# GEOLOGICAL ADVENTURES AT PARASHANT

## EXPLORING THE GEOLOGY OF GRAND CANYON-PARASHANT NATIONAL MONUMENT

NATIONAL PARK SERVICE

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# ACKNOWLEDGEMENTS

This work was completed through support from the Geological Society of America's GeoCorps Program and the National Park Service (NPS). Special thanks go to Paula Branstner, Interpretive Specialist at Grand Canyon Parashant National Monument, for her guidance and support. Jeff Bradybaugh, Monument Superintendent, reviewed all lessons and provided helpful feedback. Many monument staff members provided resources, advice, and suggestions. Ivo Lucchitta of Flagstaff, Arizona gave a constructive review of Lesson 6 on structural geology. George Billingsley (USGS Flagstaff) was very helpful with map resources and geologic reports. Bruce Nash (NPS Office of Education and Research) provided resources and support throughout my internship. Thomas McGuire spent two days on the monument discussing its geology and providing useful insights. Curtis Racker (Law Enforcement Ranger, BLM) provided an aerial tour of Parashant on his own time. This project also benefited greatly from the efforts of the educators listed below who reviewed drafts of lesson plans.

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# MODULE OVERVIEW

## *USING THE MODULE*

The module is intended for students in grades 6-9. The primary purpose of the module is to use the diverse and fascinating geologic setting of Grand Canyon-Parashant National Monument (referred to as Parashant throughout the module) as the context to help educators teach fundamental geology concepts and skills. Lessons are engaging and inquiry-based. There are nine lessons, each of which lasts two to three 45-minute class periods. Lessons are designed to be done in cooperative groups and to use a minimum amount of affordable consumable materials and supplies (e.g., lessons 2-6 use the same materials – a one-pound box of four colors of modeling clay). Teachers looking for a four to six-week unit in geology can run through the complete sequence of lessons, while others can choose lessons to suit their needs. The teacher guide for each lesson contains photos of how to set up and run hands-on activities and suggestions for making the lesson more quantitative and challenging for honors, gifted, or higher grade-level students. The student edition can serve as a master to photocopy for students. PowerPoint slide shows with photos from the lessons (and additional photos) are available for each lesson.

## *LESSON STRUCTURE*

Lessons follow the 5E instructional model outlined by Bybee and Trowbridge (1994). Each lesson in the module has five stages: 1. a warm-up question or problem to spark interest (engage), 2. hands-on activity (explore), 3. reading that features comparisons to maps or photographs of rocks, outcrops, landscapes of actual processes that occur (or have occurred) at Parashant (explain), 4. application questions that connect the activity to processes in the monument (elaborate), and 5. an assessment task or reflection questions (evaluate).

## *LESSON DESCRIPTIONS*

### 1. Exploring Parashant – an Interactive Reading Guide

Students work in pairs or groups of three to explore the Views DVD (or website) on Grand Canyon-Parashant National Monument.

### 2. Sedimentary Rocks – Exploring the Cliffs at Parashant

Students look at samples of sedimentary rocks and note characteristic features. They then build a sedimentary rock sequence using layers of modeling clay. Each layer of modeling clay stands for a kind of sedimentary rock found in the monument (sandstone, shale, siltstone, limestone). Students then use a piece of dental floss to slice one end of the layers in a manner that is consistent with how rocks weather and erode in canyon walls (i.e., shale will often form gentle slopes, and sandstone, siltstone and limestone will often form cliffs). After the activity, students read about how sedimentary rocks form to learn about the main classification scheme of sedimentary rocks and what sedimentary rocks reveal about depositional environments and Earth's history. Students save their models for use in Lesson 3.

## 3. Igneous Rocks – Lava Flows at Parashant

Students look at samples of igneous rocks and sort the rocks by texture, color, and then by texture and color. Students then model the flow of lava at Parashant by pouring liquid soap onto the top of their clay models and observing the differences in the speed of the flow (slow, medium, fast) over slopes of different gradients. Students compare their models to surface and aerial photographs of lava flows at Parashant as they read about the main types of igneous rocks (extrusive versus intrusive) and the nature and timing of eruptions at the monument. Students are asked to design and do their own experiment into lava flows using one of six research questions.

## 4. Metamorphic Rocks – Basement of Parashant

Students begin by conducting thought experiments about how heat and pressure might change rock. They then experiment with their clay models of rock layers by measuring its dimensions, compressing the model, and measuring and calculating how the model changed due to pressure. With this concrete analogy of change due to metamorphic burial and tectonic folding, students read about agents of metamorphism and how metamorphic rocks form the 1.6 to 1.8 billion year old basement rocks beneath Parashant. In the Elaborate activity, students compare samples of metamorphic rocks to common parent rocks to explore the effects of heat and pressure on igneous, sedimentary, and metamorphic rocks.

## 5. Topography – Landscapes of the Parashant

Students totally mix and reshape their modeling clay into a landform feature. Students place their models in a small transparent plastic container. They mark the sides of the container with 1 cm increments, pour water into the container to the 1-cm line, put the clear plastic cover onto the container, and use a grease pencil or non-permanent marker to outline the edge of the water along the clay. This represents a contour line. Students continue to add water and trace the pattern in one-centimeter increments. Using a scale of 1cm = 100 meters, students label the contour lines on their maps. Students then construct a profile across their contour map to continue developing their understanding of topography. Students read about topography and topographic maps and about the processes that control landscape features at the monument, then interpret topographic maps and construct profiles of different landscape features at Parashant.

## 6. Geologic Structure and the Parashant Landscape

In this activity, students use modeling clay to simulate and study three kinds of stress that create geologic structures: tensional, compressional, and shear. In Part B of the activity, they apply what they have learned about stress to model the formation of faults, folds, and uplift using their modeling clay. Each group is assigned a different type of structural feature to model. They are given block diagrams to use as a guide to produce a structure, and must create the structure using modeling clay and explain the forces that led to the feature. Each group then presents the structural model to the rest of the class. Students read about the processes of uplift, folding, and faulting in the context of plate tectonic theory and the formation of Parashant's landscape features.

## 7. Erosion and Deposition– From Washes to Canyons at Parashant

Students interpret a photograph of gravels and cobbles exposed in Whitmore Wash at the monument. They clip an overhead transparency to a photograph of the sidewall of a wash and draw lines through the longest axes of flattened cobbles, and use the overall pattern of lines to infer the direction of stream flow. Students read about the processes of erosion and deposition that are most prevalent on the monument. In an elaboration activity, students return to the photograph of Whitmore Wash to interpret the percentages of various rock types found in the deposit. After building a class data set using representative square-meter areas of the deposit, they draw inferences about the geology of the mountain range that produced the deposit.

## 8. Copper Calling at Grand Gulch Mine

Students model the mining operation at the Grand Gulch Mine. They mine for pennies in a box of wet sand and must clean, dry, and weigh the pennies, calculate the monetary value of the mined ore, and weigh this against the costs associated with the time it takes to find, remove, clean, and transport the pennies to the point of distribution. Students construct graphs of costs versus gross value for various amounts of copper at several prices per ton to determine what would be required to make the operation profitable. Students read about the actual mining operations.

## 9. Understanding Time at Parashant

Students examine photographs and schematic diagrams of rock layers, faults, unconformities, dikes, and lava flows from several different locations within the park to learn how to apply the laws of superposition, original horizontality, and cross-cutting relationships in interpreting sequences of geologic events. They read about relative and absolute age dating techniques and the geologic time scale.

## *BIG IDEAS*

This module lays the groundwork for teachers to develop student's understandings about the following ten key ideas in Earth science. (source: Earth Science by Design; http://www.esbd.org/resources/big_ideas.html).

1. The surface of Earth has identifiable major features--land masses (continents), oceans, rivers, lakes, mountains, canyons, and glaciers.
2. Earth's surface is built up and worn down by natural processes, such as rock formation, erosion, and weathering.
3. Physical evidence, such as fossils and radioisotopic dating, provide evidence for the Earth system's evolution and development.
4. The atmosphere exhibits long-term circulation patterns (climate) and short-term patterns known as weather--storms, hurricanes, and tornadoes.
5. Water cycles through the atmosphere, hydrosphere, geosphere, and biosphere.
6. Life appeared early in Earth's history and has been intimately involved in the nature of the Earth--i.e. composition of the atmosphere, weathering, carbon cycle, and rock cycle.

7. Earth scientists use representations and models, such as contour maps and satellite images to help them understand the Earth.
8. Scientists use quantitative, qualitative, experimental and non-experimental methods of scientific inquiry to understand the Earth.
9. Earth scientists make an assumption of uniformitarianism, that the processes that shaped the Earth in the past are the same processes we observe today.
10. As in all scientific disciplines, knowledge in Earth science is subject to revision.

## *NATIONAL SCIENCE EDUCATION STANDARDS ADDRESSED*

Lessons in this module can be used to develop the following understandings and abilities outlined in the National Science Education Standards (NRC, 1996).

### Structure of the Earth System

⇒ The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.

⇒ Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions.

⇒ Landforms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.

⇒ Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.

⇒ Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture.

⇒ Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans.

⇒ Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.

### Earth's History

⇒ The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet.

⇒ Fossils provide important evidence of how life and environmental conditions have changed.

## Abilities Necessary to Do Scientific Inquiry

- ⇒ Ask a question about objects, organisms, and events in the environment.
- ⇒ Plan and conduct a simple investigation.
- ⇒ Employ simple equipments and tools to gather data and extend the senses.
- ⇒ Use data to construct a reasonable explanation.
- ⇒ Communicate investigations and explanations.

## Understandings About Scientific Inquiry

- ⇒ Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- ⇒ Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).
- ⇒ Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses.
- ⇒ Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
- ⇒ Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
- ⇒ Scientists review and ask questions about the results of other scientists' work.

## Systems, Order, and Organization

- ⇒ The natural and designed world is complex; it is too large and complicated to investigate and comprehend all at once. Scientists and students learn to define small portions for the convenience of investigation. The units of investigation can be referred to as "systems." A system is an organized group of related objects or components that form a whole.
- ⇒ Science assumes that the behavior of the universe is not capricious, that nature is the same everywhere, and that it is understandable and predictable. Students can develop an understanding of regularities in systems, and by extension, the universe; they then can develop understanding of basic laws, theories, and models that explain the world.
- ⇒ Prediction is the use of knowledge to identify and explain observations, or changes, in advance. The use of mathematics, especially probability, allows for greater or lesser certainty of predictions.

⇒ Types and levels of organization provide useful ways of thinking about the world. Types of organization include the periodic table of elements and the classification of organisms. Physical systems can be described at different levels of organization.

## Evidence, Models, and Explanation

⇒ Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems.

⇒ Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations.

⇒ As students develop and understand more science concepts and processes, their explanations should become more sophisticated...frequently reflecting a rich scientific knowledge base, evidence of logic, higher levels of analysis, and greater tolerance of criticism and uncertainty.

⇒ Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements.

## Constancy, Change, and Measurement

⇒ Most things are in the process of becoming different—changing. Changes might occur, for example, in properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. Changes vary in rate, scale, and pattern, including trends and cycles.

⇒ Changes in systems can be quantified. Evidence for interactions and subsequent change and the formulation of scientific explanations are often clarified through quantitative distinctions--measurement. Mathematics is essential for accurately measuring change.

⇒ Different systems of measurement are used for different purposes. Scientists usually use the metric system.

⇒ Rate involves comparing one measured quantity with another measured quantity, for example, 60 meters per second. Rate is also a measure of change for a part relative to the whole, for example, change in birth rate as part of population growth.