Unit Summary
What do the shapes of landforms and rock formations tell us about the past?
In this unit of study, students develop understandings of the effects of weathering and the rate of erosion by water, ice, wind, or vegetation. The crosscutting concepts of patterns and cause and effect are called out as organizing concepts. Students demonstrate grade-appropriate proficiency in planning and carrying out investigations and constructing explanations. Students are also expected to use these practices to demonstrate understanding of the core ideas.
This unit is based on 4-ESS2-1 and 4-ESS1-1.
Student Learning Objectives
Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. *[Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.]* [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.*]* **(4-ESS2-1)**
Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. [Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, 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.] [*Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.*] **(4-ESS1-1)**

Quick Links

Unit Sequence	
Part A: *How can evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation be observed or measured?*	
Concepts	**Formative Assessments**
• Cause-and-effect relationships are routinely identified, tested, and used to explain change. • Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. • Rainfall helps to shape the land and affects the types of living things found in a region. • Living things affect the physical characteristics of their regions.	*Students who understand the concepts can:* • Identify, test, and use cause-and-effect relationships in order to explain change. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. • Make observations and/or measurements to produce evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. *(Note: Assessment is limited to a single form of weathering or erosion.)* Examples of variables to test could include: ✓ Angle of slope in the downhill movement of water ✓ Amount of vegetation ✓ Speed of the wind ✓ Relative rate of deposition ✓ Cycles of freezing and thawing of water ✓ Cycles of heating and cooling ✓ Volume of water flow

Unit Sequence	
Part B: *What can rock formations tell us about the past?*	
Concepts	**Formative Assessments**
• Science assumes consistent patterns in natural systems. • Patterns can be used as evidence to support an explanation. • Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. • The presence and location of certain fossil types indicate the order in which rock layers were formed.	*Students who understand the concepts can:* • Support explanations using patterns as evidence. • Identify the evidence that supports particular points in an explanation. • Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. *(Note: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.)* Examples of evidence from patterns could include ✓ Rock layers with marine shell fossils above rock layers with 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.

What It Looks Like in the Classroom
In this unit of study, students are expected to develop understanding of the effects of weathering and the rate of erosion by water, ice, wind, or vegetation. As students plan and carry out investigations using models and observe the effects of earth processes in the natural environment, they learn to identify patterns of change; recognize cause-and-effect relationships among the forces that cause change in rocks, soil, and landforms; and construct explanations of changes that occur over time to earth materials. In the first portion of the unit, fourth graders develop an understanding of cause-and-effect relationships when studying physical weathering and the rate of erosion by water, wind, ice, or vegetation. Students learn that rainfall helps to shape the land and affects the types of living things found in a region, and that living things affect the physical characteristics of a region. Students should make observations of their local environment to observe the types of living things that are common in the region, and they should look for evidence that water, ice, wind, organisms, and gravity have broken down rocks, soils, and sediments into smaller pieces and have moved them from one place to another. In the classroom, students should build and use models that demonstrate how wind, water, and ice cause change to the surface of the earth. Students should use stream tables, soil, sand, and water to simulate the effects of moving water (rain, rivers) on rocks and soil. Following these types of experiences, students need opportunities to ask questions that will lead to further investigations. They can change a variable—such as the type of earth material (sand, soil, clay, silt), the angle of a hill's slope, the volume of water flow, the speed of water flow, and the relative rate of deposition—then collect and analyze data in order to determine the effects.

In addition to using models to understand the effects of water and ice on land, students should build and use models to simulate the effects of wind on earth materials. There are a variety of models that can be easily built. Students should have opportunities to change variables, such as the speed or volume of airflow. From these experiences, students should begin to understand that wind, water, and ice cause changes to the earth's surface, and that the stronger or faster the flow of wind or water, the greater the change it causes.

In this unit, students also need opportunities to observe ways in which plants affect the weathering and erosion of earth materials. Plants can have a variety of effects on rocks, soils, and landforms. Plants often slow or stop the effects of moving wind and water on land. Students can observe this phenomenon using models. As they make observations, students can change variables, such as the amount or type of plant used to slow or stop erosion, and they can collect and analyze data to determine cause-and-effect relationships between the amount of change and the plants used to prevent it. Then students can walk around the schoolyard and nearby neighborhoods to look for examples of plants that are used to prevent erosion.

In addition to slowing or preventing erosion, plants can cause weathering of rocks. Students can easily find examples in their own environment of growing plant and tree roots causing rocks, sidewalks, and driveways to crack and break down into smaller and smaller components. This phenomenon can also be simulated with models in the classroom. Students can soak lima beans in water overnight, then "plant" them in small cups containing a 2–3 cm. layer of wet Plaster of Paris on top of potting soil. (One or two seeds should be placed in the wet layer of plaster.) After a few days, the seeds will germinate and grow, eventually causing the dried plaster to crack. Again, students need opportunities to change variables, such as the number of seeds planted (one seed vs. multiple seeds, for example) and the type of seeds, then make observations and collect data to determine the amount of weathering each change causes to the dried plaster.

In the second portion of this unit, students learn that patterns can be used as evidence to explain changes to the earth's landforms and rock formations, and that local, regional, and global patterns of rock formations reveal changes over time due to earth forces. If possible, students should make observations of local landforms; however, pictures from books and online sources can give students the opportunity to identify evidence of change from patterns in rock formations and fossils in rock layers. Students can support explanations for changes in a landscape over time in multiple ways, including the following:

- ✓ Pictures of a variety of landforms, such as sand dunes and canyons, can be used to show change due to weathering and erosion that have occurred over time.
- ✓ Pictures or diagrams of rock layers with marine shell fossils above rock layers with plant fossils and no shells can be used to indicate a change from land to water over long periods of time.
- ✓ Pictures of a canyon with different rock layers in the walls and a river at the bottom can be used to show that over time a river cut through the rock to form the canyon.

As students collect evidence, either from firsthand observations or from media resources, they should attempt to explain the changes that have occurred over time in each of the landscapes observed.

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy *To support integration of the language arts standards in this unit, students can read content-specific texts to deepen their understanding of the cause-and-effect relationships within earth systems. As they read, students should take notes, which can be used to help them understand and explain how earth processes affect the world around them. They should ask questions, such as,* ✓ *What types of soil erode faster?* ✓ *Why do some rocks weather more easily or more quickly than others?* ✓ *What patterns of change can be observed using models?* *As they attempt to answer these questions, students can cite evidence from observations and from texts to support their thinking. In addition, students can conduct short research projects that will help them gather additional evidence to support explanations. Throughout this unit, students should collect and record data in science journals and analyze the data to identify patterns of change.* *Mathematics* To support integration of the Mathematics standards into this unit, students are expected to use mathematics when analyzing quantitative data to identify patterns, explain cause-and-effect relationships, and make predictions. Students need opportunities to measure earth materials using tools, such as balances and graduated cylinders, and to measure distances and heights using rulers or tape measures. Students should also be required to solve problems involving measurement and data.

Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena.

- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Research on Student Learning

Students of all ages may hold the view that the world was always as it is now, or that any changes that have occurred must have been sudden and comprehensive. The students in these studies did not, however, have any formal instruction on the topics investigated. Moreover, middle-school students taught by traditional means are not able to construct coherent explanations about the causes of volcanoes and earthquakes (NSDL, 2015).

Prior Learning

Grade 2 Unit 4: The Earth's Land and Water

- Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.
- Maps show where things are located. One can map the shapes and kinds of land and water in any area.

Grade 2 Unit 5: Changes to Earth's Land

- Wind and water can change the shape of the land.

Future Learning

Grade 5 Unit 4: Water on Earth

- Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.

Grade 5 Unit 5: Earth Systems

- Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.

Connections to Other Units

N/A

Sample of Open Education Resources
Glaciers, Water, and Wind, Oh My! This hands-on activity allows students to explore five earth forces that may cause erosion as they model, observe, and record the effects of erosion on earth surfaces. Stations include demonstrations of chemical, wind, water, ice and heat forces as they affect weathering.
Bill Nye Video-Erosion: Bill Nye, "The Science Guy", presents a video describing the effects of weathering (wind, water, ice) on landforms. Bryce Canyon is used as an example of the ways in which freezing water, plant roots, and wind weather the earth's surface creating the means for erosion. Students in video simulate effects of weathering which can be duplicated in a classroom setting. Nye also emphasizes the passage of time in millions of years as he explains the slower erosive effects of certain types of weathering.
Gary's Sand Journal: This book allows students to observe illustrations of magnified sand particles with guided dialogue from an earth scientist who discusses sand origins. This book can be used to introduce students to types of sand, explain how earth processes were responsible for their creation, and discuss the work of earth scientists. After reading this book, students may use it as a resource when examining their own sand samples. They could list properties, discuss sand origins, and illustrate samples in a science journal.
Explaining Glaciers, Accurately: Fourth grade lessons on glacial erosion demonstrate and explain the manner in which glaciers erode the earth. The mechanisms of plucking and abrasion are discussed. Activities (either whole-class or small group) include a teacher creation of a glacier model (using dirt and rocks to simulate a mountain, ice cubes and a small amount of water for glacier), then teacher demonstration of glacier "plucking" earth as it travels in a simulation activity. Students then experiment with rock samples, wood, sandpaper, and ice as they rub materials against each other to explore how glacial striations form and abrade other surfaces. In each simulation, students are asked to predict what would happen when glacial model water freezes, as they draw before and after pictures of the model. Students are also asked to predict how glacial striations were formed as they view photos, then record results of their abrasive materials activity. Students could benefit from the expertise of a mentoring geologist who shares illustrations and information with students and teachers.
Coastal Erosion: This engineering design lesson focuses on the effects of erosion on Florida's coastline. It is one lesson offered within a larger weathering and erosion unit. Students groups work to create and use a model able to slow erosion, without damaging the coastal ecosystem. Students are responsible for developing scale diagram of their coastline erosion solution before building and testing their models in a pan to simulate the coastline. Students then complete a redesign cycle. Similar lessons from the developer can be used in conjunction with this lesson to incorporate the effects of erosion on humans and wildlife.

Teacher Professional Learning Resources

Teaching NGSS in Elementary School-Fourth Grade

The web seminar began with an introduction to NGSS, its framework for K-12 science education, and its cross-cutting concepts and core ideas by NSTA's Ted Willard. Mary Starr, Executive Director of Michigan Mathematics and Science Centers Network and Kathy Renfrew, K-5 Science Coordinator for VT Agency, began with a look into disciplinary core ideas, using the example of energy, and how they apply to the fourth grade in terms of performance expectations and an approach to science and engineering practices. Kathy also brought a special guest with her, Tracy Lavallee, a teacher from Vermont featured in the web seminar's videos. Using two videos taken from Tracy's fourth grade classroom, lesson plan ideas and approaches were discussed and teachers were able to share their thoughts and approaches on the classroom activities. A number of NSTA Learning Center tools and resources were shared as well a number of website links for further investigation. The session concluded with some final words from Ted and a Q/A.

Visit the resource collection.

Continue discussing this topic in the community forums.

NSTA Web Seminar: Teaching NGSS in K-5: Constructing Explanations from Evidence

Carla Zembal-Saul, Mary Starr, and Kathy Renfrew, provided an overview of the *NGSS* for K-5th grade. The web seminar focused on the three dimensional learning of the *NGSS*, while introducing CLAIMS-EVIDENCE-REASONING (CER) as a framework for introducing explanations from evidence. The presenters highlighted and discussed the importance of engaging learners with phenomena, and included a demonstration on using a KLEWS chart to map the development of scientific explanations of those phenomena.

To view related resources, visit the resource collection.

Continue discussing this topic in the community forums.

NGSS *Core* Ideas: Earth's Place in the Universe

The presenter was Julia Plummer from Penn State University. The program featured strategies for teaching about Earth science concepts that answer questions such as "What goes on in stars?" and "What patterns are caused by Earth's movements in the solar system?"

Dr. Plummer began the presentation by discussing what students should know about the disciplinary core idea of Earth's Place in the Universe. She talked about using the scientific and engineering practices to help engage students. Participants shared their ideas about applying this core idea to the classroom, and then Dr. Plummer shared strategies for effective instruction. She also discussed the importance of spatial thinking for students to begin thinking scientifically about these concepts.

Continue the discussion in the community forums.

Appendix A: NGSS and Foundations for the Unit
Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. *[Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.]* [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.*]* **(4-ESS2-1)**
Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. [Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, 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.] [*Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.*] **(4-ESS1-1)**
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1) **Constructing Explanations and Designing Solutions** • Identify the evidence that supports particular points in an explanation. (4-ESS1-1)	**ESS2.A: Earth Materials and Systems** • Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1) **ESS2.E: Biogeology** • Living things affect the physical characteristics of their regions. (4-ESS2-1) **ESS1.C: The History of Planet Earth** • Local, regional, and global patterns of rock formations reveal changes over time due to 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)	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1) **Patterns** • Patterns can be used as evidence to support an explanation. (4-ESS1-1) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems. (4-ESS1-1)

English Language Arts	Mathematics
Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-ESS1-1) **W.4.7** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-ESS2-1)**,**(4-ESS1-1)**W.4.8** Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-ESS1-1) **W.4.9**	Reason abstractly and quantitatively. (4-ESS2-1), (4-ESS1-1) **MP.2** Model with mathematics. (4-ESS2-1), (4-ESS1-1) **MP.4** Use appropriate tools strategically. (4-ESS2-1) **MP.5** Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. (4-ESS2-1), (4-ESS1-1) **4.MD.A.1** Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. (4-ESS2-1) **4.MD.A.2**