In your journal draw a circle in the middle at the top of the page.
   b. Write “geology” in the circle.
   c. Now think of everything you know about this concept and draw that knowledge into circles. Draw the most important things at the top, and the least important towards the bottom.
   d. Draw lines between the terms you think are related to one another.
   e. Write the nature of the relationship between the terms on each line.
   f. Write examples of each concept used.
4. Youth will individually complete their concept maps.
   a. If necessary provide them with prompts such as:
      i. What are the three types of rock?
      ii. What do you know about the geology where you are from?
      iii. What did you learn about geology in school? Etc.
5. Next, they will share their concept maps with a partner.
   a. Encourage them to ask questions about each other’s maps
   b. They may make corrections or alterations on their maps.
6. Staff should pay close attention to what youth are sharing with their partners to assess their prior knowledge and misconceptions.
   a. For example, if they are lacking basic concepts then you might need to assist them more or adjust the lesson to meet them where they are.
   b. In addition, if the activity seems too easy, then you might need to introduce more difficult concepts.

7. Transition: Tell them that they will be returning to their concept maps once they have learned more about Yellowstone’s geological landscape.

**Building Yellowstone’s Geologic Landscape (35 minutes)** (**F1**)
Youth will create miniature Yellowstone geologic landscapes to understand how the vegetation of Yellowstone today is shaped by its geologic past.

Staff will:
1. Explain that they will be stimulating what would naturally take place over millions of years in 30 minutes.
2. They will develop their own Yellowstone geologic landscape starting from scratch.
3. Ask: Where should we start? **Answer: The formation of bedrock.**
4. Divide youth into pairs and give out task cards titled “Building Yellowstone’s Geological Landscape Action Cards” (see handouts). Each pair will get to work on a large rock that will serve as the bedrock for their geologic landscape.
5. Instruct them to follow the task cards carefully since they are all key geological processes.
   Circulate around the groups to ask them to explain what is happening and see if they have any questions.

**Staff Notes:**
- In this task youth will be creating a concept map called **Systems Map with Annotated Relations.** The systems concept map organizes information in a format, which is similar to a flowchart.

(Reprinted from Novak & Canas, 2008).
Conclusion: (4 minutes) After everyone has completed their task cards, regroup and discuss the following questions:

1. Question: How does a glacier disrupt the process of soil formation?
   Answer: Glaciers interrupt soil formation by completely destroying ecosystems located within the path of the glacier. They also pick up available sediments and deposit them elsewhere.

2. Does glacier disturbance serve any other role in soil formation?
3. Why is it important to understand Yellowstone’s geologic landscape?

Revisit Concept Maps: (10 minutes) (S1)
Youth will revisit their understanding of the geologic landscape of YNP.

1. Present the concept of geology again.
2. Instruct them to follow the same directions as the previous concept map.
3. Next, they will pair up to share what they learned from the activity. As they share, ask them to add what they learned from their partner’s map to their own map.
4. The staff should pay close attention to what the youth are saying to assess what they understand about Yellowstone’s geological landscape.
5. Wrap up the lesson by having them share one “ah-ha” geology moment from their concept map.

Assessment Check Ins:
(D1): Examines prior knowledge, interests and misconceptions of geology. This information will assist the staff in planning instruction.

(F1): Provides insight into what youth have learned about Yellowstone’s geologic landscape through the miniature landscapes they created.

(S1): Assesses what they have learned from the lesson.

References:


Incorporates the Building a Forest Activity, which served as the central activity. It was modified in the following ways: Renamed to “Building Yellowstone’s Geological Landscape”; Instructional language was changed match the REC; instructional handouts were added.


Handouts:

- Building Yellowstone’s Geological Landscape Action Cards
Building Yellowstone’s Geological Landscape Action Cards

The following content material is adapted from Yellowstone Resources and Issues Handbook: 2012, 2012.

Read the following aloud, paying close attention to the bolded words.

- The objective of this activity is to understand the geology and vegetation of Yellowstone while creating a “mini” Yellowstone Geologic Landscape.
- Have these materials close at hand, but there is no need to collect them prior to the activity

Materials: A journal, pencil, water bottles, an outcropping of large rocks and small rocks, different colors of sand and soil, twigs, and leaf litter.

Read: Most of Earth’s history, from the formation of the earth 4.6 billion years ago to approximately 542 million years ago, is known as the Precambrian time. Rocks of this age are found in northern Yellowstone and in the heart of the Teton, Beartooth, Wind River, and Gros Ventre mountain ranges. During the Precambrian and the subsequent Paleozoic and Mesozoic eras, oceans, sand dunes, tidal flats, and vast plains covered the western United States at times. Near the end of the Mesozoic period, mountain-building processes created the Rocky Mountains

Step 1: Find a bare and flat-topped rock. This rock is the beginning of your Yellowstone Geologic Landscape.

Read: Made up of Sedimentary sandstone and shale that were deposited by seas during the Paleozoic and Mesozoic era 570 million to 66 million years ago.

Imagine: This is what the land looked like a long time ago before any plants.

Answer the Following Questions: What does the rock feel like? Could a plant easily grow here?

Imagine: Your fingers as roots of a plant.

Answer the Following Questions: Can roots penetrate the rock for stabilization? Are there nutrients available for plants or animals?

Read: Weathering can break down Earth’s materials from large to small particles. The freeze and thaw action of ice is one type of weathering common in Yellowstone. Agents of erosion like wind and water move weathering materials from one place to another.

Simulate: Rub smaller rocks over the larger rock to simulate this process of weathering. Then place a thin layer of sand/or other material atop the rock to represent thousands of years of weathering and sediment deposition.

Answer the Following Questions: What other agents of erosion, like abiotic factors, could be present in this landscape? Could this bedrock have all the components of an ecosystem? Why or why not?

Read: Next is the formation of topsoil and early plant succession. Small plants and saplings begin to grow on the thin soil; these are called pioneer species. In the natural world, as these plants die and decompose, they add nutrients to the soil.
Simulate: Sprinkle dark soil over the sand to represent topsoil.

Create a Question: What is a question you could ask about the soil formation?

Read: Later, species like larger trees and shrubs replaced these pioneer species. This is called plant succession.

Simulate: Place larger sticks standing up as if they are trees and leaves to represent shrubs on the rock to represent forest growth.

Draw: In your journal draw a picture of yourself standing in this landscape. What does it look like? What does it smell like? What does it feel like? After you have finished your drawing, answer the following questions: How does your geological landscape connect to the place that you are currently in? Do they look the same?

Read: As more organic matter accumulates, a thicker layer of soil forms.

Simulate: Sprinkle additional dark soil/or other material around the large sticks (i.e. trees) and the leave (i.e. shrubs) that you planted earlier.

Read: During the Cenozoic era (approximately the last 66.5 million years of Earth’s history), widespread mountain building, volcanism, faulting, and glaciation sculpted the Yellowstone area. The Absaroka Range along the park’s north and east boundaries were formed by numerous volcanic eruptions about 50 million years ago. This period of volcanism was not related to the present Yellowstone volcano. Approximately 30 million years ago, vast expanses of western North America began stretching apart along an east-west axis. This stretching process increased about 17 million years ago and continues today. This created the modern Basin and Range topography characterizing much of the West including Yellowstone.
About 16.5 million years ago, an intense period of volcanism appeared near the area now marked by the convergence of the Nevada, Oregon, and Idaho state lines.

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**Yellowstone Geological History**

- **Ma** = mega annum, or millions of years ago
- **Ka** = kilo annum, or one thousand years ago

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>542 to 66 Ma</td>
<td>Area covered by inland seas</td>
</tr>
<tr>
<td>50 to 40 Ma</td>
<td>Absaroka volcanic</td>
</tr>
<tr>
<td>30 Ma to present</td>
<td>“Basin and Range” forces creating Great Basin topography</td>
</tr>
<tr>
<td>16 Ma</td>
<td>Volcanic activity begins again in present day Nevada and Idaho</td>
</tr>
<tr>
<td>2.1 Ma</td>
<td>1st Yellowstone eruption</td>
</tr>
<tr>
<td>1.3 Ma</td>
<td>2nd Yellowstone eruption</td>
</tr>
<tr>
<td>640 ka</td>
<td>3rd Yellowstone eruption</td>
</tr>
<tr>
<td>174 ka</td>
<td>West Thumb eruption</td>
</tr>
<tr>
<td>157 to 151 ka</td>
<td>Bull Lake Glaciation underway</td>
</tr>
<tr>
<td>20 to 16 ka</td>
<td>Pinedale Glaciation maximum</td>
</tr>
</tbody>
</table>

Figure 1


**Read:** As a group, review Figure 1 to understand the geological processes as it relates to time.

**Answer:** When in Yellowstone’s geological history did vast expanses of Western North America begin stretching apart along an east-west axis? What effects did these forces have on the Yellowstone geological landscape? Are these forces still happening today?
Observe: Figure 2 The locations of Yellowstone's three calderas and two resurgent domes

![Map of Yellowstone's calderas and domes](image)

(Figure 2 (Reprinted from "Yellowstone Resources and Issues Handbook: 2012", 2012, p. 44).

Read: As a group, review Figure 2 and read the following: Repetitive volcanic eruptions can be traced across southern Idaho into Yellowstone National Park. This 500-mile trail of more than 100 calderas was created as the North American plate moved in a southwesterly direction over a shallow body of magma. About 2.1 million years ago, the movement of the North American plate brought the Yellowstone area into proximity with the shallow magma body (Yellowstone Resources and Issues Handbook: 2012, 2012, p. 44).

Create a Question: What is a question you have about volcanic eruptions in the Yellowstone area?
**Observe:** Figure 3 Yellowstone Magma Plume


**Read:** New technology has allowed scientists to map a magma plume (orange/yellow) originating several hundred miles away from Yellowstone, and far deeper than previously thought. It feeds magma into a reservoir (red in detail) beneath Yellowstone.

**Read:** Volcanism remains a driving force in Yellowstone today. Magma has been close to the surface in Yellowstone for more than 2 million years. Its heat melted rocks in the crust, creating a magma chamber of partially molten, partially solid rock. Heat from this shallow magma caused an area of the upper crust to expand, rise, and erode. Pressure caused rocks overlying the magma to break, forming faults and causing earthquakes. This is similar to how a pie might bake, the crust rises and cracks. Eventually, these faults reached the deep magma chamber. Magma oozed through these cracks, releasing pressure within the chamber, and allowed trapped gases to expand rapidly (Yellowstone Resources and Issues Handbook: 2012, 2012, p. 45).

**Simulate:** Create an indent in one section of your landscape with your hand and give it a little earthquake action.
Observe: Figure 4: Volume Comparison of Volcanic Eruptions


Read: These massive eruptions spewed volcanic ash and gas into the atmosphere often. It caused fast, superhot debris (pyroclastic) flows on the ground. As the underground magma chamber emptied, the ground above it sunk, creating the first of Yellowstone’s three calderas. The volume of material ejected during the first eruption is estimated to have been 6,000 times the size of the 1980 eruption of Mt. St. Helens in Washington, where ash was found as far away as Missouri. Approximately 1.3 million years ago, a smaller volcanic eruption occurred within the western edge of the first caldera. Then 640,000 years ago, a third massive volcanic eruption created the Yellowstone Caldera. In the past century, the net result has been to tilt the caldera floor toward the south. As a result, Yellowstone Lake’s southern shores have subsided and trees stand in water (Yellowstone Resources and Issues Handbook: 2012, 2012, p. 45).

Simulate: Spread a layer of lightly colored soil over the volcanic section of the landscape to represent ash.

Draw: In your journal, draw a picture of you standing in this landscape like you did earlier.

Read: Yellowstone and much of North America have experienced numerous periods of glaciation during the last two million years. Succeeding periods of glaciation have destroyed most surface evidence of the previous glacial periods, but scientists have found evidence of them in sediment cores from land and oceans. In Yellowstone, a glacial deposit near Tower Fall dates back 1.3 million years. Evidence of such ancient glaciers is rare (Yellowstone Resources and Issues Handbook: 2012, 2012, p. 50-1).
**Answer the Following Question:** If you were a geological scientist in Yellowstone, what would you want to study about the landscape?

**Read:** Glaciers result when more snow accumulates in an area than melts over many years. Once the snow reaches a certain depth, it turns into ice and begins to move under the force of gravity or the pressure of its own weight. During this movement, rocks are picked up and carried in the ice and they grind against Earth’s surface, eroding and carrying material away. Glaciers also deposit materials. Large U-shaped valleys, ridges of debris (moraines), and out-of-place boulders known as “erratics”, are evidence of a glacier’s passing (Yellowstone Resources and Issues Handbook: 2012, 2012, p. 51).

**Observe:** Figure 5: Two Glacier Periods the Bull Lake (orange outline) and Pinedale (blue outline).

![Figure 5](image.jpg)


**Answer the Following Questions:** Where are you currently located in Figure 5? Can you imagine what this place would look like covered by the Bull Lake Glacier?

**Read:** The Bull Lake Glaciation covered the region about 151,000 to 157,000 years ago. Evidence exists that this glacial episode extended farther south and west of Yellowstone than the Pinedale Glaciation, but no surface evidence of it is found to the north and east. This indicates that the Pinedale Glaciation covered or eroded surface evidence of Bull Lake Glaciation in these areas. The Yellowstone region’s last major glaciation, the Pinedale, is the most studied. Its beginning has been hard to pin down because field evidence is missing or inconclusive. Additionally, the dating techniques are inadequate. Ages of the Pinedale vary around the Yellowstone Ice Cap from 20,000 years ago on the east to 16,000 years ago on the north and possibly as young as 14,000 years ago on
the south. Other than the Pitchstone Plateau, most of the Yellowstone Plateau was free from ice between 13,000 to 14,000 years ago. During this period, glaciers advanced and retreated from the Beartooth Plateau, scouring the landscape we know today as the northern range.

**Simulate:** Use a water bottle to simulate a glacier bulldozing one section of your landscape.

**Draw:** In your journal, draw a picture of yourself standing in this landscape. After you have completed the drawing, compare all of the drawings.

**Read:** Glacial dams backed up water over Hayden Valley, depositing glacial sediment. Similar glacial dams also backed up water over the Lamar Valley; when these dams broke or melted, catastrophic floods sculpted the valleys, forming the modern landscape around the North Entrance of the park.

**Simulate:** Use water to simulate the catastrophic floods in the same area as the glacier bulldozing.

**Read:** During the Pinedale’s peak, nearly all of Yellowstone was covered by an ice cap that was 4,000 feet thick. Mount Washburn and Mount Sheridan were both completely covered by ice. The ice cap occurred here because the magmatic activity beneath Yellowstone had pushed up the area to a higher elevation with colder temperatures and more precipitation than the surrounding land (Yellowstone Resources and Issues Handbook: 2012, 2012, p. 51). Your Yellowstone landscape should currently reflect how the Yellowstone ecosystem was shaped by glacier and volcanic disturbance. Although these two disturbances were not happening at the same time, they do influence the current ecosystems. An important part of these disturbances was their influences on the formation of soils. Vegetation communities in the park reflect a complex interaction between many factors including the regional flora, the climate, the topography, and the local substrates/soils. The vegetation of the park is interrelated with the geology of the park (Yellowstone Resources and Issues Handbook: 2012, 2012, p. 67).

**Simulate:** Place twigs standing up to represent lodgepole pines found in this area as a factor of the local substrate and soils.

**Read:** Yellowstone is covered with miles of lodgepole pine communities, especially within the Yellowstone Caldera. This is because of the rhyolitic soils from the volcanic activity throughout geological history. These soils can be poor in the nutrients needed by firs and spruces. Therefore, lodgepole pine are dominant.

**Answer the Following Questions:** What effects do disturbances have on Yellowstone’s vegetation? How does Yellowstone's vegetation respond to change? What other disturbances effect Yellowstone’s vegetation?

If you have extra time complete the following:

**List or Draw:** Yellowstone fauna (i.e. birds and mammals) that might inhabit a lodgepole pine’s community in your journal.

**Answer the Following Questions:** Why might the fauna that you thought of in a Lodgepole pine community be present? What makes this community a habitat for those fauna? Think in terms of food, space, shelter, and water. How do different vegetation communities affect habitat for fauna in Yellowstone? Give an example.