The Changing Earth

STEM Road Map for Middle School

Grade 8

Edited by Carla C. Johnson, Janet B. Walton, and Erin Peters-Burton

nsta Press
National Science Teaching Association

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nsta Press
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Arlington, Virginia

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23 22 21 20 4 3 2 1

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Library of Congress Cataloging-in-Publication Data
Names: Johnson, Carla C., 1969- editor. | Walton, Janet B., 1968- editor. | Peters-Burton, Erin E., editor.
Title: The changing earth, grade 8 : STEM road map for middle school / edited by Carla C. Johnson, Janet B. Walton, and Erin Peters-Burton.
Description: Arlington, VA : National Science Teaching Association, [2020] | Includes bibliographical references and index.
Identifiers: LCCN 2019051383 (print) | LCCN 2019051384 (ebook) | ISBN 9781681404684 (paperback) | ISBN 9781681404691 (pdf)
Subjects: LCSH: Geodynamics--Study and teaching (Middle school)
Classification: LCC QE505.5 .C43 2020 (print) | LCC QE505.5 (ebook) | DDC 551.1071/2--dc23
LC record available at *https://lccn.loc.gov/2019051383*
LC ebook record available at *https://lccn.loc.gov/2019051384*

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ACKNOWLEDGMENTS

This module was developed as a part of the STEM Road Map project (Carla C. Johnson, principal investigator). The Purdue University College of Education, General Motors, and other sources provided funding for this project.

See *www.routledge.com/products/9781138804234* for more information about *STEM Road Map: A Framework for Integrated STEM Education*.

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THE CHANGING EARTH MODULE OVERVIEW

Stephen Burton, Michael Wagner, Carla C. Johnson, Janet B. Walton, and Erin Peters-Burton

THEME: Cause and Effect

LEAD DISCIPLINE: Science

MODULE SUMMARY

The idea that Earth is shaped by dynamic and ongoing geologic processes is a powerful one for a scientifically literate society to understand. This module focuses on helping students understand more about this idea: Knowing that flooding, earthquakes, and volcanoes can alter the landscape in a short amount of time will help students recognize the inherent risks of living in specific locations around the globe. Understanding the impact that the geology of an area plays on the establishment of a community will help students better appreciate the challenges communities face and the diversity in culture that arises as a result of the geology. And recognizing that some short-term events (e.g., earthquakes and volcanoes) have underlying causes that are modifying Earth on a much longer time scale is critical for students to better understand our place on this planet.

From a geologic perspective, this module also offers an opportunity for students to more fully appreciate the nature and process of science. Students often have a naïve view that the only way to know what happened in the past is to look at human recorded history. This module is intended to address this misconception and help students develop the understanding that the rock record is a valid account of history. Through this unit, they will gain a better understanding of how scientific knowledge changes as new ideas, technology, and evidence emerge. Students also will recognize that geologists can examine current processes and use that knowledge to retrodict about Earth's past (to *retrodict* is to make conclusions about the past based on the condition of the Earth in the present). Furthermore, students will gain a deeper understanding of the role of evidence, conjecture, and modeling in developing scientific knowledge.

In this module, students have the opportunity to explore the historical scientific debates regarding the geologic history of the Earth. These complex scientific debates are simplified here so that students can understand the basic principles of how science progresses without requiring the extensive background knowledge necessary to appreciate the full complexity of the original arguments. Students also have the opportunity to appreciate that scientists, by being skeptical, add to the scientific knowledge already determined by others.

As an assessment in the module, students develop a museum display to explore the geology of an assigned area in the Northern Hemisphere (primarily in North America but also including Great Britain). Within the museum displays, students present a poster that focuses on the geology of their assigned areas. This poster will include models of rock formation for the three types of rocks students studied during the module, a set of images showing the types of rocks found within their assigned areas, and timelines showing the major rock-forming events that occurred within their study areas. Along with this poster, students present two scale models of their study areas—one model that shows the major topographic features and the major groups of rocks found in the bedrock and a second that shows the major topographic features and the ages of the different regions. Finally, students create a second poster that focuses on the impact of geology on culture and communities within their study areas. This poster will also describe the importance that geology and the resulting topography has played in the location of major cities and towns in the region (adapted from Johnson et al. 2015).

ESTABLISHED GOALS AND OBJECTIVES

At the conclusion of this module, students will be able to do the following:

- Understand that Earth is a dynamic system, shaped by many geological processes that are driven by energy from the Sun and internally from Earth
- Understand that scientific knowledge is built on empirical evidence
- Explain the actions of the rock cycle that form and break down the different types of rocks
- Explain how the Sun's energy and heat from Earth's core drive the rock cycle
- Build a model that include a textual explanation as well as visual representations of processes, based on evidence, to explain the evidence suggesting that Earth's surface has changed in the past and will continue to change in the future
- Evaluate claims based on the evidence provided
- Use mathematical content and skills to collect and analyze data to support or refute a claim
- Use appropriate graphical or tabular representations to summarize data

CHALLENGE OR PROBLEM FOR STUDENTS TO SOLVE: GEOLOGY AND THE COMMUNITY CHALLENGE

Students are challenged to work in teams to create a museum display that relates multiple geologic ideas about an area. Each group's display should include a poster that describes a model of the rock cycle the students will develop over the course of the module and a timeline of geologic events that occurred within the region. In addition, they will provide a narrative explaining how geologists use different rock types and knowledge of the rock cycle to determine the geologic past of an area. The museum display should also include a second poster that describes the geologic threats from volcanoes and earthquakes that a particular region might face and a narrative that describes how communities can prepare for and diminish the potential impacts if such a disaster occurs. Finally, the display should include a physical model of the topography of the assigned region. Students first share their displays with each other and other members of their school community (plan on having a space such as a hallway with tables, an auditorium, or gym for the displays) and then have the opportunity to share these displays with local elementary schools. The displays are intended to not to be manned, so students should build them in a way that communicates information effectively.

Driving Question: Using only a display, how can we communicate vital information about the geology of an area and how that affects the building of a community?

CONTENT STANDARDS ADDRESSED IN THIS STEM ROAD MAP MODULE

A full listing with descriptions of the standards this module addresses can be found in the appendix. Listings of the particular standards addressed within lessons are provided in a table for each lesson in Chapter 4.

STEM RESEARCH NOTEBOOK

Each student should maintain a STEM Research Notebook, which will serve as a place for students to organize their work throughout the module (see p. 12 for more general discussion on setup and use of this notebook). All written work in the module should be included in the notebook, including records of students' thoughts and ideas, fictional accounts based on the concepts in the module, and records of student progress through the engineering design process that is used in this module. The notebooks may be maintained across subject areas, giving students the opportunity to see that although their classes may be separated during the school day, the knowledge they gain is connected.

Lessons in this module include student handouts that should be kept in the STEM Research Notebooks after completion, as well as prompts to which students should respond in their notebooks. You may also wish to have students include the STEM Research Notebook Guidelines student handout in their notebooks.

Emphasize to students the importance of organizing all information in a Research Notebook. Explain to them that scientists and other researchers maintain detailed Research Notebooks in their work. These notebooks, which are crucial to researchers' work because they contain critical information and track the researchers' progress, are often considered legal documents for scientists who are pursuing patents or who wish to provide proof of their discovery process.

STUDENT HANDOUT

STEM RESEARCH NOTEBOOK GUIDELINES

STEM professionals record their ideas, inventions, experiments, questions, observations, and other work details in notebooks so that they can use these notebooks to help them think about their projects and the problems they are trying to solve. You will each keep a STEM Research Notebook during this module that is like the notebooks that STEM professionals use. In this notebook, you will include all your work and notes about ideas you have. The notebook will help you connect your daily work with the big problem or challenge you are working to solve.

It is important that you organize your notebook entries under the following headings:

1. **Chapter Topic or Title of Problem or Challenge:** You will start a new chapter in your STEM Research Notebook for each new module. This heading is the topic or title of the big problem or challenge that your team is working to solve in this module.
2. **Date and Topic of Lesson Activity for the Day:** Each day, you will begin your daily entry by writing the date and the day's lesson topic at the top of a new page. Write the page number both on the page and in the table of contents.
3. **Information Gathered From Research:** This is information you find from outside resources such as websites or books.
4. **Information Gained From Class or Discussions With Team Members:** This information includes any notes you take in class and notes about things your team discusses. You can include drawings of your ideas here, too.
5. **New Data Collected From Investigations:** This includes data gathered from experiments, investigations, and activities in class.
6. **Documents:** These are handouts and other resources you may receive in class that will help you solve your big problem or challenge. Paste or staple these documents in your STEM Research Notebook for safekeeping and easy access later.
7. **Personal Reflections:** Here, you record your own thoughts and ideas on what you are learning.
8. **Lesson Prompts:** These are questions or statements that your teacher assigns you within each lesson to help you solve your big problem or challenge. You will respond to the prompts in your notebook.
9. **Other Items:** This section includes any other items your teacher gives you or other ideas or questions you may have.

MODULE LAUNCH

Begin the module by showing students images from various geologically interesting locations. Then, present students with the following discussion prompt: "If you have ever paid attention to the landscape as you were riding in a car, you may have noticed lots of different and interesting rock formations. Geologists looking at that same landscape are often perplexed with the following questions: What kind of rocks are they? How did they get there?" Finally, introduce to students the following dilemma: How we can figure out what has happened to Earth in the past when there was no human-recorded history?

Introduce the module challenge by informing the students that they will be helping a local museum produce an exhibit that helps elementary school students explore the geologic past of the local region, North America, and the world. Explain that they will be learning a variety of concepts to help them create the museum exhibit. In science, students learn how to look at Earth like a geologist and describe Earth's history using a theoretical model that explains how changes could have occurred. In social studies, students explore how to represent information through maps, with an emphasis on topographic maps, and consider how geologic features might determine the historical location of community settlements. They also explore the impact that geology has on communities, including examining how communities prepare and respond to earthquakes, floods, and volcanoes. In mathematics, students explore mathematical concepts that are useful in summarizing, analyzing, and communicating data. Finally, in English language arts (ELA), students examine ways to identify and evaluate the sources they will use as resources to create their exhibit. They will also learn to evaluate and communicate a scientific argument.

Each museum display will focus on a particular location. Assign groups of students one of the following areas

- Study Area 1: Great Britain
- Study Area 2: Virginia
- Study Area 3: Wyoming
- Study Area 4: Washington state
- Study Area 5: Western British Columbia
- Study Area 6: Eastern British Columbia

PREREQUISITE SKILLS FOR THE MODULE

Students enter this module with a wide range of preexisting skills, information, and knowledge. Table 3.1 provides an overview of prerequisite skills and knowledge that students are expected to apply in this module, along with examples of how they apply this knowledge throughout the module. Differentiation strategies are also provided for students who may need additional support in acquiring or applying this knowledge.

Table 3.1. Prerequisite Key Knowledge and Examples of Applications and Differentiation Strategies

Prerequisite Key Knowledge	Application of Knowledge by Students	Differentiation for Students Needing Additional Support
Science • Analyze and interpret data from maps to describe patterns of Earth's features.	*Science* • Understand that topography is a result of weathering and tectonic activity and recognize that topographical differences provide clues to past geologic events.	*Science* • Model interpreting topography using aerial photos and topographic maps and provide exercises where students do the same.
Mathematics • Understand basic graph types.	*Mathematics* • Communicate and interpret rate flow by creating graphs.	*Mathematics* • Have one-on-one discussions with students as they are exploring the communication of rate data.
English Language Arts • Know the basic mechanics of grammar, syntax, and punctuation. • Understand organization and flow of narrative.	*English Language Arts* • Create several narratives and arguments using appropriate grammar, syntax, punctuation, and organization.	*English Language Arts* • Provide worksheets and resources for students to work on grammar, syntax, punctuation, and organization as homework.
Social Studies • Understand directionality (north, south, east, west)	*Social Studies* • Apply the concept of orientation in relation to the north in learning about maps and provide an orientation of their assigned locations.	*Social Studies* • Review directions of north, south, east, and west during Lesson 1. Spend one-on-one time with students to help them understand that directions are in relation to orientation on the globe and the poles.

POTENTIAL STEM MISCONCEPTIONS

Students enter the classroom with a wide variety of prior knowledge and ideas, so it is important to be alert to misconceptions, or inappropriate understandings of foundational knowledge. These misconceptions can be classified as one of several types: "preconceived notions," opinions based on popular beliefs or understandings; "nonscientific beliefs," knowledge students have gained about science from sources outside the scientific community; "conceptual misunderstandings," incorrect conceptual models based on incomplete understanding of concepts; "vernacular misconceptions," misunderstandings of words based on their common use versus their scientific use; and "factual misconceptions," incorrect or imprecise knowledge learned in early life that remains unchallenged (NRC 1997, p. 28). Misconceptions must be addressed and dismantled in order for students to reconstruct their knowledge, and therefore teachers should be prepared to take the following steps:

- *Identify students' misconceptions.*
- *Provide a forum for students to confront their misconceptions.*
- *Help students reconstruct and internalize their knowledge, based on scientific models. (NRC 1997, p. 29)*

Keeley and Harrington (2010) recommend using diagnostic tools such as probes and formative assessment to identify and confront student misconceptions and begin the process of reconstructing student knowledge. Keeley's *Uncovering Student Ideas in Science* series contains probes targeted toward uncovering student misconceptions in a variety of areas and may be useful resources for addressing student misconceptions in this module.

Students will have various types of prior knowledge about the science concepts presented and used in this module. Table 3.2 outlines some common misconceptions students may have concerning these concepts. Because of the breadth of students' experiences, it is not possible to anticipate every misconception that students may bring as they approach the lessons. Incorrect or inaccurate prior understanding of concepts can influence student learning in the future, however, so it is important to be alert to misconceptions such as those presented in the table. The American Association for the Advancement of Science has also identified misconceptions that students frequently hold regarding science concepts (see the links at *http://assessment.aaas.org/topics*).

Table 3.2. Common Misconceptions About the Concepts in This Module

Topic	Student Misconception	Explanation
Engineering design process (EDP)	Engineers use only a scientific process to solve problems in their work.	A scientific process is used to test predictions and explanations about the world. An EDP, on the other hand, is used to create a solution to a problem. In reality, engineers use both kinds of processes.
Sedimentary rocks (rocks formed by cementing together materials from the Earth)	Layered rocks are always sedimentary.	Many metamorphic rocks are layered, and even a few igneous rocks can have layers.
Rock cycle (the processes by which rocks change among the three types: igneous, metamorphic, and sedimentary)	One type of rock can only change to another type.	All three rock types can change into another.
	Metamorphic rocks are a "little melted."	If there is melting, then the process is igneous.
	Metamorphic rocks require both heat and pressure.	There are cases of metamorphism that are just heat or predominantly pressure.

SRL PROCESS COMPONENTS

Table 3.3 (p. 32) illustrates some of the activities in The Changing Earth module and how they align with the self-regulated learning (SRL) process before, during, and after learning.

Table 3.3. SRL Process Components

Learning Process Components	Example From The Changing Earth Module	Lesson Number and Learning Component
BEFORE LEARNING		
Motivates students	Students engage with a flyover video of the Grand Canyon and are then challenged to think about how much they pay attention to the geology around their own community.	Lesson 1, Introductory Activity/ Engagement
Evokes prior learning	Students participate in a discussion, "What do you know about rocks?" Students also have an opportunity to describe any experiences they have had with maps.	Lesson 1, Introductory Activity/Engagement
DURING LEARNING		
Focuses on important features	Students discuss their findings from the rock cycle activities. This discussion should focus on the key knowledge: • Sedimentary rocks form from the compaction and cementation process. • Cementation process is a result of minerals forming in the spaces between grains that "glue" the particles together. • The type of minerals that form can influence the strength of the "glue." • Sedimentary rocks form in layers as materials are deposited.	Lesson 1, Explanation
Helps students monitor their progress	Students create a conceptual model for how sedimentary rocks form. Students are encouraged to consider if their model provides them a way to think about rocks in the location they were assigned. If it does not, then students revise the conceptual model.	Lesson 1, Explanation
AFTER LEARNING		
Evaluates learning	Students create a museum display that relates multiple geologic ideas about an area, including posters about the relevant rock cycle, timeline of geologic events that occurred in the region, and how communities are affected by geologic events. First students share these products with their classmates and school community, and then they share them with local elementary schools.	Lesson 6, Explanation
Takes account of what worked and what did not work	Students reflect on the feedback they receive when they present to their school community.	Lesson 6, Elaboration, Application of Knowledge

STRATEGIES FOR DIFFERENTIATING INSTRUCTION WITHIN THIS MODULE

For the purposes of this curriculum module, differentiated instruction is conceptualized as a way to tailor instruction—including process, content, and product—to various student needs in your class. A number of differentiation strategies are integrated into lessons across the module. The problem- and project-based learning approach used in the lessons is designed to address students' multiple intelligences by providing a variety of entry points and methods to investigate the key concepts in the module (e.g., when creating a museum display, students are given choices in the ways they can communicate their knowledge). Differentiation strategies for students needing support in prerequisite knowledge can be found in Table 3.1 (p. 29). You are encouraged to use information gained about student prior knowledge during introductory activities and discussions to inform your instructional differentiation. Strategies incorporated into this lesson include flexible grouping, varied environmental learning contexts, assessments, compacting, and tiered assignments and scaffolding.

Flexible Grouping. Students work collaboratively in a variety of activities throughout this module. Grouping strategies you might employ include student-led grouping, grouping students according to ability level or common interests, grouping students randomly, or grouping them so that students in each group have complementary strengths (for instance, one student might be strong in mathematics, another in art, and another in writing).

Varied Environmental Learning Contexts. Students have the opportunity to learn in various contexts throughout the module, including alone, in groups, in quiet reading and research-oriented activities, and in active learning in inquiry and design activities. In addition, students learn in a variety of ways, including through doing inquiry activities, journaling, reading texts, watching videos, participating in class discussion, and conducting web-based research.

Assessments. Students are assessed in a variety of ways throughout the module, including individual and collaborative formative and summative assessments. Students have the opportunity to produce work via written text, oral and media presentations, and modeling. You may choose to provide students with additional choices of media for their products (e.g., slide presentations, posters, or student-created websites or blogs).

Compacting. Based on student prior knowledge, you may wish to adjust instructional activities for students who exhibit prior mastery of a learning objective. For instance, if some students exhibit mastery with maps in Lesson 1, you may wish to limit the amount of time they spend practicing these skills and instead introduce associated activities.

Tiered Assignments and Scaffolding: Based on your awareness of student ability, understanding of concepts, and mastery of skills, you may wish to provide students with variations on activities by adding complexity to assignments or providing more or fewer learning supports for activities throughout the module. For instance, some students may need additional support in identifying key search words and phrases for web-based research or may benefit from cloze sentence handouts to enhance vocabulary understanding. Other students may benefit from expanded reading selections and additional reflective writing or from working with manipulatives and other visual representations of mathematical concepts. You may also work with your school librarian to compile a set of topical resources at a variety of reading levels.

STRATEGIES FOR ENGLISH LANGUAGE LEARNERS

Students who are developing proficiency in English language skills require additional supports to simultaneously learn academic content and the specialized language associated with specific content areas. WIDA (2012) has created a framework for providing support to these students and makes available rubrics and guidance on differentiating instructional materials for English language learners (ELLs). In particular, ELL students may benefit from additional sensory supports such as images, physical modeling, and graphic representations of module content, as well as interactive support through collaborative work. This module incorporates a variety of sensory supports and offers ongoing opportunities for ELL students to work with collaboratively. The focus in this module on understanding the geology of a specific area provides opportunities to access the culturally diverse experiences of ELL students in the classroom.

When differentiating instruction for ELL students, you should carefully consider the needs of these students as they introduce and use academic language in various language domains (listening, speaking, reading, and writing) throughout this module. To adequately differentiate instruction for ELL students, you should have an understanding of the proficiency level of each student. The following five overarching WIDA learning standards are relevant to this module:

- Standard 1: Social and Instructional Language. Focus on social behavior in group work and class discussions.
- Standard 2: The Language of Language Arts. Focus on forms of print, elements of text, picture books, comprehension strategies, main ideas and details, persuasive language, creation of informational text, and editing and revision.
- Standard 3: The Language of Mathematics. Focus on numbers and operations, patterns, number sense, measurement, and strategies for problem solving.
- Standard 4: The Language of Science. Focus on safety practices, scientific process, and scientific inquiry.
- Standard 5: The Language of Social Studies. Focus on change from past to present, historical events, resources, map reading, and location of objects and places.

SAFETY CONSIDERATIONS FOR THE ACTIVITIES IN THIS MODULE

The safety precautions associated with each investigation are based in part on the use of the recommended materials and instructions, legal safety standards, and better professional safety practices. Selection of alternative materials or procedures for these investigations may jeopardize the level of safety and therefore is at the user's own risk. Remember that an investigation includes three parts: (1) setup, in which you prepare the materials for students to use; (2) the actual hands-on investigation, in which students use the materials and equipment; and (3) cleanup, in which you or the students clean the materials and put them away for later use. The safety procedures for each investigation apply to all three parts. For more general safety guidelines, see the Safety in STEM section in Chapter 2 (p. 18).

We also recommend that you use a safety acknowledgment form and that you go over the safety rules that are included as part of the form with your students before beginning the first investigation. Once you have gone over these rules with your students, have them sign the safety acknowledgment form. You should also send the form home with students for parents or guardians to read and sign to acknowledge that they understand the safety procedures that must be followed by their children. A sample middle school safety acknowledgment form can be found at *http://static.nsta.org/pdfs/SafetyAcknowledgmentForm-MiddleSchool.pdf*.

DESIRED OUTCOMES AND MONITORING SUCCESS

The desired outcome for this module is outlined in Table 3.4 (p. 36), along with suggested ways to gather evidence to monitor student success. For more specific details on desired outcomes, see the Established Goals and Objectives section for the module (p. 24) and for the individual lessons.

Table 3.4. Desired Outcome and Evidence of Success in Achieving Identified Outcome

Desired Outcome	Evidence of Success: Performance Tasks	Evidence of Success: Other Measures
Students create museum displays that relate multiple geologic ideas about an area. The displays should include two posters and a physical model of the topography of the assigned region.	• Students are assessed on their ability to use knowledge regarding formation of rocks to describe major geologic events that have shaped their local area, North America, and the world based on their museum displays. *(Science and Engineering Practices: Developing and Using Models, Analyzing and Interpreting Data, Constructing Explanations and Designing Solutions)* • Their understanding of the role the rock cycle and continental drift has played on shaping and reshaping the earth will also be evaluated. *(Crosscutting Concepts: Patterns, Stability and Change)* • Students' understanding of potential geologic threats from volcanoes and earthquakes and the impacts and means to mitigate losses will be assessed as will their ability to interpret maps, with a particular focus on topographic maps. *(Science and Engineering Practice: Developing and Using Models)*	Students are assessed on collaboration, participation in class, individual activity sheets, and development of the materials that will be used in the final museum display.

Note: The "Performance Tasks" column includes related science and engineering practices and crosscutting concepts from the *Next Generation Science Standards*.

ASSESSMENT PLAN OVERVIEW AND MAP

Table 3.5 provides an overview of the major group and individual *products* and *deliverables,* or things that student teams will produce in this module, that constitute the assessment for this module. See Table 3.6 for a full assessment map of formative and summative assessments in this module.

Table 3.5. Major Products and Deliverables for Groups and Individuals

Lesson	Major Group Products and Deliverables	Major Individual Products and Deliverables
1	• Rock cycle models	• Class participation • Individual investigation activity sheets • STEM Research Notebook entries
2	• Rock cycle models	• Class participation • Individual investigation activity sheets • STEM Research Notebook entries
3	• Rock cycle models • Topographic model of assigned area	• Class participation • Individual investigation activity sheets • STEM Research Notebook entries
4	• Class participation rubric	• Class participation • Individual investigation activity sheets
5	• Rock cycle models • Geologic threats poster	• Class participation
6	• Geologic timeline poster	• Challenge product

Table 3.6. Assessment Map for The Changing Earth Module

Lesson	Assessment	Group/ Individual	Formative/ Summative	Lesson Objective Assessed
1	Identification of the rocks in the students' study area	Group	Formative	• Use a dichotomous key to identify different kinds of sedimentary rocks. *(SEP: Developing and Using Models)*
1	Rock Cycle Model—Sedimentary Rock *rubric*	Group	Formative	• Describe the basic mechanisms for the formation of sedimentary rocks. *(CC: Stability and Change)*
1	Sedimentary rock activities *handouts*	Individual	Formative	• Describe the basic mechanisms for the formation of sedimentary rocks. *(CC: Stability and Change)*

Continued

Table 3.6. (*continued*)

Lesson	Assessment	Group/ Individual	Formative/ Summative	Lesson Objective Assessed
1	Steno's laws of stratigraphy *handouts*	Individual	Formative	• Explain Steno's laws of stratigraphy • Relate Steno's laws to figuring out the relative ages of rocks *(SEP: Developing and Using Models)*
1	Reading a map activity *handouts*	Individual	Formative	• Describe how latitude and longitude can be used to pinpoint a location on a map. • Define scale in terms of a map. • Explain how differences in scale would alter the view of a map. *(CC: Scale, Proportion, and Quantity)*
1	STEM Research Notebook *prompt*	Group	Formative	• Identify maps and their features. *(CC: Scale, Proportion, and Quantity)*
2	Identification of the rocks in the students' study area	Group	Formative	• Create a dichotomous key to use to identify different kinds of igneous rocks. *(SEP: Developing and Using Models)*
2	Rock Cycle Model—Sedimentary and Igneous Rocks *rubric*	Group	Formative	• Describe the formation of igneous rocks. • Describe the difference between intrusive and extrusive rocks. • Relate igneous rock formation using the terms *felsic, mafic*, and *intermediate.* *(CC: Stability and Change)*
2	Reading a map activity *handouts*	Individual	Formative	• Use a map legend to explain features shown on a map. • Describe ways in which maps can be used to communicate information. *(CC: Scale, Proportion, and Quantity)*
2	STEM Research Notebook *prompt*	Individual	Formative	• Describe the formation of igneous rocks. *(CC: Stability and Change)*

Continued

Table 3.6. (*continued*)

Lesson	Assessment	Group/ Individual	Formative/ Summative	Lesson Objective Assessed
3	Identification of the rocks in their study area	Group	Formative	• Use a dichotomous key to identify different kinds of metamorphic rocks. *(SEP: Developing and Using Models)*
3	Rock Cycle Model—Sedimentary, Igneous, and Metamorphic Rocks *rubric*	Group	Formative	• Describe the role of weathering, transport, and deposition in the rock cycle. • Describe the role of uplift and intrusion in the rock cycle. *(CC: Stability and Change)*
3	Data Communication *rubric*	Group/ Individual	Formative	• Identify appropriate methods for visually displaying rate data. *(SEPs: Developing and Using Models, Planning and Carrying Out Investigations)*
3	Argumentation *graphic organizer*	Group/ Individual	Formative	• Define the terms *claim, evidence*, and *reasoning.* • Explain the relationships among claim, evidence, and reasoning in a scientific argument. *(SEP: Constructing Explanations and Designing Solutions)*
3	Topographic Model *rubric*	Group/ Individual	Formative	• Describe the role that topography has on the placement of community infrastructure. • Explain how a topographic map describes the topography of a region. *(CCs: Scale, Proportion, and Quantity; Stability and Change)*
3	How Do Rocks Weather? *handout*	Group/ Individual	Formative	• Explain the mechanisms of weathering. • Describe the role of weathering, transport, and deposition in the rock cycle. *(SEP: Developing and Using Models)*
3	How Does Weathered Rock Material Move? *handout*	Group/ Individual	Formative	• Explain the mechanisms of weathering. • Describe the role of weathering, transport, and deposition in the rock cycle. *(SEP: Developing and Using Models)*

Continued

Table 3.6. (*continued*)

Lesson	Assessment	Group/ Individual	Formative/ Summative	Lesson Objective Assessed
3	Web Exploration—Weathering and Sediment Movement *handout*	Group	Formative	• Explain the mechanisms of weathering. • Describe the role of weathering, transport, and deposition in the rock cycle. *(SEP: Developing and Using Models)*
3	Comparing Metamorphic, Sedimentary, and Igneous Rocks *handout*	Group	Formative	• Differentiate between metamorphic, sedimentary, and igneous rocks. *(CC: Stability and Change)*
4	Timeline of Geologic Events *rubric*	Group	Summative	• Use terms to describe rock formation. • Apply all aspects of rock formation, weathering, and uplift to describe geologic events. • Describe type of rock(s) found in local geography. • Explain why type of rock(s) is found in local area. *(SEPs: Developing and Using Models, Planning and Carrying Out Investigations)*
4	Geologic Threats *rubric*	Group	Summative	• Identify geologic threats to communities. • Explain how geologic threats affect communities. • Identify loss and damage information related to geologic threats. • Explain how communities attempt to diminish loss and damage from geologic threats. • Create specific recommendations to mitigate or minimize geologic threats. *(SEPs: Developing and Using Models, Analyzing and Interpreting Data)*
4	Radiometric Dating handout	Group	Formative	• Describe the use of exponential growth (or loss of size) to calculate the age of a rock. *(SEP: Constructing Explanations and Designing Solutions)*
4	Mapping Major Threats *handout*	Group/ Individual	Formative	• Describe the potential geologic threats to an area. *(SEP: Developing and Using Models)*

Continued

Table 3.6. *(continued)*

Lesson	Assessment	Group/ Individual	Formative/ Summative	Lesson Objective Assessed
5	Final Rock Cycle Model *rubric*	Group	Summative	• Describe the basic mechanisms for the formation of sedimentary rocks. • Describe the formation of igneous rocks. • Describe the formation of metamorphic rocks. • Describe the role of weathering, transport, and deposition in the rock cycle. • Describe the role of uplift and intrusion in the rock cycle. • Explain continental drift theory. • Describe the connection between rock material cycling and the mechanisms of uplift and subduction. • Explain the role of evidence in developing new scientific knowledge. *(SEPs: Developing and Using Models, Analyzing and Interpreting Data; CC: Patterns)*
5	Geologic Threats Poster *rubric*	Group	Summative	• Create a narrative explanation of the major geologic threats to their study areas. • Create a poster describing the major geologic threats to their study areas. *(SEPs: Developing and Using Models, Analyzing and Interpreting Data)*
6	Geologic Timeline Poster *rubric*	Group	Summative	• Communicate the geological timeline for assigned area. • Use images to help readers understand how geologists determine the past geologic events of an area. • Use narratives to help readers understand how geologists determine the past geologic events of an area. *(SEPs: Developing and Using Models, Planning and Carrying Out Investigations, Analyzing and Interpreting Data)*

Note: The "Lesson Objective Assessed" column includes the related science and engineering practices (SEPs) and crosscutting concepts (CCs) from the *Next Generation Science Standards* for each assessment.

MODULE TIMELINE

Tables 3.7–3.11 (pp. 42–44) provide lesson timelines for each week of the module. These timelines are provided for general guidance only and are based on class times of approximately 45 minutes.

Table 3.7. STEM Road Map Module Schedule for Week One

Day 1	Day 2	Day 3	Day 4	Day 5
Lesson 1 *Rocks and Topography* • Launch module and engage students with maps.	*Lesson 1* *Rocks and Topography* • Identify rocks using a dichotomous key. • Explore map reading.	*Lesson 1* *Rocks and Topography* • Explore mechanisms of sedimentary rock formation. • Hold neptunist theory discussion. • Continue map reading.	*Lesson 1* *Rocks and Topography* • Explore Steno's Laws of Stratigraphy. • Create first rock cycle model. • Explore different kinds of maps.	*Lesson 2* *Igneous Rock Formation* • Introduce plutonist theory. • Create a dichotomous key for igneous rocks. • Explore what information can be learned from a map.

Table 3.8. STEM Road Map Module Schedule for Week Two

Day 6	Day 7	Day 8	Day 9	Day 10
Lesson 2 *Igneous Rock Formation* • Explore igneous rock characteristics further. • Explore topographic maps.	*Lesson 3* *Weathering, Transport, Deposition, Uplift, and Metamorphic Rock Formation* • Modify rock formation model, looking at topography of assigned areas.	*Lesson 3* *Weathering, Transport, Deposition, Uplift, and Metamorphic Rock Formation* • Explore weathering scientifically and mathematically. • Explore the relationship between topography and communities. • Begin discussing argumentation.	*Lesson 3* *Weathering, Transport, Deposition, Uplift, and Metamorphic Rock Formation* • Continue exploring weathering scientifically and mathematically. • Introduce building a topographic model. • Discuss creating an argument.	*Lesson 3* *Weathering, Transport, Deposition, Uplift, and Metamorphic Rock Formation* • Explore transport and deposition. • Build the model for assigned areas. • Discuss evaluating scientific arguments.

Table 3.9. STEM Road Map Module Schedule for Week Three

Day 11	Day 12	Day 13	Day 14	Day 15
Lesson 3 *Weathering, Transport, Deposition, Uplift, and Metamorphic Rock Formation* • Introduce influence of James Hutton on understanding rock formation. • Build the model for assigned areas • Apply argumentation.	*Lesson 3* *Weathering, Transport, Deposition, Uplift, and Metamorphic Rock Formation* • Explore metaphoric rock formation. • Build the model for assigned areas • Apply argumentation.	*Lesson 4* *Using the Rock Cycle to Determine Past Geologic Events and Geologic Threats to Communities* • Build geologic event timelines. • Introduce radiometric dating. • Map major geologic threats.	*Lesson 4* *Using the Rock Cycle to Determine Past Geologic Events and Geologic Threats to Communities* • Continue building geologic event timelines. • Examine impacts of geologic threats.	*Lesson 4* *Using the Rock Cycle to Determine Past Geologic Events and Geologic Threats to Communities* • Compare regions' geologic events and timelines. • Share impacts of geologic threats.

Table 3.10. STEM Road Map Module Schedule for Week Four

Day 16	Day 17	Day 18	Day 19	Day 20
Lesson 4 *Using the Rock Cycle to Determine Past Geologic Events and Geologic Threats to Communities* • Compare geological events and timelines across multiple areas. • Create maps of geologic threats.	*Lesson 5* *Continental Drift and the Rock Cycle* • Introduce Wegener's puzzle. • Develop geologic threats posters.	*Lesson 5* *Continental Drift and the Rock Cycle* • Examine evidence for continental drift—earthquake distribution and topography. • Continue developing geologic threats posters.	*Lesson 5* *Continental Drift and the Rock Cycle* • Examine evidence for continental drift—ocean floor age and GPS tracking. • Continue developing geologic threats posters.	*Lesson 5* *Continental Drift and the Rock Cycle* • Examine geologic implications of continental drift—uplift and subduction. • Finalize geologic threats posters.

Table 3.11. STEM Road Map Module Schedule Week Five

Day 21	Day 22	Day 23	Day 24	Day 25
Lesson 6 *Putting It All Together* • Develop geologic timeline posters. • Organize museum display.	*Lesson 6* *Putting It All Together* • Continue developing geologic timeline posters. • Continue organizing museum display.	*Lesson 6* *Putting It All Together* • Finalize geologic timeline posters. • Continue organizing museum display.	*Lesson 6* *Putting It All Together* • Finalize museum display.	*Lesson 6* *Putting It All Together* • Present museum display to class and elementary school students.

RESOURCES

In this module, several of the activities work better if students are able to access the internet via computer or mobile device and have graphing resources (e.g., graphing calculator, spreadsheet programs). The school's media specialist can help teachers locate resources to explore images and literature about rocks, the history of the theory of plate tectonics, and maps and map development. Special education and reading specialists along with staff from the English language office at the school can help students who need support with the module as necessary. Community support for understand geology and mapping can be provided by contacting the local government soil scientists and mapping office.

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Page numbers printed in **boldface type** indicate tables, figures, or handouts.

Grade 8

STEM Road Map for Middle School

The Changing Earth

What if you could challenge your eighth graders to help people recognize the inherent risks of living in a region that's prone to flooding, earthquakes, and volcanoes? With this volume in the *STEM Road Map Curriculum Series*, you can!

The Changing Earth outlines a journey that will steer your students toward authentic problem solving while grounding them in integrated STEM disciplines. Like the other volumes in the series, this book is designed to meet the growing need to infuse real-world learning into K–12 classrooms.

This interdisciplinary, six-lesson module uses project- and problem-based learning to introduce the powerful idea that Earth is shaped by ongoing geologic processes that can alter our landscape in a short time. The module also helps students appreciate the nature and process of science, including the roles of evidence, conjecture, and modeling. Students will learn about the rock cycle, including how it's driven by the Sun's energy and heat from Earth's core. To support this goal, students will do the following:

- Learn that Earth is a dynamic system, shaped by many geological processes that are driven by energy from the Sun and internally from Earth.
- Build a model to explain the evidence suggesting that Earth's surface has changed in the past and will continue to change in the future.
- Evaluate claims based on provided evidence.
- Use mathematics content and skills to collect and analyze data to support or refute a claim, and use appropriate graphics or tables to summarize data.
- Create a museum display to explore the geology of an area in North America or Great Britain. Students' displays will include scale models of influential rock formations in their assigned area and posters about topics such as geology's impact on culture and community.

The *STEM Road Map Curriculum Series* is anchored in the *Next Generation Science Standards*, the *Common Core State Standards*, and the Framework for 21st Century Learning. In-depth and flexible, *The Changing Earth* can be used as a whole unit or in part to meet the needs of districts, schools, and teachers who are charting a course toward an integrated STEM approach.

PB425X14
ISBN 978-1-68140-468-4

Grade 8

nsta Press
National Science Teaching Association