Earth History Theories

Relative Age Dating Lab With Additions for Mining and Mineral Exploration

BY LAURA ELLIS, ELLIE BUSSE, MELISSA JURKIEWICZ, AND NICOLE LINNEY

Keep the introduction short but be sure to clearly explain to the reader what your article is about. The introduction is a great place to include reference to pertinent research.

Geologists use *stratig*[illegible] lay-ers, called strata, an[illegible]hose layers, a process cal[illegible]tig-raphy helps geologists inv[illegible]tory study fossils and assign ag[illegible]ers. Mining geologists rely on characteristics of stratigraphy to explore ore and mineral deposits. This article describes a three-day stratigraphy lab that incorporates relative age dating, ore and fossil deposits, making a geologic model using modeling clay as rock layers, and exploring the ways in which scientists discover mineral deposits (see NSTA Connection for complete student instructions and worksheets). We use the 5E learning cycle to outline the lesson plan and provide suggestions for implementation, based on previous implementation experiences at a middle school in Nevada.

Engage

While not required, the 5E instructional model makes it easier for the reader to follow the sequence of your described activities.

We designed the engagem[illegible]wl-edge and help students [illegible]een what they know and what they do not, because relative age dating can be a difficult concept to grasp. To help students begin to think about relative ages, we ask them to consider the ages of their family members. Each student records his or her family members in order from oldest to youngest. As a class, we discuss the types of evidence that exist to help them determine who is older or younger in their families. We then inform students that they can do the same relative age dating with rocks; we explain, however, that they need to know what types of evidence to look for. Additionally, we talk about the importance of relative age dating in understanding Earth's history. We explain that understanding family history is similar to dating rocks, because it is important to know the ages of family members so we can know when you (the student) were born and other important facts related to the timing of your life. By using relative age dating, mineral resources can be found in specific geologic units, so we have to understand

how the units form in order to search for specific minerals and fossils. The lab uses knowledge of relative age dating to simulate a geologist discovering important pieces of evidence related to Earth's history, such as fossils and ore minerals.

Explore

Students are tasked with creating a geologic model of stratigraphic layers with embedded fossils and mineral deposits. Different colors of modeling clay represent the stratigraphic layers. They build the model in groups of four and each group member is assigned one of four different roles: (1) Chief Geologist (leader), (2) Sedimentologist (sedimentary layer builders), (3) Paleontologist (fossil and ore producer), and (4) Geologic Historian (recorder).

Each modeling clay layer represents the deposition of a sedimentary rock layer. The Sedimentologist and Paleontologist construct the layers and embedded features: The Sedimentologist flattens clay into stratigraphic layers, and the Paleontologist cuts out fossils to place between the layers to represent buried fossils and uses the red sprinkles to represent deposited ore. Deposits of fossils and mineral ore are each their own events. For example, if a leaf becomes caught between two rock layers, the bottom layer is one depositional event, the burial of the fossil leaf is the next event, and the deposition of the top layer is the following event. The Geologic Historian records the rock layers of the group's geologic model and records the location of the fossil and ore deposits. On the second lab day, the groups will switch geologic models to discover the fossil and ore deposits of another group's model during the Extend and Elaborate phases (see Figure 1 for an example of one of the geologic models). Models were built and stored on paper plates and covered with plastic wrap overnight. Play-Doh–type modeling clay was used in our lesson, which can be made from any number of recipes found on the internet. *Safety note:* Remind students to keep clay and ingredients contained in the workspace, properly handle scissors, and carefully use the excavation tools.

All activity-based articles provide the reader with a quick glimpse into the big idea, essential pre-existing knowledge, and costs associated with conducting the activity.

CONTENT AREA

Earth science

GRADE LEVEL

6–8

BIG IDEA/UNIT

Modeling stratigraphy and distribution of Earth's resources

ESSENTIAL PRE-EXISTING KNOWLEDGE

Sedimentary rocks are formed by weathering, transportation, and deposition of sediments. Many natural resources, such as minerals, are found in the Earth's crust and are used commonly by humans in a variety of ways.

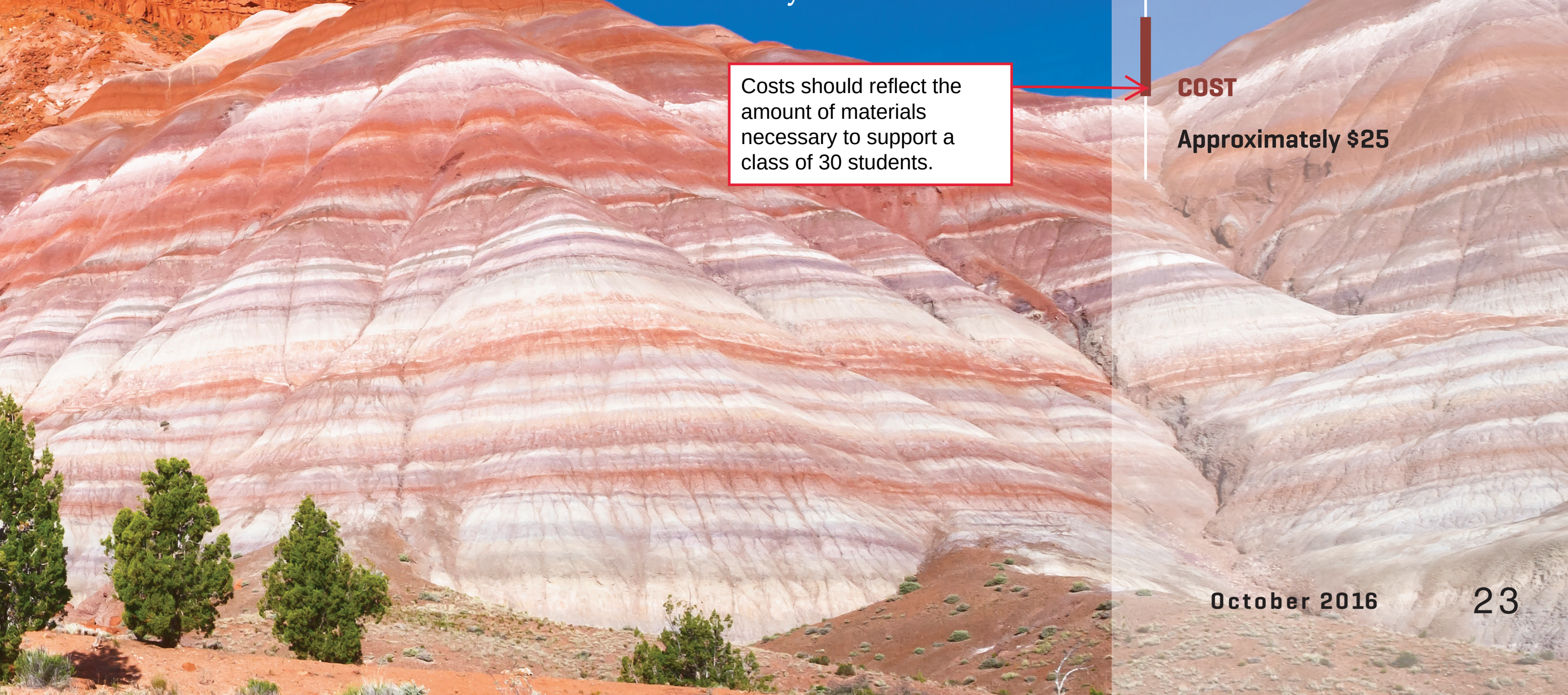
TIME REQUIRED

Three 55-minute class periods

COST

Approximately $25

Costs should reflect the amount of materials necessary to support a class of 30 students.



Explain

During the Explain phase students make sense of their observations and data collection during the prior Explore phase. Teachers should tailor this portion of the lesson to meet the specific needs of their students. For this phrase, we suggest reviewing or introducing Steno's Laws and the definitions of *sedimentary rocks* and *rock strata*. The stratigraphic principles of Steno's laws are crucial to understanding how sedimentary layers are formed and examining the evidence of the geologic history presented in a stratigraphic model. The laws are as follows:

1. Law of Original Horizontality: Beds of sediment deposited in water form as horizontal (or nearly horizontal) layers due to gravitational settling.
2. Law of Superposition: In undisturbed strata, the oldest layer lies at the bottom and the youngest layer lies at the top.
3. Law of Lateral Continuity: Horizontal strata extend laterally until they thin to zero thickness (*pinch out*) at the edge of their basin of deposition.

The concept of relative age dating is also crucial to examining the evidence of geologic history presented in a stratigraphic model. Relative dating in geology and resource (e.g., minerals, oil) exploration involves the correlation or comparison of fossils of similar ages, but from different regions. The important idea is that if a fossil is included in a rock layer and we know the time period the animal lived, we can conclude that the rock was formed during that period. The general concept of relative dating will be familiar to students on a basic level from the previous exercise in the Engage phase of the lesson (ordering family members from oldest to youngest).

This activity also warrants a discussion of how a fossil is formed. The basic steps of fossilization include an organism dying and becoming buried and preserved by some means. There are many means of preserving organism remains, and teachers will need to decide what is appropriate regarding level of detail in these concepts. Some ideas that might be included are carbonization, permineralization, mineral replacement, and the creation of casts and molds.

Lastly, a discussion of ore deposits and miner cluded, wh because th other choic models in phases. The class can discuss the process of the deposition of gold into a layer, along various faults and fractures, or binding within stratigraphic units. Nuggets can be incorporated into a sedimentary layer through the movement of water, such as a stream, and deposition. Additional concepts, which would logically follow, are the basic principles of stream sampling and exploration geology.

FIGURE 1: One group's geologic model, with four layers of modeling clay, and the tools used to explore on the second lab day

ALL PHOTOS COURTESY OF THE AUTHORS

Pictures help convey exactly what the students accomplished during the lesson(s). Don't forget to get a signed model release (http://www.nsta.org/publications/release.aspx) for any students who can be identified in your photos.

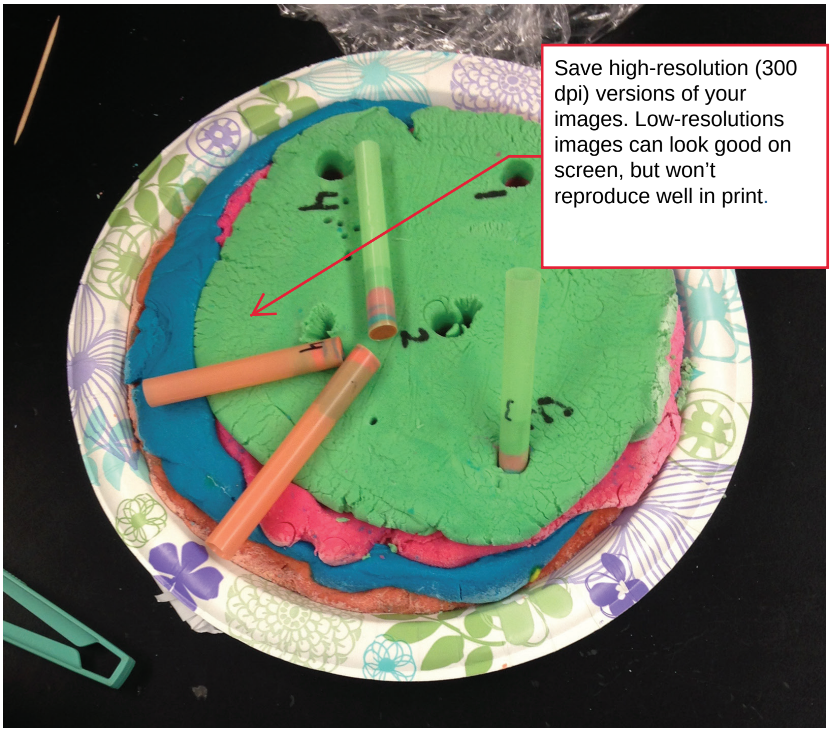
Extend and Elaborate

During the Extend phase, students assume the role of an Exploration Geologist. Student groups exchange their geologic models with another group but withhold their written geologic history of the model, which will be used as an answer key for determining whether the other group can unravel the history of the first group's model. After exchanging models, the groups use straws to "drill" core samples to collect and analyze (Figure 2). We instructed our students to drill at least four holes; however, six to eight holes will yield more information and likely better results. Students record their findings on a Drill Core Log. In the core samples, students find ore deposits and fossils in the stratigraphic layers, which provide evidence to support the geologic history of the core samples. After they drill for ore, students uncover the layers of sediment from their classmates' model and explore for the mineral ore. The Geologic Historian writes the list of events in a Geologic History Inte

Classroom management tips are always appreciated.

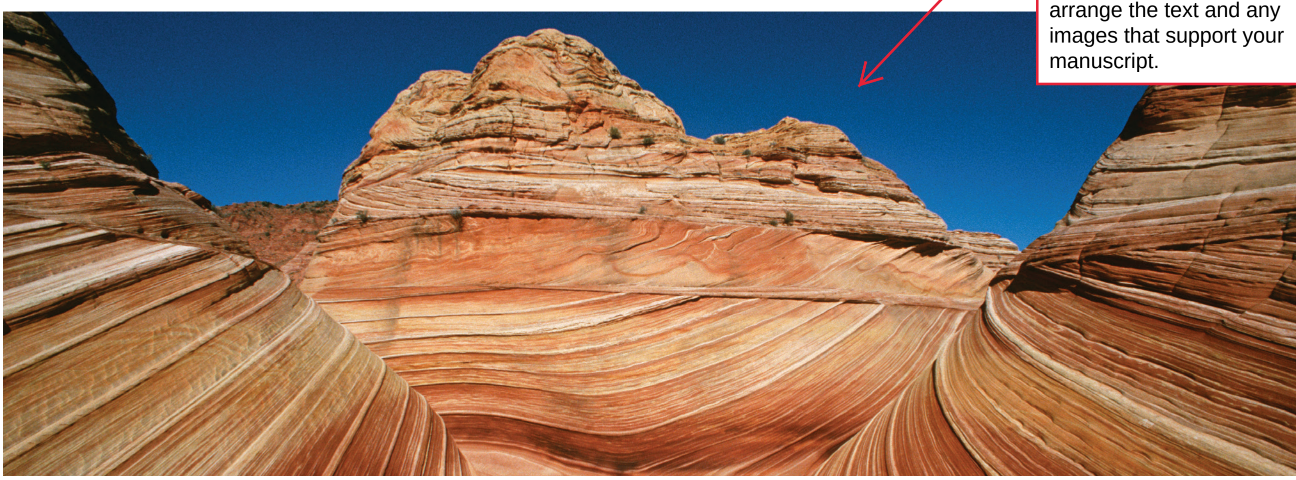
a list of the geologic events, writte occurred, based on the students' interpretation, as the group discusses and "mines" their classmates' model. It is helpful to remind students that the layers they are uncovering at the top are actually the youngest events. To support student learning, we recommend providing students with fill-in sheets for the Drill Core Log and the Geologic History Interpretation (see Online Supplemental Materials). Students are again reminded ~~of safe scissors handling.~~ At the end of the lab portion, students may keep their models themselves, or try to separate and recover as much modeling clay as possible to save and store in resealable bags. Any clay that clearly cannot be reused can be kept by students or discarded. All other scraps and ta cleaned up before students are

FIGURE 2: Straw drill cores, with samples inside



Save high-resolution (300 dpi) versions of your images. Low-resolutions images can look good on screen, but won't reproduce well in print.

The NSTA design team will select appropriate art work for your manuscript and will arrange the text and any images that support your manuscript.



The homemade clay we used had more moisture, which in many cases caused the fossils and sprinkles to dissolve. We could have used more rigid material for our fossils and ore, such as plastic toy fossils and beads for ore. The clay recipe used was a no-cook recipe, of which there are many versions on the internet.

Evaluate

We used a grading rubric for the lab implemented in an eighth-grade classroom, for a total of 50 points (see Online Supplemental Materials). The lab sheets, including the Drill Core Log and the Geologic History Interpretation, were collected as part of the formal assessment as well.

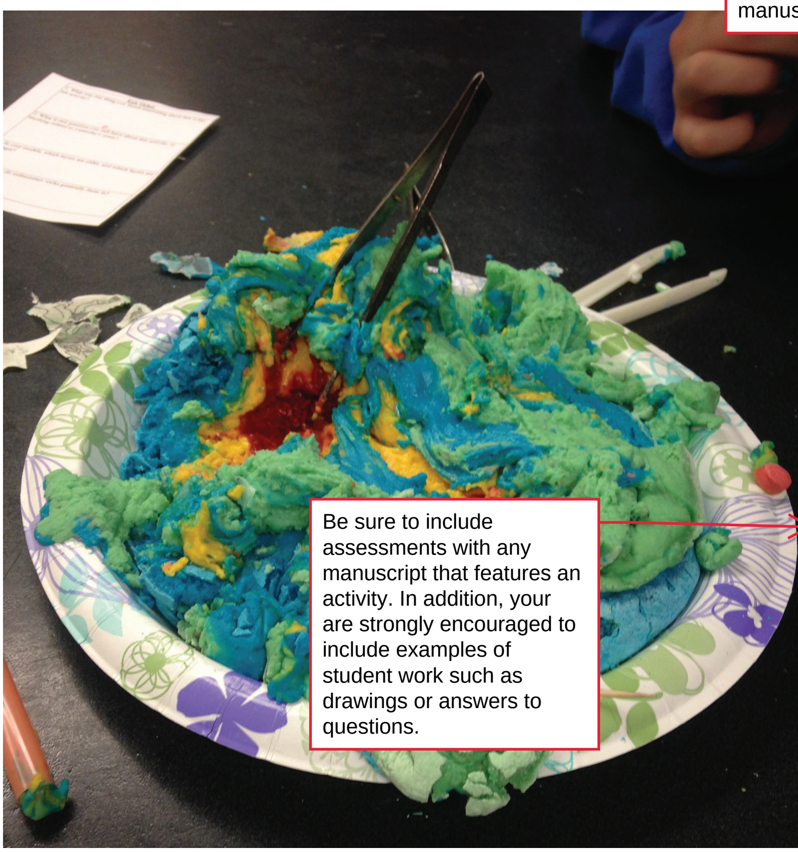
Lab implementation reflection

During our implementation of the lab, we made clay, as opposed to purchasing it. The homemade clay we used had more moisture, which in many cases caused the fossils and sprinkles to dissolve. We could have used more rigid material for our fossils and ore, such as plastic toy fossils and beads for ore. The clay recipe used was a no-cook recipe, of which there are many versions on the internet. We figured this would be a more economical approach, rather than buying clay. We made the clay as a class, and due to time constraints, we were rushed, and in some groups' cases, the recipe was not followed exactly. In the future, it may be more practical to buy premade modeling clay to e

Although it is not necessary to have a specific section of your manuscript set aside for reflection, it is important to provide as many tips as possible. These insights assist teachers who are replicating your activity in their classroom. Your comments also help indicate that the activity was one that was piloted in the classroom, which is an important consideration when decisions are made regarding manuscripts.

W ll six to eigh nly four results. le clay, on over ally led to students picking at the models with the tweezers, and in some cases, obliterating the models until ore and fossils were discovered (Figure 3). We encouraged groups with obliterated models to look at other intact models around the room so that they were still able to see the fossils and ore that were discovered. Students who did not find fossils or ore could still deconstruct their model to determine the geologic history and record their interpretations in their logs.

FIGURE 3: The gooey red ore, which students found using tweezers



Be sure to include assessments with any manuscript that features an activity. In addition, your are strongly encouraged to include examples of student work such as drawings or answers to questions.

Assessment

After finishing the activity, students complete an exit ticket, which includes these questions:

1. What was one thing you found most interesting about this lab activity?

2. What is one question you still have

about this activity or anything related to yesterday's notes?

3. In your models, which layers are older, and which layers are younger?
4. In what geometric shape do sedimentary rocks generally form?

S… misconception that … r or cylindrical beca… which was built on a… ause of the core sam… e tube-shaped. Therefore, we discussed the purpose, benefits, and drawbacks of scientific models.

Follow the reference style you see in any issue of *Science Scope*. List only the references you have cited in the text body. [If you include links to online resources, list them separately in a section labeled "Resources."]

Conclusion

A conclusion is a good way to end the manuscript. You can briefly summarize student learning here.

Our stratigraphy and … suc-cessful in introducing … a fun and hands-on manner. Students achieved the learning goals and explained that stratigraphic layers are older toward the bottom and younger toward the top by applying this concept to their models and using this concept when "mining" and completing their geologic history. Students can also more easily conceptualize the laws of Horizontality and Continuity through building their models with their groups and exploring how the layers are created. ●

REFERENCES

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*.

Totten, I. 2005. Using an artificial rock outcropping to teach geology. *Science Scope* 29(3): 30–33.

RESOURCE

Fossil coloring pages—*www.fossils-fa… coloring_pages.html*

Teachers appreciate printer-friendly resources! Please include any materials you have created that will assist teachers in replicating the activity described in your manuscript.

ONLINE SUPPLEMENTAL MAT…

Download instructions, student worksh… rubric at *www.nsta.org/scope1610*.

Laura Ellis (*lellis@washoeschools.net*) is an eighth-grade science teacher at Dilworth STEM Academy in Sparks, Nevada. **Ellie Busse** is a graduate student teacher in the Department of Education at the University of Nevada, Reno, in Reno, Nevada. **Melissa Jurkiewicz** (*jurkiewiczma@mercer.edu*) is an associate professor of science and STEM education at Mercer University in Macon, Georgia. **Nicole Linney** is an eighth-grade science teacher at Edward L. Pine Middle School in Reno, Nevada.

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectations listed below.

The connections box outlines how the activities the students perform are linked to the NGSS standards. If your state hasn't yet adopted the *NGSS*, please visit www.nextgenscience.org to familiarize yourself with the document and see how your manuscript aligns with the Science and Engineering Practices, Disciplinary Core Ideas, and Cross Cutting Concepts.

Standard

MS-ESS2: Earth's Systems
www.nextgenscience.org/dci-arrangement/ms-ess2-earths-systems

MS-ESS3: Earth and Human Activity
www.nextgenscience.org/dci-arrangement/ms-ess3-earth-and-human-activity

Performance Expectation

MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practice	
Constructing Explanations	Students construct explanations of the geologic history while deconstructing their model.
Disciplinary Core Idea	
MS-ESS3-1: Natural Resources • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes	Students build models that incorporate distributions of fossils and mineral ore and then "mine" for the fossils and ore, demonstrating an approach and understanding for the concept of natural resource distribution within the Earth's crust.
Crosscutting Concept	
Cause and Effect	Students apply their knowle[...] the relative ages of rock layers o[...]

While not all activities may feature Connections to the Common Core State Standards, it is a good idea to include them when appropropriate.

Connections to the *Common Core State Standards* (NGAC and CCSSO 2010)

ELA

SL.8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

RST.6-8.1 Science: Cite specific textual evidence to support analysis of science and technical texts.