Plate Tectonics and Rock Layers of Grand Staircase - Escalante National Monument

Teacher Guide

BLM

Grand Staircase-Escalante National Monument

Plate Tectonics and Rock Layers of Grand Staircase-Escalante National Monument

Grade Level

9-12 and 6-8 (with adaptations)

Duration

90 minutes

Description

Students explore 270 million years of geologic history in Grand Staircase-Escalante National Monument by studying the major rock formations of the Grand Staircase and the changing environments that created them as Earth's tectonic plates shifted in geologic time.

Goals

- Identify the major rock formations of Grand Staircase-Escalante National Monument by: name, time formed, type of rock, appearance, special features, environment when formed, and similar modern day habitat.
- Use online paleogeographic maps to follow the tectonic movement of Grand Staircase Escalante National Monument and correlate changing environments with the rock layers formed over a period of 270 million years.

Academic Content Standards

The following standards are drawn from *Content Knowledge*[1].

Earth Science Standard 2
Understands Earth's composition and structure
Level IV (Grades 9-12)
Benchmark 1
Understands the concept of plate tectonics (e.g., the outward transfer of the Earth's internal heat and the action of gravitational forces on regions of different density drive convection circulation in the mantle; these convection currents propel the Earth's crustal plates, which move very slowly, pressing against one another in some places and pulling apart in other places.)
Benchmark 2
Knows effects of the movement of crustal plates (e.g., earthquakes occur along the boundaries between colliding plates; sea floor spreading occurs where plates are moving apart; mountain building occurs where plates are moving together; volcanic eruptions release pressure created by molten rock beneath the Earth's surface.)
Level III (Grades 6-8)
Benchmark 2
Know how land forms are created through a combination of constructive and destructive forces (e.g., constructive forces such as crustal deformation,

[1] *Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 4th Edition,* Mid-Continent Research for Education and Learning in Aurora, Colorado. http://www.mcrel.org/standards-benchmarks/

volcanic eruptions, and deposition of sediment; destructive forces such as weathering and erosion.)

Benchmark 4

Knows that the Earth's crust is divided into plates that move at extremely slow rates in response to movements in the mantle.

Benchmark 5

Knows processes involved in the rock cycle (e.g., old rocks at the surface gradually weather and form sediments that are buried, then compacted, heated, and often recrystallized into new rock. This new rock is eventually brought to the surface by the forces that drive plate motions, and the rock cycle continues.

Benchmark 6

Knows that sedimentary, igneous, and metamorphic rocks contain evidence of the minerals, temperatures, and forces that created them.

Benchmark 7

Knows how successive layers of sedimentary rock and the fossils contained within them can be used to confirm the age, history, and changing life forms of the Earth, and how this evidence is affected by the folding, breaking, and uplifting of layers.

Benchmark 8

Knows that fossils provide important evidence of how environmental conditions have changed on the Earth over time (e.g., changes in atmospheric composition, movement of lithospheric plates, impact of an asteroid or comet)

Nature of Science Standard 11

Understands the nature of scientific knowledge

Level IV (Grade 9-12)

Benchmark 3

Understands how scientific knowledge changes and accumulates over time (e.g., all scientific knowledge is subject to change as new evidence becomes available; some scientific ideas are incomplete and opportunity exists in these areas for new advances; theories are continually tested, revised, and occasionally discarded)

Benchmark 4

Knows that from time to time, major shifts occur in the scientific view of how the world works, but usually the changes that take place in the body of scientific knowledge are small modifications of prior knowledge.

Level III (Grades 6-8)

Benchmark 2

Understands the nature of scientific explanations (e.g., use of logically consistent arguments; emphasis on evidence; use of scientific principles models, and theories; acceptance or displacement of explanations based of new scientific evidence.)

Benchmark 3

Knows that all scientific ideas are tentative and subject to change and improvement in principle, but for most core ideas in science, there is much experimental and observational confirmation.

Materials

- *Plate Tectonics and the Rock Layers of Grand Staircase Escalante National Monument – Student Activity*
- Computer with internet access
- Video or DVD, *Traces in Time,* produced by GSENM

Objectives

1. Identify major rock formations of the Grand Staircase differentiated by: name, time formed, type of rock, appearance, special features, environment when formed, and similar habitats on Earth today.
2. Using online paleogeographic maps, follow the tectonic movement of Grand Staircase-Escalante National Monument and correlate the locations, over geologic time, with major rock layers of the Monument.
3. Synthesize the information in Objectives 1 and 2 to identify artists' illustrations of different environments that existed in the geologic history of GSENM.

Procedures

This is a good team activity. The time required can be significantly cut if teams or small groups of students work together and divide the online research component in Objective 2.

1. Students begin this activity with an overview of the different geographic regions of Grand Staircase-Escalante National Monument (pages 1-2). Show the video "Traces in Time", produced by the Monument, to give students an idea of the widely varied terrain of the Monument.

2. Step 1 - *Geologic Formations of Grand Staircase Escalante National Monument,* (pages 3-14) serves primarily as reference material for the next two objectives. Students should familiarize themselves with the different rock formations and the type of information provided for each: name, time formed, typed of rock, appearance, special features, environment when formed, and similar modern-day habitats.

3. Step 2 - *Geography of Ancient Earth,* (pages 15-18) requires student to access the internet and view a series of paleogeographic maps for North America. These maps delineate the state of Utah. An illustration in the Student Activity will help them locate the Monument on these maps.

Once students have located the paleographic maps in step 2 they're asked to evaluate them and hypothesize what type of environment might have existed at that period in geologic time. It might be helpful to review some basic geographic points: climates near the equator, rain shadows, etc. Several examples of how to read a paleomap are included in Step 1.

After students have formed their hypotheses they can check their accuracy in the rock formations data of step 1.

To complete step 2, students write a brief synopsis of the environment and rock layers formed during each geologic period. They will use this information in step 3.

4. Step 3 - *Ancient Environments,* (pages 19-20) is a series of artists' illustrations for different geologic times. Using the information in Step 1, and their summary and formation lists from step 2, students should be able to identify most of the illustrations accurately. Some illustrations could apply to more than one time period, but flora and fauna are important clues. Answers are supplied in the Answer Key.

Adaptations

Younger students may have difficulty with the vocabulary in step 1. You may choose to introduce new vocabulary before beginning the activity or limiting the new vocabulary in step 1 by having students use only the information for "time formed" and "environment when formed." Locating the Monument on the paleogeographic maps online should not be a problem nor should correlating the time periods with rock formations. Step 3 may require a brief discussion of what the environment in each illustration represents, i.e., shallow sea, ocean, swamp, sand desert.

Extensions

The paleogeographic map links in this activity are just a few of the online resources available to students through the Department of Geology at Northern Arizona University. The following websites will be fascinating for students to explore.

Paleogeography and Geologic Evolution of North America
http://jan.ucc.nau.edu/~rcb7/nam.html

Global Paleogeographic Views of the Earth – Late Precambrian to Recent
http://jan.ucc.nau.edu/~rcb7/globaltext2.html

Regional Paleogeographic Views of Earth History-
http://jan.ucc.nau.edu/~rcb7/globaltext.html

Paleogeography of the Southwest
http://jan.ucc.nau.edu/~rcb7/paleogeogwus.html

References

Books/Periodicals

Chan, Marjorie A. and William T. Parry, *Rainbow of Rocks, Mysteries of Sandstone Colors and Concretions in Colorado Plateau Canyon Country*, Utah Geological Survey Public Information Series 7, ISBN 1-55791-681-0

Loope, David B., Maureen B. Steiner, Clinton M. Rowe and Nicholas Lancaster, *Tropical westerlies over Pangaean sand seas*, Sedimentology (2004) 51, ppg 315-322.

Websites

Paleogeography and Geologic Evolution of North America
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Paleogeography of the Southwest http://jan.ucc.nau.edu/~rcb7/paleogeogwus.html

PALEOMAP Project
www.scotese.com

Assessment

At the end of this activity students should be able to:

- Identify the characteristics that differentiate one rock formation from another in GSENM
- Explain how the movement of tectonic plates affected the environment of GSENM in geologic time
- Correlate the geographic location and types of rocks formed in the Monument over 270 million years

Answer Key

Question 1

In the space below each geologic period write a brief synopsis of the environment that existed and list the rock layer(s) formed.

Answers will vary

Question 2

Following are illustrations of nine different environments that existed while the rock layers of the Monument were being formed in the geologic past. These pictures do not cover all of the different environments, just a few.

Use information from earlier in the activity to identify the geologic time period and the rock formation that could have been made when the environment looked like the illustration. Write the name(s) of the rock layers and the geologic time that you think each illustration represents.

a) Straight Cliffs Formation ~ 85 mya
b) Navajo Formation ~ 185 mya
c) Tropic Shale Formation ~ 93 mya
d) Moenkopi Formation ~ 245 mya
e) Chinle Formation ~ 210 mya
f) Kayenta Formation ~193 mya
g) Kaibab Formation ~270 mya
h) Carmel Formation ~ 166 mya
i) Wahweap Formation ~ 80 mya

Vocabulary

Cenozoic	Belonging or relating to the most recent era of geological time, covering the period from the present to about 65 million years ago, during which modern plants and animals evolved.
Formation	Unit of rock consisting of a succession of strata or an igneous intrusion.
Jurassic	The period of geologic time during which dinosaurs flourished and birds and mammals first appeared, extending from 200 million years to 145 million years ago.
Limestone	Sedimentary rock formed from the skeletons and shells of marine organisms that consists chiefly of calcium carbonate and is used widely in construction and in making lime and cement.
Members	A division of a formation, generally of distinct lithologic character or of only local extent.
Mesozoic	Belonging to or dating from an era of geologic time 250 to 65 million years ago, between the Paleozoic and Cenozoic Eras, when dinosaurs, birds, and flowering plants first appeared.
Mudstone	A sedimentary rock formed from mud, similar to shale but with less developed lamination.
Paleozoic	The Era of geologic time when fish, insects, amphibians, reptiles, and land plants first appeared, about 550 million to 250 million years ago.
Sabhka	A coastal environment in an arid climate where evaporation rates are high. The term is also applied to interior flat areas where, from either deflation or evaporation, saline minerals are present (salt flat)
Sandstone	Sedimentary rock made up of sand particles, mostly quartz, bound together by a mineral cement, along with some feldspar, mica, and rock debris.
Shale	A dark fine-grained sedimentary rock composed of layers of compressed clay, silt, or mud.
Siltstone	A form of fine-grained sandstone consisting of compressed silt.
Strata	Plural of stratum, any of several parallel layers levels.

Unconformity	A surface of erosion, or non-deposition, between younger strata and older rocks.