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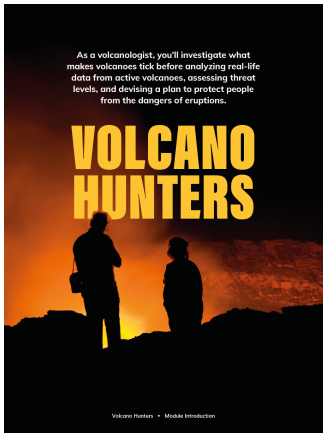
Volcano Hunters

Twig Science was built from the ground up for the Next Generation Science Standards by award-winning STEM education specialists.

Reviewing our program, you'll find:

- A clear conceptual flow across the program, clearly set out in the program NGSS Framework Alignment
- Modules that bundle different scientific disciplines including engineering and environmental principles and concepts (as defined by the CDE), aligned 1:1 with the segments of the NGSS Topic Arrangements
- Making sense of clearly-presented phenomena and problems at the heart of each module, with Scope and Sequence tables that show how the dimensions flow and build in sophistication across the program
- Module Contents that tell the story of how students apply the three dimensions in a module, with Investigative Problems and Driving Questions that scaffold their learning journey
- Three-dimensional lessons and assessments that clearly outline the dimensions applied.





This is why we score so highly on the EQuIP
This rubric has been completed for the Volcano Hunters module and is designed to highlight where you can find evidence for the NGSS 3D Design, NGSS Instructional Supports, and NGSS Monitoring Student Progress.

The rubric includes citations to the printed Teacher Edition and Twig Journal (Student Edition).

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Volcano Hunters Storyline

In this module, students take on the role of volcanologists. They make sense of the **Anchor Phenomenon**:

> *The residents of Kathmandu, Bougainville Island, Auckland, and Yogyakarta all live in the shadow of hills and mountains. Three of the locations are near the ocean, and three have similar rocks. Some locations have experienced devastating volcanic eruptions in the past that have affected local residents. Sometimes local residents are able to be protected.*

They experience this phenomenon during the first session of the module, through visual media, datasets, maps, and hands-on exploration. They ask **Wonder Questions** about their experience, and use these questions to drive their learning to make sense of the phenomenon. The materials suggest the following progression through student **Wonder Questions**, as ideas build from one session to the next, though teachers can adjust this to meet the needs and suggestions of individual classes.

Lesson 1 comprises the suggested student **Wonder Questions** that build toward students being able to answer: Can we identify volcanoes in the landscape surrounding Kathmandu, Bougainville Island, Auckland, and Yogyakarta?

Session 2: Where do we find volcanoes? **Investigative Phenomenon:** There is a pattern in where volcanoes are found. *Students explore why there is a pattern in where volcanoes are found.*
Session 3: Do volcanoes always look the same? **Investigative Phenomenon:** Volcanoes form at tectonic boundaries and hotspots, changing landscapes. *Students build on their understanding of tectonic processes to explore how the geologic forces and energy at plate boundaries affect a volcano's appearance.*
Session 4: Why are rocks different from each other? **Investigative Phenomenon:** Rocks have different observable properties depending on where they are found. *Students explore how geologic processes affect observable rock properties.*
Sessions 5 and 6: How do physical and chemical processes affect rocks in a volcanic landscape?

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Investigative Phenomenon: The features of a landscape change over time. *Students build on their explorations to explain how geologic processes affect rocks at different physical and temporal scales.*
Session 7: How does a volcano change over its lifetime? **Investigative Phenomenon:** Volcanoes change over time. *Students build on the previous sessions by applying their understanding of change at different physical and temporal scales to a volcano case study.*
Session 8: Can we identify volcanoes in the landscape surrounding Kathmandu, Bougainville Island, Auckland, and Yogyakarta? *Students synthesize their understanding from the lesson to explain part of the Anchor Phenomenon.*

Lesson 2 comprises the suggested student **Wonder Questions** that build toward students being able to answer: Are all volcanoes equally dangerous to communities?

Sessions 1 and 2: What are eruptions like? **Investigative Phenomena:** Volcanoes erupt in lots of different ways. Lava from different volcanoes is different. *Students observe different eruptions and explore how the properties of lava can affect eruptions.*
Session 3: Why do some volcanoes explode? **Investigative Phenomenon:** Gas moves differently through different lava viscosities. *Students build on this by exploring the combined effect of viscosity and gas content on eruptions.*
Session 4: What properties do dangerous volcanoes share? **Investigative Phenomenon:** Different volcanic eruptions have different effects. *Students build on this by exploring the properties of different types of volcanoes and their relationship to risk.*
Session 5: What makes eruptions dangerous? **Investigative Phenomenon:** Different volcanic eruptions have different effects. *Students extend their understanding by exploring the wider hazards posed to communities by volcanoes.*

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Session 6: Are all volcanoes equally dangerous to communities? *Students synthesize their understanding from the lesson to explain part of the Anchor Phenomenon.*

Lesson 3 comprises the suggested student **Wonder Questions** that build toward students being able to answer: What can be done to minimize the risk from volcanoes to communities?

Session 1: Are there any warning signs of an eruption? **Investigative Phenomenon:** Volcanoes change in observable ways before an eruption. *Students observe data from volcanoes far from and close to an eruption to identify patterns.*
Session 2: How do scientists collect warning sign data from volcanoes? **Investigative Phenomenon:** Volcanoes change in measurable ways before an eruption. *Students build on this to understand the different types of data that can be collected and the pros and cons of each technique.*
Sessions 3 and 4: Can we predict when an eruption might occur? **Investigative Phenomenon:** Volcanoes change in measurable ways before an eruption. *Students build on their understanding to use different data to make predictions about eruptions.*
Session 5: Which volcanoes should we monitor? **Investigative Phenomenon:** Not all volcanoes are monitored to the same extent. *Students build on this to observe under-monitored volcanoes and make decisions about which volcanoes should be monitored.*
Session 6: What can be done to minimize the risk from volcanoes to communities? *Students synthesize their understanding from the lessons to finalize their explanations of the Anchor Phenomenon.*

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EQuIP Rubric for Lessons & Units: Science

Lessons and units designed for the NGSS include clear and compelling evidence of the following:

I. NGSS 3D Design	II. NGSS Instructional Supports	III. Monitoring NGSS Student Progress
The lesson/unit is designed so students make sense of phenomena and/or design solutions to problems by engaging in student performances that integrate the three dimensions of the NGSS. A. **Explaining Phenomena/Designing Solutions:** Making sense of phenomena and/or designing solutions to a problem drive student learning. i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving. ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems. iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences. B. **Three Dimensions:** Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions. i. Provides opportunities to develop and use specific elements of the SEP(s). ii. Provides opportunities to develop and use specific elements of the DCI(s). iii. Provides opportunities to develop and use specific elements of the CCC(s). C. **Integrating the Three Dimensions:** Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.	The lesson/unit supports three-dimensional teaching and learning for ALL students by placing the lesson in a sequence of learning for all three dimensions and providing support for teachers to engage all students. A. **Relevance and Authenticity:** Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world. i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations). ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate. iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience. B. **Student Ideas:** Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and to respond to peer and teacher feedback orally and/or in written form as appropriate. C. **Building Progressions:** Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers: i. Explicitly identifying prior student learning expected for all three dimensions ii. Clearly explaining how the prior learning will be built upon D. **Scientific Accuracy:** Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning. E. **Differentiated Instruction:** Provides guidance for teachers to support differentiated instruction by including: i. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers, etc.) for students who are English language learners, have special needs, or read well below the grade level. ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations. iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the	The lesson/unit supports monitoring student progress in all three dimensions of the NGSS as students make sense of phenomena and/or design solutions to problems. A. **Monitoring 3D student performances:** Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions. B. **Formative:** Embeds formative assessment processes throughout that evaluate student learning to inform instruction. C. **Scoring guidance:** Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students. D. **Unbiased tasks/items:** Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.

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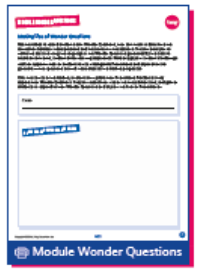
	practices, disciplinary core ideas, and crosscutting concepts.	

EQuIP Rubric for Lessons & Units: Science
Units designed for the NGSS will also include clear and compelling evidence of the following additional criteria:

I. NGSS 3D Design	II. NGSS Instructional Supports	III. Monitoring NGSS Student Progress
D. **Unit Coherence:** Lessons fit together to target a set of performance expectations. i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences. ii. The lessons help students develop toward proficiency in a targeted set of performance expectations. E. **Multiple Science Domains:** When appropriate, links are made across the science domains of life science, physical science and Earth and space science. i. Disciplinary core ideas from different disciplines are used together to explain phenomena. ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted. F. **Math and ELA:** Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.	F. **Teacher Support for Unit Coherence:** Supports teachers in facilitating coherent student learning experiences over time by: i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.). ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions. G. **Scaffolded differentiation over time:** Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.	E. **Coherent Assessment system:** Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning. F. **Opportunity to learn:** Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.

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Category I: NGSS 3D Design (lessons and units)

Lesson and Unit Criteria Lessons and units designed for the NGSS include clear and compelling evidence of the following:	Specific evidence from materials (what happened/where did it happen) and reviewer's reasoning (how/why is this evidence)	Evidence of Quality
A. **Explaining Phenomena/Designing Solutions:** Making sense of phenomena and/or designing solutions to a problem drive student learning. i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving. ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems. iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.	Evidence of i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving. In the first session of the module, students use the **Co-Craft Questions language routine** to ask scientific questions about the **Anchor Phenomenon**, which they experience through visual media, datasets, maps, and hands-on exploration. These are recorded on a **Wonder Questions chart**. The teacher then uses these questions to identify the sessions in the program that can help students answer them. After using the **Co-Craft Questions language routine** to generate **Wonder Questions** in the first session, students return to these questions as each lesson progresses. The first session of each subsequent lesson has an opportunity for students to generate and add to their **Wonder Questions Chart** using the **Co-Craft Questions language routine**. After generating **Wonder Questions**, students are invited to suggest which questions they want to answer first, and discuss what they already know about the questions and how they might answer	Evidence of i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving. **Think Talk—Co-Craft Questions** Use the Co-Craft Questions language routine to generate Wonder Questions about the Anchor Phenomenon. Have students work individually and then in small groups and record their questions on scratch paper. Prompt groups to share their Wonder Questions, and record them on the board. Have the class reframe the questions as investigable questions. Discuss ways of grouping questions together, and whether there are any missing questions. Based on the discussion, develop a physical or digital Class Wonder Questions chart. Guide students to group questions that consider: • How and why an area might change as a result of geoscience processes associated with volcanic activity (Lesson 1) • What makes volcanoes dangerous to human populations (Lesson 2) • How we can predict eruptions and protect communities from the risks they pose (Lesson 3). Share with students the group of questions they will be investigating this lesson. Have students record the questions in their Wonder Questions charts on pages 4–5 in their Twig Journals. During or after the session, use the **Module Wonder Questions** to create a map that connects student questions to the sessions.  Pre-Assessment Have students complete the **Co-Craft Questions language routine, TE p. 14**

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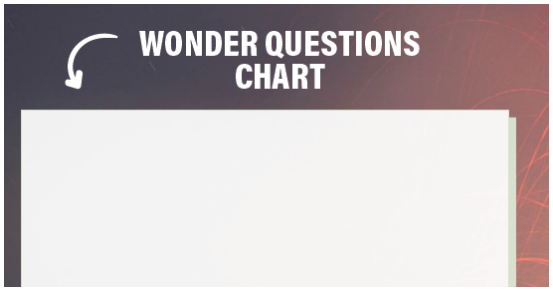
them.

At the start of the next session, students review the Wonder Question that they will be exploring using either the Class Wonder Questions Chart or the Lesson Presentation slides. They are asked to share what they already know that can help them answer the question, and how they might answer the question.

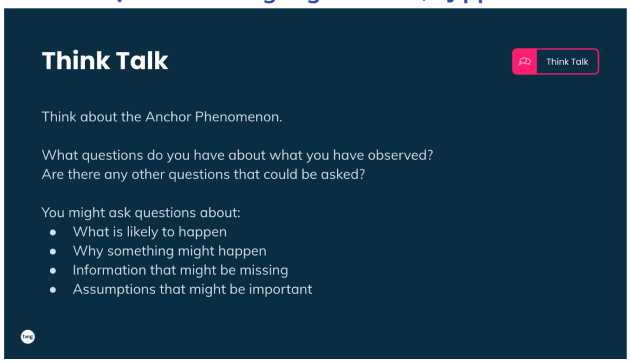
Module-specific introductory tasks also allow students to recall and recap prior experiences from within or outside the classroom. For example, in Volcano Hunters, students are encouraged to use prior knowledge from outside the classroom to describe a volcano (L1 S1) and to use information from Lesson 2 to discuss what signs might indicate a volcano is about to erupt (L3 S1).

Toward the end of a session, students update their Phenomena Trackers to record their sense-making about the Investigative and Anchor Phenomena, and respond to any Wonder Questions they can answer. They then suggest any new Wonder Questions, and they are invited to determine which questions they want to answer next (Lesson Presentation slides). They discuss what they already know about the question and how they might answer it.

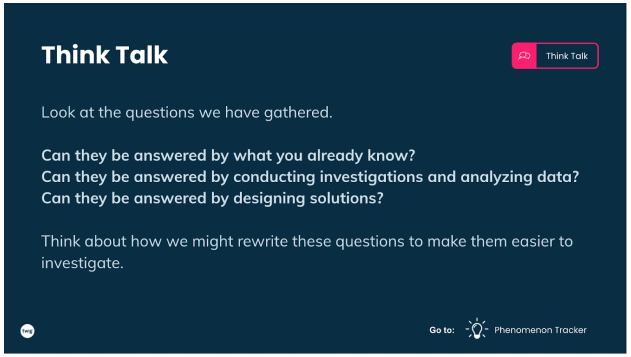
This process is repeated as students progress through the module. In Volcano Hunters, the Co-Craft Questions language routine, Wonder Questions Chart Routine, and Phenomena



Co-Craft Questions language routine, TJ pp. 4–5



Co-Craft Questions language routine, Lesson Presentation slides

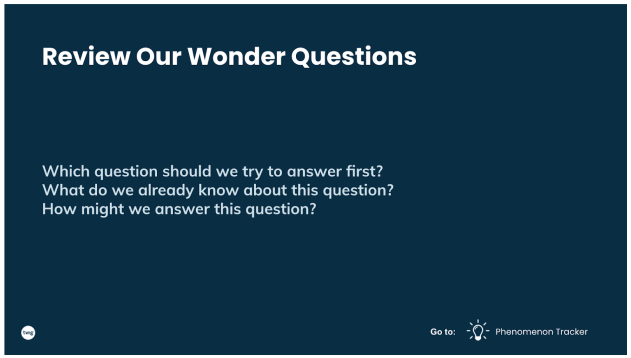


Co-Craft Questions language routine, Lesson Presentation slides

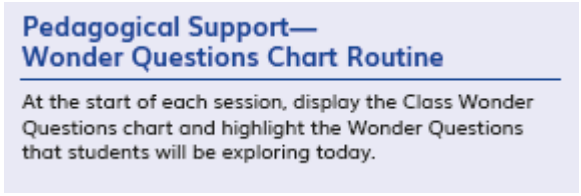
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Tracker Routine appear in these sessions:

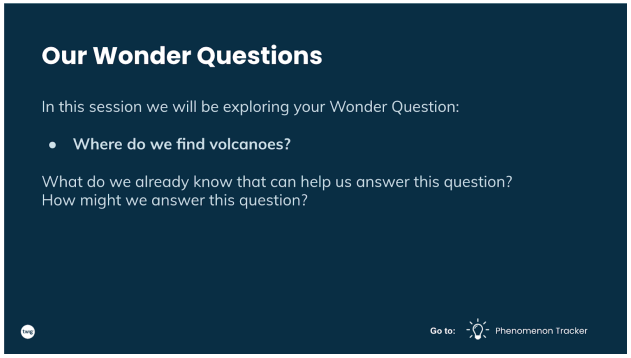
- Co-Craft Questions language routine: L1 S1, L2 S1, L3 S1
- Wonder Questions Chart Routine: L1 S2–8, L2 S1–6, L3 S1–6
- Phenomena Tracker Routine: L1 S2–4, L1 S6–7, L2 S1–5, L3 S1–5



Co-Craft Questions language routine, Lesson Presentation slides

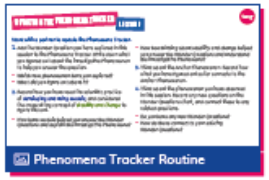
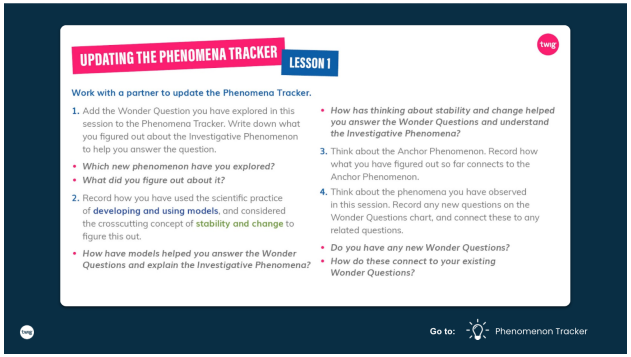


Wonder Questions Chart Routine, TE p. 18



Wonder Questions Chart Routine, Lesson Presentation slides

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	Evidence of ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems. In every module, students work toward making sense of and explaining an **Anchor Phenomenon**. They gather evidence to respond to their questions about the **Anchor Phenomenon**,	Update the Phenomena Tracker Display the **Phenomena Tracker Routine visual**. Invite students to use the routine to make sense of their Wonder Questions and connect to the Anchor Phenomenon. Have students share ideas and add new Wonder Questions to the Class Wonder Questions chart. Take note of the Wonder Questions you will be exploring in the next session and highlight these.  **Phenomena Tracker Routine, TE p. 20**  **Phenomena Tracker Routine, Lesson Presentation slides** Evidence of ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.

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through their exploration of various **Investigative Phenomena**.

The **Anchor Phenomenon** for Volcano Hunters is:

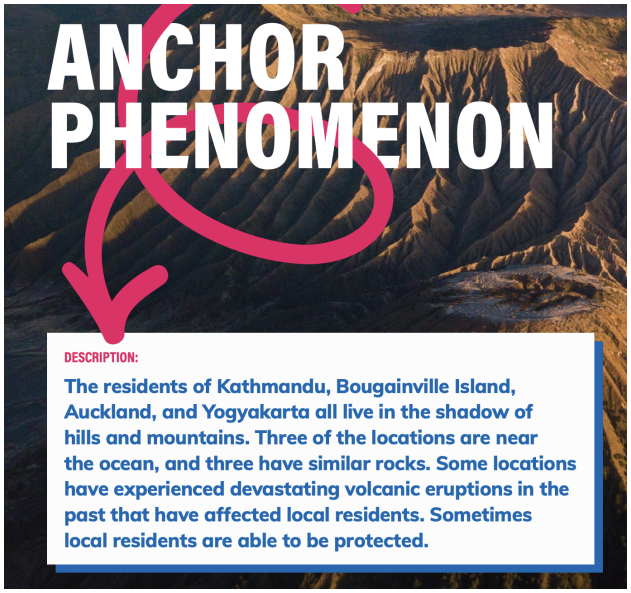
- *The residents of Kathmandu, Bougainville Island, Auckland, and Yogyakarta all live in the shadow of hills and mountains. Three of the locations are near the ocean, and three have similar rocks. Some locations have experienced devastating volcanic eruptions in the past that have affected local residents. Sometimes local residents are able to be protected.*

In **L1**, students explore the following **Investigative Phenomena**:

- *There is a pattern in where volcanoes form.* (**L1 S2**)
- *Volcanoes form at tectonic boundaries, changing landscapes.* (**L1 S3**)
- *Rocks have different observable properties depending on where they are found.* (**L1 S4**)
- *The features of a landscape change over time.* (**L1 S5**, **L1 S6**)
- *Volcanoes change over time.* (**L1 S7**)

In **L2**, students explore the following **Investigative Phenomena**:

- *Volcanoes erupt in lots of different ways.* (**L2 S1**)



Anchor Phenomenon, TJ p. 2



Investigative Phenomenon, TE p. 17

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- *Lava from different volcanoes is different.* (L2 S2)
- *Gas moves differently through different lava viscosities.* (L2 S3)
- *Different volcanic eruptions have different effects.* (L2 S4)
- *Volcanoes change in observable ways before an eruption.* (L2 S5)

In L3, students explore the following Investigative Phenomena:

- *Volcanoes change in observable ways before an eruption.* (L3 S1)
- *Volcanoes change in measurable ways before an eruption.* (L3 S2, L3 S3, L3 S4)
- *Not all volcanoes are monitored to the same extent.* (L3 S5)

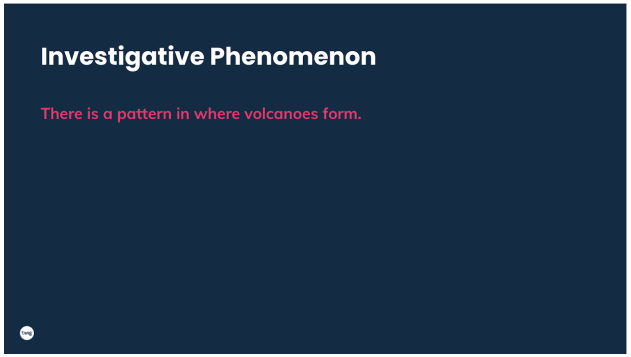
Students experience the Anchor and Investigative Phenomena within the sessions of the module. Students discuss the phenomena, and are presented with a consolidated description in the Twig Journal and on the Lesson Presentation slides.

Driven by their Wonder Questions, students complete 3-D tasks to develop understanding of the Investigative Phenomena and Wonder Questions related to the Anchor Phenomenon.

Students update the Phenomena Tracker to make sense of Investigative Phenomena, respond to Wonder Questions, and develop explanations of the Anchor Phenomenon using the **Phenomena**



Investigative Phenomenon, TJ p. 16



Investigative Phenomenon, Lesson Presentation slides

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Tracker Routine visual for each lesson as a prompt.

Students construct written explanations of the Anchor Phenomenon at the end of each lesson.

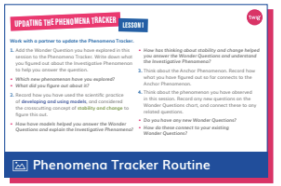
For example, in L1 S4, students use the **Rock Models visual** and 3-D crayon models (pre-prepared by the teacher) to observe and compare different types of rocks, each from a different location. They discuss their observations and share their ideas about how the rocks (and corresponding crayon models) formed. They are then introduced to the Investigative Phenomenon through the Lesson Presentation slides:

- Rocks have different observable properties depending on where they are found.

Students then complete a hands-on investigation where they try to recreate the 3-D crayon models, using processes including melting, breaking down, and applying pressure. They discuss how the processes they used compare to environmental processes, connecting their experiences of crayon model formation to rock formation and how this is affected by location.

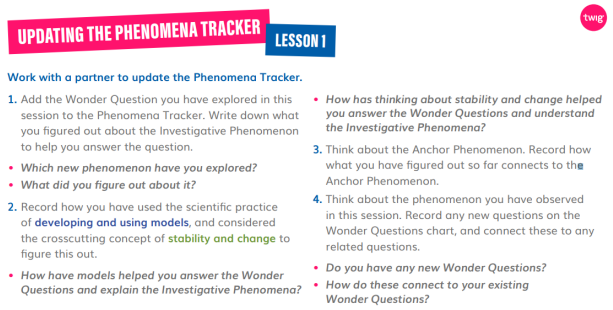
They update their Phenomena Trackers, prompted by the **Phenomena Tracker Routine visual**, and are supported to make sense of the Investigative Phenomenon and answer their Wonder Questions.

Update the Phenomena Tracker



Display the **Phenomena Tracker Routine visual**. Invite students to use the routine to make sense of their Wonder Questions and connect to the Anchor Phenomenon. Have students share ideas and add new Wonder Questions to the Class Wonder Questions chart. Take note of the Wonder Questions you will be exploring in the next session and highlight these.

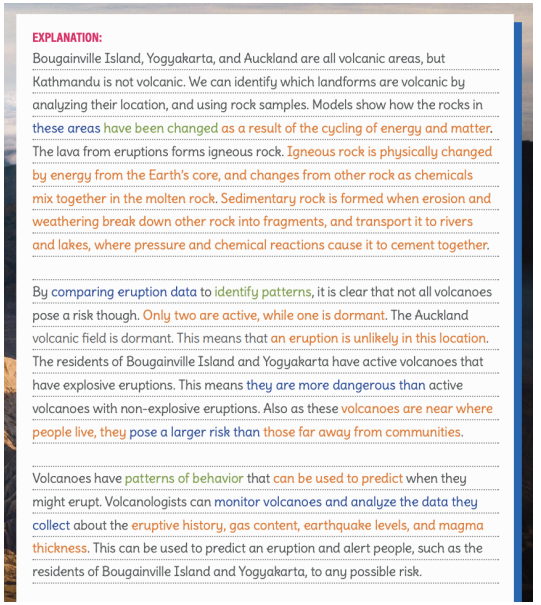
Phenomena Tracker Routine, TE p. 20


UPDATING THE PHENOMENA TRACKER LESSON 1

Work with a partner to update the Phenomena Tracker.

1. Add the Wonder Question you have explored in this session to the Phenomena Tracker. Write down what you figured out about the Investigative Phenomenon to help you answer the question.
   - *Which new phenomenon have you explored?*
   - *What did you figure out about it?*
2. Record how you have used the scientific practice of **developing and using models**, and considered the crosscutting concept of **stability and change** to figure this out.
   - *How have models helped you answer the Wonder Questions and explain the Investigative Phenomena?*
   - *How has thinking about stability and change helped you answer the Wonder Questions and understand the Investigative Phenomena?*
3. Think about the Anchor Phenomenon. Record how what you have figured out so far connects to the Anchor Phenomenon.
4. Think about the phenomenon you have observed in this session. Record any new questions on the Wonder Questions chart, and connect these to any related questions.
   - *Do you have any new Wonder Questions?*
   - *How do these connect to your existing Wonder Questions?*

Phenomena Tracker Routine visual

	They build on these ideas in the following sessions (**L1 S5–6**), and at the end of the lesson (**L1 S8**) are able to use their ideas about rock formation and location on Earth to begin to make sense of the **Anchor Phenomenon**.	### Review the Anchor Phenomenon Display the Class Wonder Questions chart and review the Anchor Phenomenon. Summarize the Wonder Questions that have been looked at in full or in part so far. Ask students to discuss which new aspects of the Anchor Phenomenon they can now explain. Have students write their partial explanations as a short paragraph on page 3 in their Twig Journals. Remind them to include information about how they used the scientific practice of developing and using models, and thought about the phenomena through the lens of stability and change. **Review the Anchor Phenomenon, TE p. 49**  **EXPLANATION:** Bougainville Island, Yogyakarta, and Auckland are all volcanic areas, but Kathmandu is not volcanic. We can identify which landforms are volcanic by analyzing their location, and using rock samples. Models show how the rocks in these areas have been changed as a result of the cycling of energy and matter. The lava from eruptions forms igneous rock. Igneous rock is physically changed by energy from the Earth's core, and changes from other rock as chemicals mix together in the molten rock. Sedimentary rock is formed when erosion and weathering break down other rock into fragments, and transport it to rivers and lakes, where pressure and chemical reactions cause it to cement together. By comparing eruption data to identify patterns, it is clear that not all volcanoes pose a risk though. Only two are active, while one is dormant. The Auckland volcanic field is dormant. This means that an eruption is unlikely in this location. The residents of Bougainville Island and Yogyakarta have active volcanoes that have explosive eruptions. This means they are more dangerous than active volcanoes with non-explosive eruptions. Also as these volcanoes are near where people live, they pose a larger risk than those far away from communities. Volcanoes have patterns of behavior that can be used to predict when they might erupt. Volcanologists can monitor volcanoes and analyze the data they collect about the eruptive history, gas content, earthquake levels, and magma thickness. This can be used to predict an eruption and alert people, such as the residents of Bougainville Island and Yogyakarta, to any possible risk. **Anchor Phenomenon, TJ pp. 2–3**

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L1 S4 Rock Models visual

Describe the Investigative Phenomenon (Session 4)

Display the **Rock Models visual**. Explain that each of the rocks were found at a different location.



- ***What do you observe about these rocks?***
  They all look different
  Some contain different colors or materials.
- ***How might these rocks have been formed? What makes you think that?***
  The rock at Location 1 looks like it's made up of lots of different pieces. Maybe this was formed by pushing different materials together.
  The rock at Location 3 is all the same color and smoother. This could have been melted.

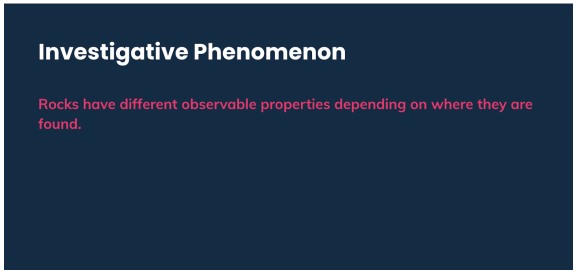
Distribute the prepared 3-D crayon rock models throughout the class. Hold up or pass around the sedimentary, metamorphic, and igneous rock samples. **Note:** Students don't need to know the different rock types at this stage.

- ***What do you observe about these rocks? What do you observe about the crayon models?***
  The crayon models look like models of the different types of rock.
- ***Match the crayon models to each of the three locations in the visual. Explain your reasoning.***
  The crayon model with all the pieces matched the rock at Location 1. (Sedimentary rock model)
  The crayon model that has melted pieces looks like the rock at Location 2. (Metamorphic rock model)
  The crayon model that looks most melted matches the smooth rock at Location 3. (Igneous rock model)

Let students know that the 3-D models were formed using a particular process, just like the real rocks they are models of. Have students share their observations and ideas about formation.

L1 S4 Describe the Investigative Phenomenon, TE p. 29

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L1 S4 Investigative Phenomenon, Lesson Presentation slides

Investigate Changing Crayons

Organize students into teams of four, and have them turn to pages 34–35 in their Twig Journals. Explain that each team will use crayons to try to recreate the 3-D rock models, using different processes. Introduce the materials that can be used to change the crayons, and let students know they may also use their hands and feet.

- ***With these materials, what processes could you use to form the different rock models?***
  We could put aluminum foil on the hot plate and melt the crayons.
  We could melt the crayons with the foil and hot plate and then let them cool.
  We could use the crayon sharpener to shave off pieces of different crayons.
  We could use our hands to squish together tiny pieces of crayon.
  We could use heavy books, a rolling pin, or even stand on top of the crayons to apply pressure and squash them.

Have teams develop their own versions of the rock models. Prompt them to write and draw 2-D models of the processes they used on pages 34–35 in their Twig Journals. **Note:** It is not important at this stage whether they used the correct process for forming each rock model. The goal of this activity is to invite students to explore the different processes that are comparable to those that form and change rocks.

If students need support, guide them to explore these processes:

- **Heating and Melting:** Placing crayons on aluminum foil, and then on top of a heat source
- **Cooling:** Leaving material to cool
- **Breaking Down:** Using a crayon sharpener to break the crayon into smaller pieces
- **Pressure:** Adding pressure with heavy books, a rolling pin, or standing on top of the material

L1 S4 Investigate Changing Crayons, TE p. 30

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<table>
<tr>
<td></td>
<td>Evidence of iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

Engineering is not covered in this module.</td>
<td>Update the Phenomena Tracker

Display the Phenomena Tracker Routine visual. Invite students to use the routine to make sense of their Wonder Questions and connect to the Anchor Phenomenon. Have students share ideas and add new Wonder Questions to the Class Wonder Questions chart. Take note of the Wonder Questions you will be exploring in the next session and highlight these.

L1 S4 Discuss 3-D Models/Update the Phenomena Tracker, TE p. 31

The lava from eruptions forms igneous rock. Igneous rock is physically changed by energy from the Earth's core, and changes from other rock as chemicals mix together in the molten rock. Sedimentary rock is formed when erosion and weathering break down other rock into fragments, and transport it to rivers and lakes, where pressure and chemical reactions cause it to cement together.

Anchor Phenomenon, TJ p. 3

Evidence of iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

Engineering is not covered in this module.</td>
</tr>
<tr>
<td>B. Three Dimensions: Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions.

i. Provides opportunities to develop and use specific elements of the SEP(s).
ii. Provides opportunities to develop and use specific elements of the DCI(s).
iii. Provides opportunities to develop and use specific elements of the CCC(s).</td>
<td>Evidence of i–iii. Provides opportunities to develop and use specific elements of the SEPs, DCIs, and CCCs.

Specific elements of grade-appropriate SEP(s)

In Volcano Hunters, students are provided with opportunities to develop and use the following SEP elements:
• Develop and use a model to describe phenomena. (SEP-2)
• Analyze and interpret data to determine similarities and differences in findings. (SEP-4)</td>
<td>Evidence of i–iii. Provides opportunities to develop and use specific elements of the SEPs, DCIs, and CCCs.

<table><tr><th></th><th>Working with Prior Knowledge</th><th>Working Toward Mastery</th><th>Demonstrating Mastery</th></tr><tr><td colspan="4">MS-ESS2-1 Earth's Systems</td></tr><tr><td>SEP-2</td><td>Lesson 1 Session 2</td><td>Lesson 1 Session 4
Lesson 1 Session 5</td><td>Lesson 1 Session 6
Lesson 1 Session 8</td></tr><tr><td>ESS2.A*</td><td>Lesson 1 Session 2
Lesson 1 Session 3</td><td>Lesson 1 Session 4
Lesson 1 Session 5</td><td>Lesson 1 Session 6
Lesson 1 Session 7
Lesson 1 Session 8</td></tr></table>
Online Performance Expectation Progressions</td>
</tr>
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How they are developed and used to make sense of phenomena

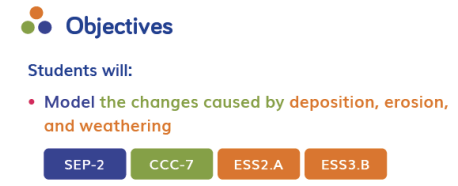
Development of the SEP elements over the lesson and/or module is clearly set out in the online Performance Expectation Progressions, which show the sessions where students are working with prior knowledge of the dimension, where they are working toward grade level, and where they are working at grade level. For example, the online Performance Expectation Progressions for Volcano Hunters indicate that students are working with prior knowledge of SEP-4 in L3 S1, working toward grade level mastery in L3 S3, and working at grade level (demonstrating mastery) in L3 S4–6.

In relevant sessions, students' engagement with the SEP elements is highlighted for the teacher in the Objectives (e.g., L1 S3, L3 S4).

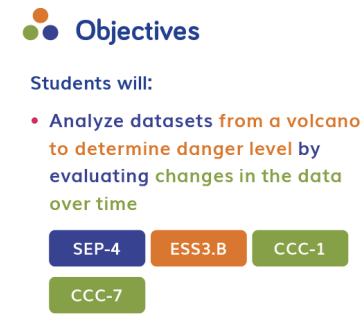
In L1, students are developing mastery of the SEP aligned with **MS-ESS2-1**:

- **SEP-2**: Develop and use a model to describe phenomena.

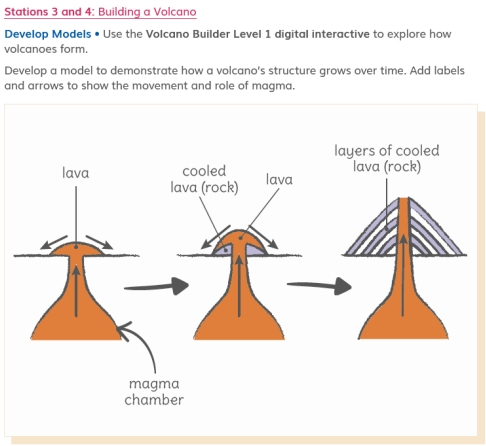
Students begin engaging with the dimension in L1 S3, where they develop 2-D and 3-D models of geologic processes including weathering, erosion, and deposition. At this early stage, they work in teams. In L1 S4, students begin to develop a 2-D model focusing on processes that change the landscape and how these form the rock cycle. The landscape background is provided for them, so



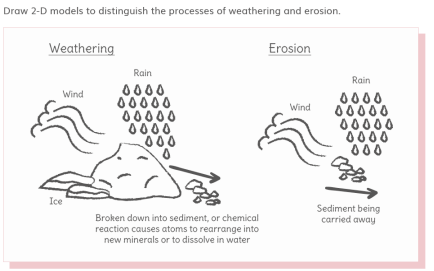
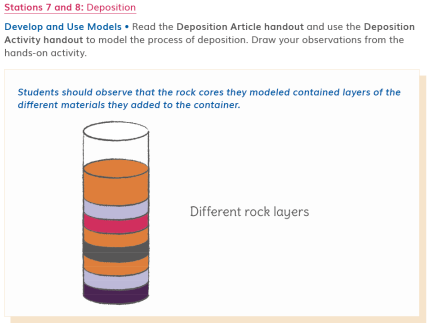
L1 S3 Objectives, TE p. 21



L3 S4 Objectives, TE p. 96



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	that they have a more scaffolded starting point. In L1 S5 students use a think-pair-share to discuss the processes that make up their models, and work with partners to further develop their 2-D models. Their work is assessed (**Different Types of Rocks Teacher Rubric**) at this midway stage so that the teacher can provide feedback and future support as needed. In L1 S5, teachers are also prompted to use the **Developing and Using Models handout** to support students who are struggling to create their models. In L1 S6, students read a scientific text about different rock types and how they form. They use a Productive Discussion language routine to discuss the rock types in the context of their landscape models, allowing them to share and develop their ideas with their peers. They then use their learning to add grade-appropriate terminology to their 2-D landscape models. In L1 S7, students independently develop a 2-D model showing changes to Mount Mazama over time. None of the model elements are pre-printed for them, showing progression from the models they developed earlier in the lesson. In L1 S8, students independently develop models that describe processes and physical and chemical changes that result in different rock types. They use their model to describe how the landscapes of four different locations formed. In this task, students are engaging with the practice	**L1 S3 Develop Models, TJ p. 27**   **L1 S3 Develop and Use Models, TJ p 29**

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at grade level, as they are both developing and using models to describe phenomena.

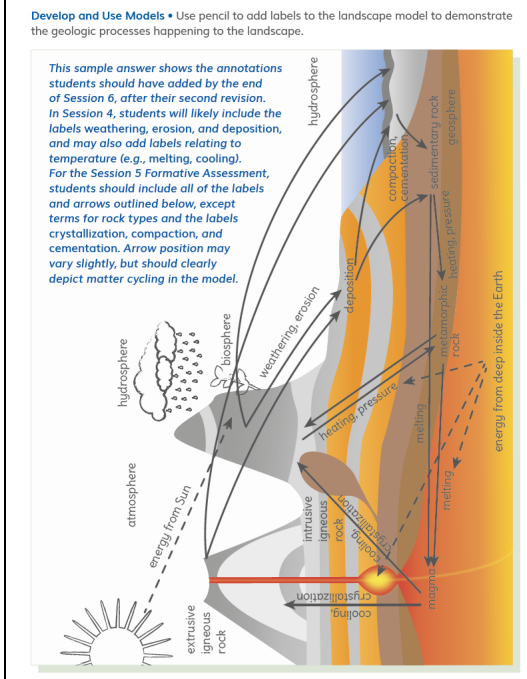
In L2 and L3, students are developing mastery of the SEP aligned with **MS-ESS3-2**:

- **SEP-4**: Analyze and interpret data to determine similarities and differences in findings.

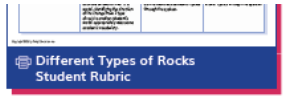
Students begin engaging with the dimension in L2 S2, where they determine similarities and differences in the behavior of different-viscosity liquids. They continue their explorations in L2 S3 as they use the **Volcano Builder digital interactive** to investigate and analyze how lava type affects a volcano's eruptive behavior, considering similarities and differences in findings.

In L2 S6, students interpret the data they've collected across the lesson from investigations and text, providing evidence to support the claim: Some volcanoes are more dangerous than others. Their work is assessed (**Dangerous Volcanoes Teacher Rubric**) at this midway stage so that the teacher can provide feedback and future support as needed.

In L3 S1, students collect data during a video lab and compare similarities and differences in data during eruptive and non-eruptive periods. They use this understanding to analyze and interpret volcanic data in L3 S3–4, applying warning levels to periods in the dataset according to eruptive



L1 S4 Develop and Use Models, TJ p. 33



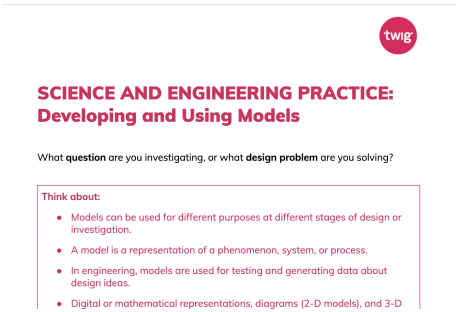
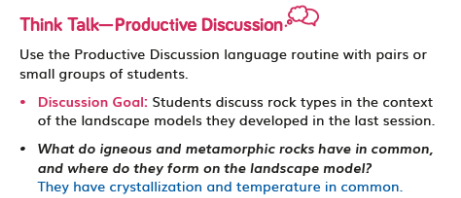
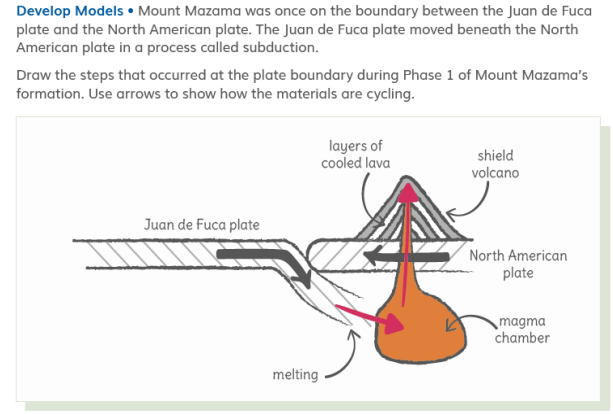
Explain the Rock Cycle Journey

Have students add their rock journey to the landscape model on page 33 in their Twig Journals. Ask them to add arrows and labels to their rock cycle journey, using the information they recorded during the activity. Have students use a think-pair-share to discuss their rock cycle journeys.

- ***What happens to magma when it erupts?***
  It cools on the surface. Over a long period of time, the cooled magma can create a large volcanic feature

L1 S5 Explain the Rock Journey, TE p. 35

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	risk. In L3 S3, teachers are prompted to use the **Analyzing and Interpreting Data handout** to support students struggling to interpret the historic data, and, in L3 S4, their work is assessed (**Warning Levels Teacher Rubric**) so that the teacher can provide feedback and future support as needed. In L3 S5–6, students analyze data from a set of volcanoes and interpret similarities and differences in the data to determine which of the volcanoes they think should be prioritized for additional monitoring. They write a monitoring plan to justify their choice, which is assessed with the **Monitoring Volcanoes Teacher Rubric**. These examples show how students have opportunities to develop and use elements of the SEPs over the course of the module.	 **SCIENCE AND ENGINEERING PRACTICE: Developing and Using Models** What **question** are you investigating, or what **design problem** are you solving? **Think about:** • Models can be used for different purposes at different stages of design or investigation. • A model is a representation of a phenomenon, system, or process. • In engineering, models are used for testing and generating data about design ideas. • Digital or mathematical representations, diagrams (2-D models), and 3-D **Developing and Using Models handout**  **Think Talk—Productive Discussion** Use the Productive Discussion language routine with pairs or small groups of students. • **Discussion Goal:** Students discuss rock types in the context of the landscape models they developed in the last session. • ***What do igneous and metamorphic rocks have in common, and where do they form on the landscape model?*** They have crystallization and temperature in common. **L1 S6 Think Talk—Productive Discussion, TE p. 39**  **Develop Models** • Mount Mazama was once on the boundary between the Juan de Fuca plate and the North American plate. The Juan de Fuca plate moved beneath the North American plate in a process called subduction. Draw the steps that occurred at the plate boundary during Phase 1 of Mount Mazama's formation. Use arrows to show how the materials are cycling. **L1 S7 Develop Models, TJ p. 53**

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3-D Assessment • Develop a landscape model to describe the processes and physical and chemical changes that result in different rock types. Your model should include labels and arrows to show the source(s) and flow of energy and the movement of matter. You should indicate where the rocks from the four locations would have formed.

L1 S8 3-D Assessment, TJ p. 58

Investigate Lava Types

Divide students into teams of four and distribute materials. Have teams read the instructions on pages 65–66 in their Twig Journals. Then have them complete the three investigations into the effects of viscosity, tephra, and slope on lava flow, and record their observations on pages 65–66 in their Twig Journals.

L2 S2 Investigate Lava Types, TE p. 61

Explore Explosivity with the Digital Interactive

Have students meet in small teams and explore the **Volcano Builder Level 2 digital interactive**. Prompt them to select different amounts of gas for their eruptions.



Ask students to record their observations on page 67 in their Twig Journals.

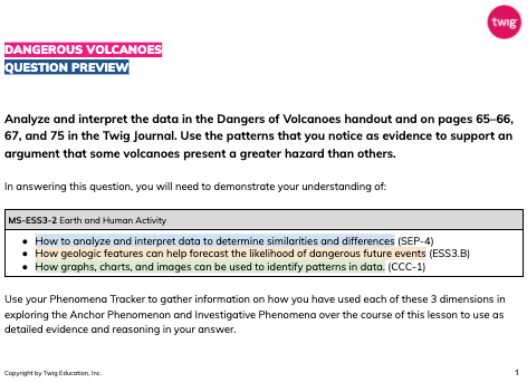
L2 S3 Explore Explosivity with the Digital Interactive, TE p. 65

3-D Assessment • Analyze and interpret the data in the **Dangers of Volcanoes handout** and on pages 65–66, 67, and 75. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others.

Some volcanoes are more dangerous than others. The magma content of volcanoes can vary a lot. Some volcanoes have really runny magma, but others have really viscous magma. Gas content can also vary. When gas moves through magma, it creates pressure. Volcanoes with very viscous magma and

L2 S6 3-D Assessment, TJ p. 88

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DANGEROUS VOLCANOES
QUESTION PREVIEW

Analyze and interpret the data in the Dangers of Volcanoes handout and on pages 65–66, 67, and 75 in the Twig Journal. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others.

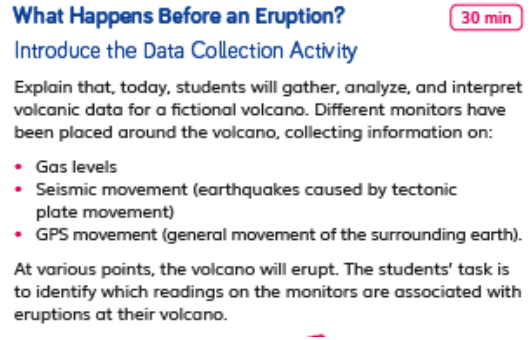
In answering this question, you will need to demonstrate your understanding of:

MS-ESS3-2 Earth and Human Activity
• How to analyze and interpret data to determine similarities and differences (SEP-4) • How geologic features can help forecast the likelihood of dangerous future events (ESS3.B) • How graphs, charts, and images can be used to identify patterns in data. (CCC-1)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

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Dangerous Volcanoes Teacher Rubric



What Happens Before an Eruption? 30 min

Introduce the Data Collection Activity

Explain that, today, students will gather, analyze, and interpret volcanic data for a fictional volcano. Different monitors have been placed around the volcano, collecting information on:

- Gas levels
- Seismic movement (earthquakes caused by tectonic plate movement)
- GPS movement (general movement of the surrounding earth).

At various points, the volcano will erupt. The students' task is to identify which readings on the monitors are associated with eruptions at their volcano.

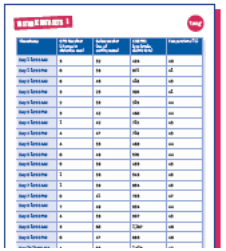
L3 S1 What Happens Before an Eruption?, TE p. 84

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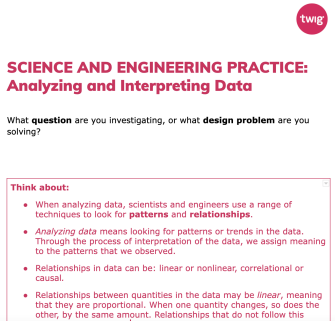
Analyze and Interpret Data

Ask teams to assign the correct period to each of the **Historic Dataset handout** pages (ten days before, two months before, six months before, or several years before).

Have them arrange their pages in order and record this on page 105 in their Twig Journals. Reveal the



L3 S3 Analyze and Interpret Data, TE p. 95



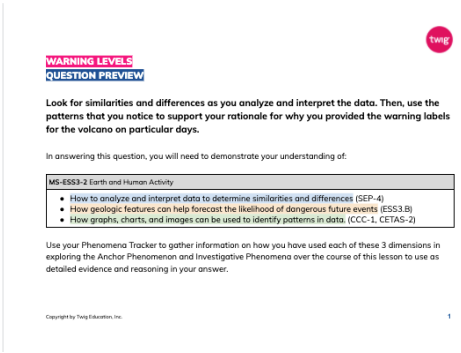
SCIENCE AND ENGINEERING PRACTICE:
Analyzing and Interpreting Data

What **question** are you investigating, or what **design problem** are you solving?

Think about:

- When analyzing data, scientists and engineers use a range of techniques to look for **patterns** and **relationships**.
- *Analyzing data* means looking for patterns or trends in the data. Through the process of interpretation of the data, we assign meaning to the patterns that we observed.
- Relationships in data can be: linear or nonlinear, correlational or causal.
- Relationships between quantities in the data may be *linear*, meaning that they are proportional. When one quantity changes, so does the other, by the same amount. Relationships that do not follow this

Analyzing and Interpreting Data handout



WARNING LEVELS
QUESTION PREVIEW

Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days.

In answering this question, you will need to demonstrate your understanding of:

MS-ESS3-2 Earth and Human Activity
• How to analyze and interpret data to determine similarities and differences (SEP-4) • How geologic features can help forecast the likelihood of dangerous future events (ESS3.B) • How graphs, charts, and images can be used to identify patterns in data. (CCC-1, CETAS-2)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

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Warning Levels Teacher Rubric

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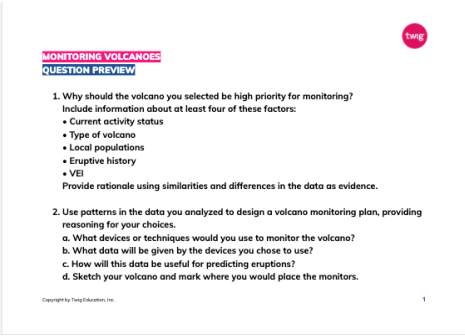
Analyze Hazard Risks

Have students meet in small teams. Distribute the **Undermonitored Volcanoes handout**.

Ask teams to identify one volcano from the dataset they think should be prioritized for monitoring. They should consider:



L3 S5 Analyze Hazard Risks, p. 103



MONITORING VOLCANOES
QUESTION PREVIEW

1. Why should the volcano you selected be high priority for monitoring?
   Include information about at least four of these factors:
   - Current activity status
   - Type of volcano
   - Local populations
   - Eruptive history
   - VEI

   Provide rationale using similarities and differences in the data as evidence.

2. Use patterns in the data you analyzed to design a volcano monitoring plan, providing reasoning for your choices.
   a. What devices or techniques would you use to monitor the volcano?
   b. What data will be given by the devices you chose to use?
   c. How will this data be useful for predicting eruptions?
   d. Sketch your volcano and mark where you would place the monitors.

Monitoring Volcanoes Teacher Rubric

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Specific elements of DCI(s)

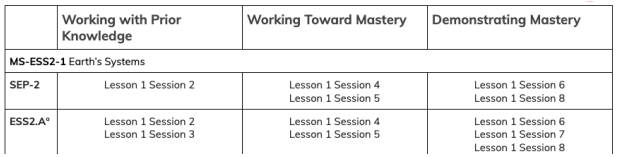
In Volcano Hunters, students are provided with opportunities to develop and use the following DCI elements:

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (ESS2.A)[a]
- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (ESS3.B)

[a]Energy flows within living organisms is mastered in the Future Food module. Energy flows within the atmosphere and hydrosphere are mastered in the The Great Air Race and Model Earth modules.

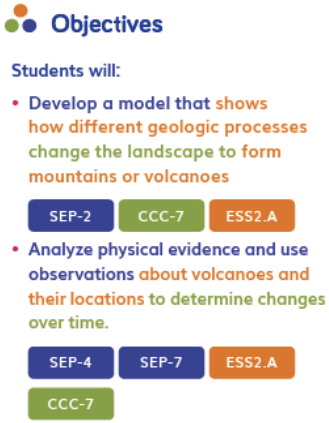
How they are developed and used to make sense of phenomena

Development of the DCI elements over the lesson and/or module is clearly set out in the online Performance Expectation Progressions, which show the sessions where students are working with prior knowledge of the dimension, where they are working toward grade level, and where they are working at grade level. For example, the



	Working with Prior Knowledge	Working Toward Mastery	Demonstrating Mastery
MS-ESS2-1 Earth's Systems			
SEP-2	Lesson 1 Session 2	Lesson 1 Session 4 Lesson 1 Session 5	Lesson 1 Session 6 Lesson 1 Session 8
ESS2.A[a]	Lesson 1 Session 2 Lesson 1 Session 3	Lesson 1 Session 4 Lesson 1 Session 5	Lesson 1 Session 6 Lesson 1 Session 7 Lesson 1 Session 8

Online Performance Expectation Progressions



L1 S8 Objectives, TE p. 46

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online Performance Expectation Progressions for Volcano Hunters indicate that students are working with prior knowledge of ESS2.A in L1 S2, working toward grade level mastery in L1 S4, and working at grade level in L1 S6.

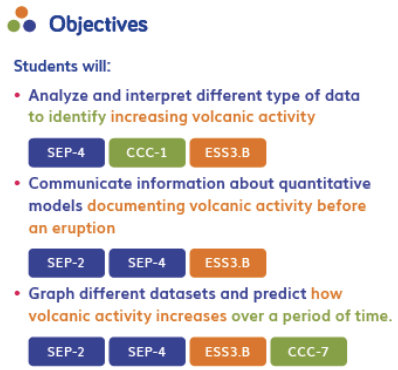
In relevant sessions, students' engagement with the DCI elements is highlighted for the teacher in the Objectives (e.g., L1 S8, L3 S3).

In L1, students are developing mastery of the DCI element aligned with **MS-ESS2-1**:

- **ESS2.A**: All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.[a]

[a]Energy flows within living organisms is mastered in the Future Food module. Energy flows within the atmosphere and hydrosphere are mastered in the The Great Air Race and Model Earth modules.

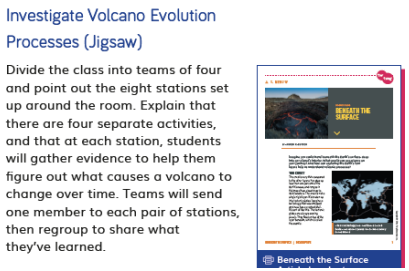
Students begin engaging with the dimension in L1 S2 as they use information from the **Volcano Explorer digital interactive** and a scientific text to explain how volcanoes form, thinking about the flow of energy. They build on this in L1 S3, where they complete one of several stations looking at landscape changes (e.g., erosion, deposition) and consider the energy that drives these processes.



L3 S3 Objectives, TE p. 91



L1 S2 Observe the Investigative Phenomenon (Session 2), TE p. 18



L1 S3 Investigate Volcano Evolution Processes (Jigsaw), TE p. 24

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In L1 S3, teachers are prompted to support students who are working below grade level in developing understanding of the dimension by playing the **Erosion and Weathering video**.

In L1 S4–6, students explore and model rock cycle processes, thinking about how energy flows and matter cycles among the Earth's systems and identifying the sources of energy. They record these processes on their landscape models, which are assessed in L1 S5 (**Different Types of Rocks Teacher Rubric**). As highlighted in the rubric, this formative assessment deliberately does not address the "chemical and physical" portion of the dimension, but establishes students' understanding of the other aspects, providing a scaffolded approach to mastery of the DCI element. The Pedagogical Support sidebar in L1 S6 supports teachers to reinforce how energy flows and the cycling of matter drive the transformations of the rock cycle, and the Below-Level Learners sidebar provides video supports (e.g., **Rock Cycles video**) for students working below grade level.

In L1 S7, students investigate the changes that happened to a single volcano across several thousands of years. They develop models that show how matter cycled through the landscape.

Finally, in L1 S8, students develop models and construct explanations about the processes and physical and chemical changes that result in different rock types, including information about

Below-Level Learners

Scaffold Stations 5 and 6 for students by playing the **Erosion and Weathering video.**

L1 S3 Below-Level Learners sidebar, TE p. 24

Describe the Investigative Phenomenon (Session 4)

Display the **Rock Models visual**. Explain that each of the rocks were found at a different location.

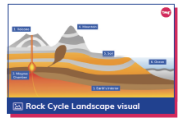


- ***What do you observe about these rocks?***
  They all look different
  Some contain different colors or materials.
- ***How might these rocks have been formed? What makes you think that?***
  The rock at Location 1 looks like it's made up of lots

L1 S4 Describe the Investigative Phenomenon, TE p. 29

Investigate Geologic Processes

Display the **Rock Cycle Landscape visual**. Explain that this is the same landscape model students saw in the previous session. However, point out the six labels on the visual and point out the corresponding stations set up



L1 S5 Investigate Geologic Processes, TE p. 34

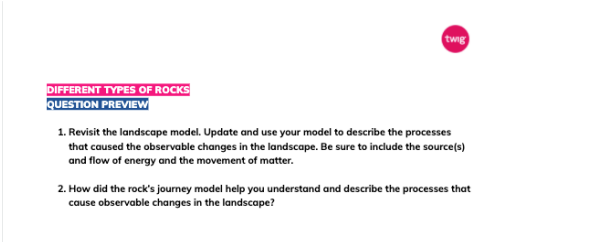
3-D Assessment • Revisit the landscape model on page 33. Update and use your model to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter.

How did the rock's journey model help you understand and describe the processes that cause observable changes in the landscape?

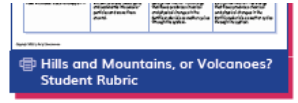
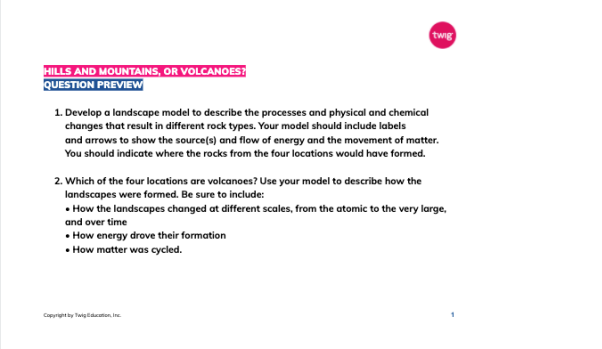
Modeling the rock's journey helped me observe processes that are very hard to see because they are so tiny (like chemical weathering) or so big like a volcano erupting.

L1 S5 3-D Assessment, TJ p. 37

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	the sources and flow of energy and the movement of matter. The teacher assesses their mastery of the dimension using the **Hills and Mountains, or Volcanoes? Teacher Rubric**. The rubric makes it clear that some parts of the dimension ("and living organisms") are addressed separately, in a later module. In L2 and L3, students are developing mastery of the DCI element aligned with **MS-ESS3-2**: • **ESS3.B**: Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. Students begin engaging with the dimension in L2 S1, where they make observations of model eruptions from different volcanoes and think about how dangerous each volcano is. They continue their explorations in L2 S2–3 as they conduct hands-on investigations and use the **Volcano Builder digital interactive** to investigate the relationship between lava type, gas content, and eruptive behavior, and to think about how lava type and gas content might affect a future eruption. In L2 S4–5, students obtain information from texts to develop their understanding of volcanic hazards and to begin to consider methods to forecast the likelihoods of future eruptions. In L2 S6, students provide evidence from the	 DIFFERENT TYPES OF ROCKS QUESTION PREVIEW 1. Revisit the landscape model. Update and use your model to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter. 2. How did the rock's journey model help you understand and describe the processes that cause observable changes in the landscape? Different Types of Rocks Teacher Rubric **Pedagogical Support—Disciplinary Core Ideas** **Earth's Materials and Systems** As students read the text and complete the graphic organizer, they should consider how energy transfers from the Sun and matter cycles in the Earth's hot interior drive the transformations of the rock cycle. L1 S6 Pedagogical Support—Disciplinary Core Ideas sidebar, TE p. 38 **Below-Level Learners** Support students by playing the **Sedimentary Rock Glossary video**, **Igneous Rock Glossary video**, and **Metamorphic Rock Glossary video** before they take part in the language routine. Then, support students by playing the **Rock Cycles video** as they develop their models. L1 S6 Below-Level Learners sidebar, TE p. 39 Critically Read the Scientific Text In this session, students will learn about another volcano that left a lasting mark on the US landscape: Mount Mazama in Oregon. Ask students to read the "Life and Times of Mount Mazama" article on pages 50–52 in their Twig Journals. Their L1 S7 Critically Read the Scientific Text, TE p. 43

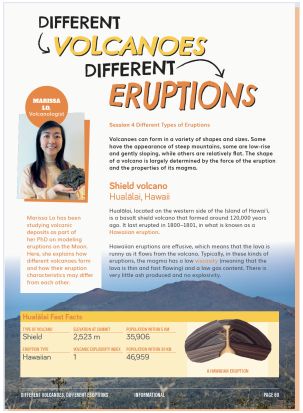
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	lesson to support the claim: Some volcanoes are more dangerous than others. Their work is assessed (**Dangerous Volcanoes Teacher Rubric**) at this midway stage so that the teacher can provide feedback and future support as needed. Teachers are prompted to support students who are working below grade level in developing understanding of the dimension by playing the **What Is a Volcano? video**. In L3 S1, students complete a video lab to collect and analyze volcanic data during eruptive and non-eruptive periods, thinking about how data can forecast the likelihood of an eruption. Teachers are prompted to support students who are working below grade level in developing understanding of the dimension by playing the **Volcanic Eruptions video**. In L3 S2, students obtain information from texts about tools and techniques used by volcanologists to monitor volcanic activity and forecast future events. The Pedagogical Support sidebar in L3 S2 clarifies how students use their understanding of the SEP and CCC to develop their understanding of the DCI. The Below-Level Learners sidebar offers additional supports (**Monitor Placement visual**) for students working below grade level in attaining understanding of the DCI. Students go on to analyze and interpret volcanic data in L3 S3–4, applying warning levels to periods in the dataset according to eruptive risk.	Develop Models  Hills and Mountains, or Volcanoes? Student Rubric Have students turn to page 58 in their Twig Journals. Ask them to develop and use a model to describe how the different rocks found at the four different sites could have formed. **L1 S8 Develop Models, TE p. 48** 3-D Assessment • Develop a landscape model to describe the processes and physical and chemical changes that result in different rock types. Your model should include labels and arrows to show the source(s) and flow of energy and the movement of matter. You should indicate where the rocks from the four locations would have formed. **L1 S8 3-D Assessment, TJ p. 58**  HILLS AND MOUNTAINS, OR VOLCANOES? QUESTION PREVIEW 1. Develop a landscape model to describe the processes and physical and chemical changes that result in different rock types. Your model should include labels and arrows to show the source(s) and flow of energy and the movement of matter. You should indicate where the rocks from the four locations would have formed. 2. Which of the four locations are volcanoes? Use your model to describe how the landscapes were formed. Be sure to include: • How the landscapes changed at different scales, from the atomic to the very large, and over time • How energy drove their formation • How matter was cycled. **Hills and Mountains, or Volcanoes? Teacher Rubric**

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	In L3 S3, teachers are prompted to use the **Analyzing and Interpreting Data handout** to support students struggling to interpret the historic data, and, in L3 S4, teachers are prompted to support students who are working below grade level in developing understanding of the dimension by playing the **Predicting Volcanic Eruptions video**. Students' work is assessed (**Warning Levels Teacher Rubric**) in L3 S4 so that the teacher can provide feedback and future support as needed. In L3 S5–6, students analyze data to determine which of a set of volcanoes they think should be prioritized for additional monitoring, considering factors including activity status, volcano type, and eruptive history. They write a monitoring plan to justify their choice, outlining the various tools and techniques they would use and how these methods would help in predicting eruptions. Their plans are assessed with the **Monitoring Volcanoes Teacher Rubric**. Teachers are prompted to support students who are working below grade level in developing understanding of the dimension by playing the **Volcanoes: LECD Response video** and the **Volcanoes: MEDC Response video**. These examples show how students have opportunities to develop and use elements of the DCIs over the course of the module.	Model Eruptions Explain that students will observe two different models of eruptions. One model will be of the Auckland volcanic field and the other will be of a Merapi eruption. Have students move to the outdoor location you chose for the activity and ask them to put on their safety goggles. Complete these steps, first with the Auckland model and then with the Merapi model. 1. Ask a volunteer to gently shake the bottle. 2. Place the bottle on the plastic table cover. 3. Hold the bottle firmly and quickly open it, keeping your face away from the opening. Have students write their observations on page 64 in their Twig Journals. • ***What happened in the Auckland model?*** The cola fizzed up quickly, and some of it came out of the bottle. Some of the cola was frothy, but it was still very runny. There was still a lot of cola left in the bottle after the eruption. The eruption was not very explosive. **L2 S1 Model Eruptions, TE p. 56** **Plan and Carry Out Investigations** • Follow these steps to investigate how lava behaves. **Investigation 1: Steepness of Slope** 1. Place the plastic table cover on your work area. Use books and a flat surface to set up a shallow slope on top of the cover. 2. Pour 1 tbsp of your assigned liquid from the top of the slope. a. Time how long it takes for the liquid to reach the bottom of the slope. b. Use a ruler to measure how far the liquid travels. c. Record the time and distance in the Measurements column. 3. Add books to raise the height of your slope, creating a medium slope. **L2 S2 Plan and Carry Out Investigations, TJ p. 65**

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L2 S4 “Different Volcanoes, Different Eruptions” article, TJ pp. 69–73

Record Research

Distribute copies of the **Dangers of Volcanoes handout** and encourage students to refer to this and their Twig Journals.



Invite students to use the graphic organizer on page 87 in their Twig Journals to collect the evidence and reasoning for their scientific arguments.

L2 S6 Record Research, TE, p. 77

Below-Level Learners

Support students who are still struggling with understanding volcanic hazards by playing the **What Is a Volcano? video.**

L2 S6 Below-Level Learners sidebar, TE p. 78

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What Happens Before an Eruption? 30 min

Introduce the Data Collection Activity

Explain that, today, students will gather, analyze, and interpret volcanic data for a fictional volcano. Different monitors have been placed around the volcano, collecting information on:

- Gas levels
- Seismic movement (earthquakes caused by tectonic plate movement)
- GPS movement (general movement of the surrounding earth).

At various points, the volcano will erupt. The students' task is to identify which readings on the monitors are associated with eruptions at their volcano.

L3 S1 Introduce the Data Collection Activity, TE, p. 84

Below-Level Learners

Support students by playing the **Volcanic Eruptions video** before they observe the visual.

L3 S1 Below-Level Learners sidebar, TE p. 83

Obtain Information • Complete the chart for each of the monitoring techniques explained in the blog posts.

Equipment/Technique	Data Output	Summary
Seismometer	Number/strength of earthquakes	*Students should summarize the key points from their text to use in the pros and cons comparison.*
GPS Receiver	Change in ground movement	

L3 S2 Obtain Information, TJ p. 96

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Pedagogical Support—Disciplinary Core Ideas

Natural Hazards

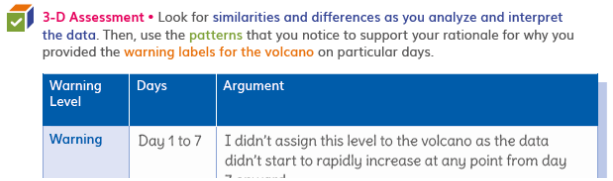
As students participate in the language routine, they will need to connect the data they've analyzed and the patterns they've identified throughout Lessons 2 and 3 to the idea of forecasting.

L3 S2 Pedagogical Support—Disciplinary Core Ideas sidebar, TE p. 90

Below-Level Learners

Use the **Monitor Placement visual** and encourage students to place different devices onto the volcano map. They can add more than one device to each slot on the map. As students place their monitors, ask them to provide one reason why they have made their choice.

L3 S2 Below-Level Learners sidebar, TE p. 90

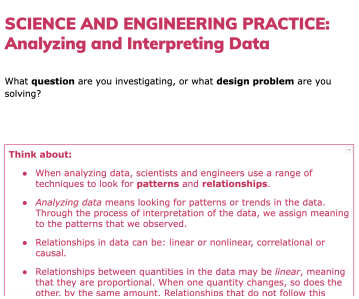


3-D Assessment • Look for **similarities and differences as you analyze and interpret the data**. Then, use the **patterns** that you notice to support your rationale for why you provided the **warning labels for the volcano** on particular days.

Warning Level	Days	Argument
Warning	Day 1 to 7	I didn't assign this level to the volcano as the data didn't start to rapidly increase at any point from day

L3 S4 3-D Assessment, TJ, p. 110

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SCIENCE AND ENGINEERING PRACTICE:
Analyzing and Interpreting Data

What **question** are you investigating, or what **design problem** are you solving?

Think about:

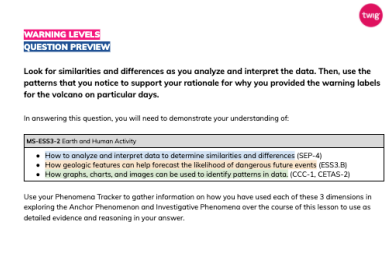
- When analyzing data, scientists and engineers use a range of techniques to look for **patterns** and **relationships**.
- *Analyzing data* means looking for patterns or trends in the data. Through the process of interpretation of the data, we assign meaning to the patterns that we observed.
- Relationships in data can be: linear or nonlinear, correlational or causal.
- Relationships between quantities in the data may be *linear*, meaning that they are proportional. When one quantity changes, so does the other, by the same amount. Relationships that do not follow this

Analyzing and Interpreting Data handout

Below-Level Learners

Scaffold the activity for students by playing the **Predicting Volcanic Eruptions video.**

L3 S4 Below-Level Learners sidebar, TE p. 97



WARNING LEVELS
QUESTION PREVIEW

Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days.

In answering this question, you will need to demonstrate your understanding of:

MS-ESS3-2 Earth and Human Activity

- How to analyze and interpret data to determine similarities and differences (SEP-4)
- How geologic features can help forecast the likelihood of dangerous future events (ESS3.B)
- How graphs, charts, and images can be used to identify patterns in data. (CCC-1, CETAS-2)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

Warning Levels Teacher Rubric

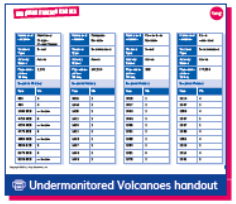
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Summative Assessment: 30 min

Identifying Undermonitored Volcanoes

Analyze Hazard Risks

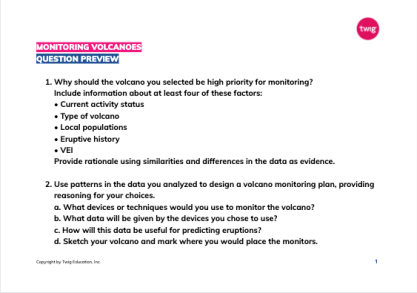
Have students meet in small teams. Distribute the **Undermonitored Volcanoes handout**.



Ask teams to identify one volcano from the dataset they think should be prioritized for monitoring. They should consider:

- The activity status of the volcano
- The type of volcano
- The local population
- The eruptive history.

L3 S5 Analyze Hazard Risks, TE, p. 103



MONITORING VOLCANOES
QUESTION PREVIEW

1. Why should the volcano you selected be high priority for monitoring?
   Include information about at least four of these factors:
   - Current activity status
   - Type of volcano
   - Local populations
   - Eruptive history
   - VEI

   Provide rationale using similarities and differences in the data as evidence.

2. Use patterns in the data you analyzed to design a volcano monitoring plan, providing reasoning for your choices.
   a. What devices or techniques would you use to monitor the volcano?
   b. What data will be given by the devices you chose to use?
   c. How will this data be useful for predicting eruptions?
   d. Sketch your volcano and mark where you would place the monitors.

Monitoring Volcanoes Teacher Rubric

Below-Level Learners

Support students' understanding of volcano monitoring with the **Volcanoes: LECD Response video** and the **Volcanoes: MEDC Response video.**

L3 S6 Below-Level Learners sidebar, TE p. 106

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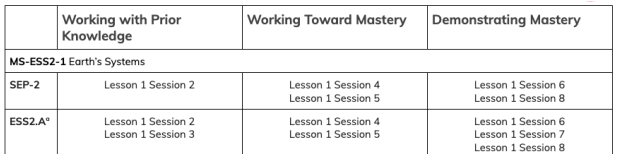
Specific elements of CCC(s)

In Volcano Hunters, students are provided with opportunities to develop and use the following CCC elements:

- Graphs, charts, and images can be used to identify patterns in data. (CCC-1)
- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (CCC-7)
- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (CETAS-2)

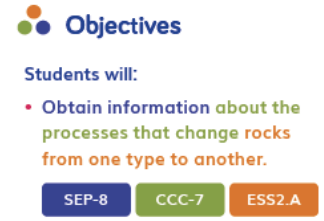
How they are developed and used to make sense of phenomena

Development of the CCC elements over the lesson and/or module is clearly set out in the online Performance Expectation Progressions, which show the sessions where students are working with prior knowledge of the dimension, where they are working toward grade level, and where they are working at grade level. For example, the online Performance Expectation Progressions for Volcano Hunters indicate that students are

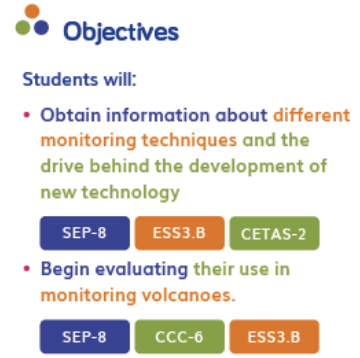


	Working with Prior Knowledge	Working Toward Mastery	Demonstrating Mastery
MS-ESS2-1 Earth's Systems			
SEP-2	Lesson 1 Session 2	Lesson 1 Session 4 Lesson 1 Session 5	Lesson 1 Session 6 Lesson 1 Session 8
ESS2.A°	Lesson 1 Session 2 Lesson 1 Session 3	Lesson 1 Session 4 Lesson 1 Session 5	Lesson 1 Session 6 Lesson 1 Session 7 Lesson 1 Session 8

Online Performance Expectation Progressions

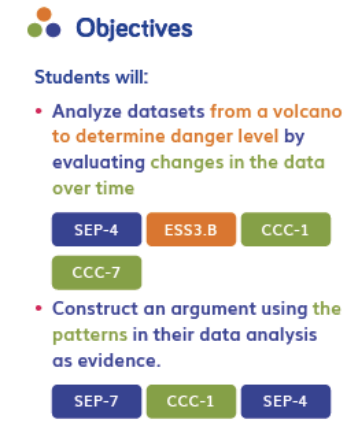
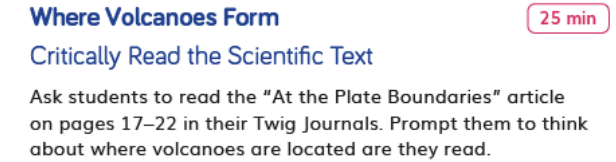
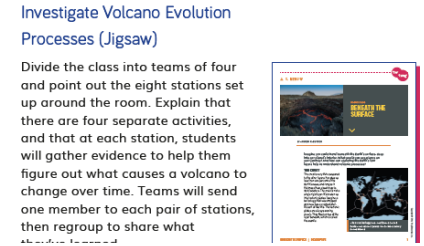


L1 S6 Objectives, TE p. 37



L3 S2 Objectives, TE p. 87

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	working with prior knowledge of CCC-7 in L1 S2, working toward grade level mastery in L1 S4, and working at grade level in L1 S6. In relevant sessions, students' engagement with the CCC elements is highlighted for the teacher in the Objectives (e.g., L1 S6, L3 S2, L3 S4). In L1, students are developing mastery of the CCC element aligned with **MS-ESS2-1**: • **CCC-7**: Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. Students begin engaging with the dimension in L1 S2 as they use information from the **Volcano Explorer digital interactive** and a scientific text to explain how volcanoes form. They build on this in L1 S3, where they complete one of several stations looking at types of change in the landscape (e.g., erosion, deposition). Teachers are prompted to use the **Stability and Change handout** to support students who are struggling with the concept of slow or fast changes over different timescales. In L1 S4–6, students explore and model rock cycle processes, considering how these change rocks over time. They record these processes on their landscape models, which are assessed in L1 S5 (**Different Types of Rocks Teacher Rubric**). As	 L3 S4 Objectives, TE p. 96  L1 S2 Critically Read the Scientific Text, p. 19  L1 S3 Investigate Volcano Evolution Processes (Jigsaw), TE p. 24

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highlighted in the rubric, this formative assessment deliberately does not address the "at different scales, including the atomic scale" portion of the dimension, but establishes students' understanding of the other aspects, providing a scaffolded approach to mastery of the CCC element.

In L1 S6, teachers are supported to connect students' learning to CCC-7 through prompt questions about stability and change, time span, and observability.

In L1 S7, students investigate the changes that happened to a single volcano across several thousands of years. They use the **Stronger and Clearer Each Time language routine** to cement their ideas around change and stability, processes of change, and speed of change in the context of Mount Mazama.

Finally, in L1 S8, students construct explanations that include how given landscapes changed over time and at different scales, from the atomic to the very large. The teacher assesses their mastery of the dimension using the **Hills and Mountains, or Volcanoes? Teacher Rubric**.

In L2 and L3, students are developing mastery of the CCC elements aligned with **MS-ESS3-2**:

- **CCC-1**: Graphs, charts, and images can be used to identify patterns in data.
- **CETAS-2**: The uses of technologies and any limitations on their use are driven by

CROSSCUTTING CONCEPT: Stability and Change

What **question** are you investigating, or what **design problem** are you solving?

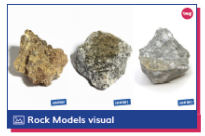
Think about:

- *Stability* refers to when part of a system seems to be stable or unchanging.
- The physical or time **scale** of observation affects whether parts of a system appear stable or changing.
- Time scales ranging from less than a second to billions of years can be helpful for examining or **explaining** systems.
- The physical scale can range from very small (e.g., the atomic scale) to massive (e.g., the scale of whole galaxies).

Stability and Change handout

Describe the Investigative Phenomenon (Session 4)

Display the **Rock Models visual**. Explain that each of the rocks were found at a different location.

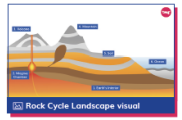


- ***What do you observe about these rocks?***
  They all look different
  Some contain different colors or materials.
- ***How might these rocks have been formed? What makes***

L1 S4 Describe the Investigative Phenomenon (Session 4), TE p. 29

Investigate Geologic Processes

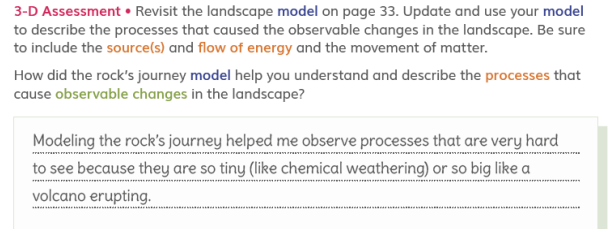
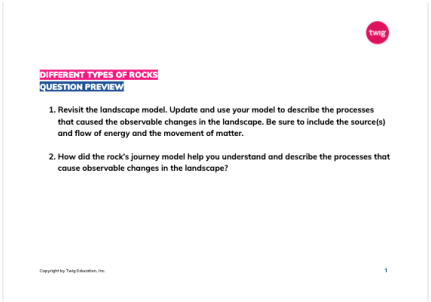
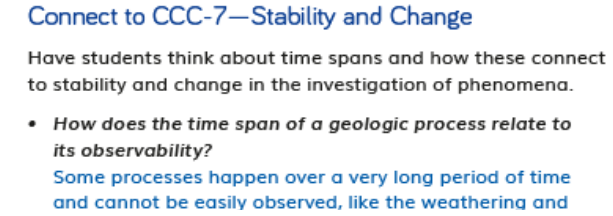
Display the **Rock Cycle Landscape visual**. Explain that this is the same landscape model students saw in the previous session. However, point out the six labels on the visual and point out the corresponding stations set up around the classroom.



- ***What environmental processes are occurring at each station?***

L1 S5 Investigate Geologic Processes, TE p. 34

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	individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. Students begin engaging with the dimensions in L2 S2, where they identify patterns in the behavior of different-viscosity liquids. They continue their explorations in L2 S3 as they use the **Volcano Builder digital interactive** to investigate patterns between lava type and eruptive behavior. In L2 S4, students obtain information from text and identify patterns between volcanic features and level of potential risk. Teachers are also prompted to use the **Patterns handout** to support students who are struggling to identify common features of the most and least dangerous volcanoes. In L2 S4–5, students also engage with CETAS-2 as they learn more about the dangers of eruptions and the societal need for predicting them. In L2 S5, they additionally consider the financial aspects of monitoring, learning that funding for this was significantly increased after the 1980 eruption of Mount St. Helens. In L2 S6, students analyze pie charts and data tables relating to the eruptive history and risk of different volcanoes, and use these and evidence from the lesson to support the claim: Some volcanoes are more dangerous than others. Their	 3-D Assessment • Revisit the landscape model on page 33. Update and use your model to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter. How did the rock's journey model help you understand and describe the processes that cause observable changes in the landscape? Modeling the rock's journey helped me observe processes that are very hard to see because they are so tiny (like chemical weathering) or so big like a volcano erupting. L1 S5 Formative Assessment, TJ p. 37  DIFFERENT TYPES OF ROCKS QUESTION PREVIEW 1. Revisit the landscape model. Update and use your model to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter. 2. How did the rock's journey model help you understand and describe the processes that cause observable changes in the landscape? Different Types of Rocks Teacher Rubric  Connect to CCC-7—Stability and Change Have students think about time spans and how these connect to stability and change in the investigation of phenomena. • *How does the time span of a geologic process relate to its observability?* Some processes happen over a very long period of time and cannot be easily observed, like the weathering and L1 S6 Connect to CCC-7—Stability and Change, TE p. 40

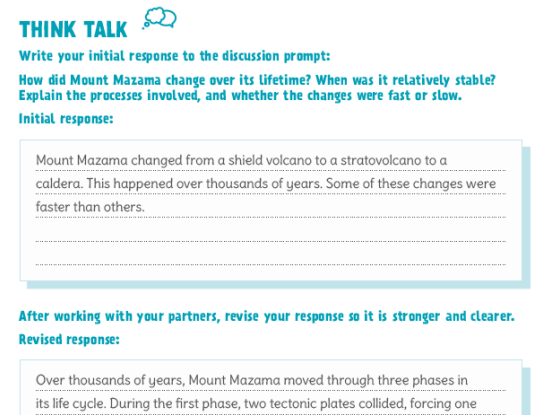
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work is assessed (**Dangerous Volcanoes Teacher Rubric**) at this midway stage so that the teacher can provide feedback and future support as needed.

In L3 S1–4, students continue to develop and use CCC-1 as they analyze current and historic volcanic data, creating graphs of the data and using these to identify patterns between measurements and volcanic behavior. In L3 S3, teachers are prompted to use the **Patterns handout** to support students who struggle to identify patterns in data and, in L3 S4, students' work is assessed (**Warning Levels Teacher Rubric**) so that the teacher can provide feedback and future support as needed.

In these sessions, students also develop and use CETAS-2 as they are introduced to different types of tools and techniques for monitoring volcanoes and the limitations on their use.

In L3 S5–6, students further develop and use CETAS-2 as they watch the **Undermonitored Volcanoes video**, understanding how the use of monitoring technologies varies between regions and the reasons for this (e.g., financial constraints, societal needs). They use CETAS-2 and CCC-1 as they use pie charts and data tables to identify patterns and determine which of a set of volcanoes they think should be prioritized for additional monitoring. They write a monitoring plan to justify their choice, which is assessed with the **Monitoring Volcanoes Teacher Rubric**.



THINK TALK

Write your initial response to the discussion prompt:

How did Mount Mazama change over its lifetime? When was it relatively stable? Explain the processes involved, and whether the changes were fast or slow.

Initial response:

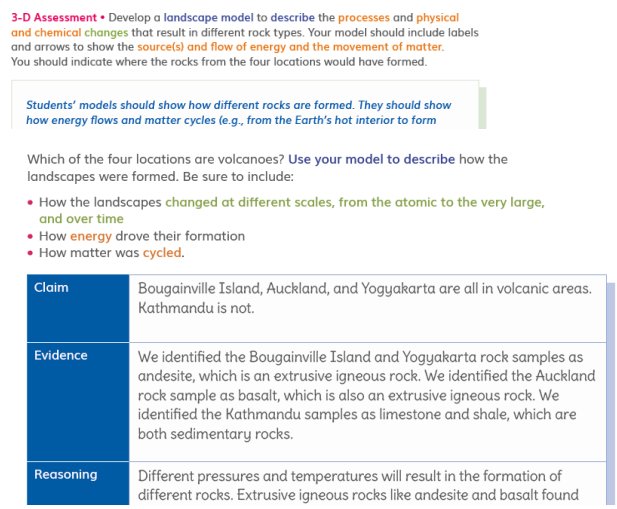
Mount Mazama changed from a shield volcano to a stratovolcano to a caldera. This happened over thousands of years. Some of these changes were faster than others.

After working with your partners, revise your response so it is stronger and clearer.

Revised response:

Over thousands of years, Mount Mazama moved through three phases in its life cycle. During the first phase, two tectonic plates collided, forcing one

L1 S7 Think Talk, TJ p. 55



3-D Assessment • Develop a landscape model to describe the processes and physical and chemical changes that result in different rock types. Your model should include labels and arrows to show the source(s) and flow of energy and the movement of matter. You should indicate where the rocks from the four locations would have formed.

Students' models should show how different rocks are formed. They should show how energy flows and matter cycles (e.g., from the Earth's hot interior to form

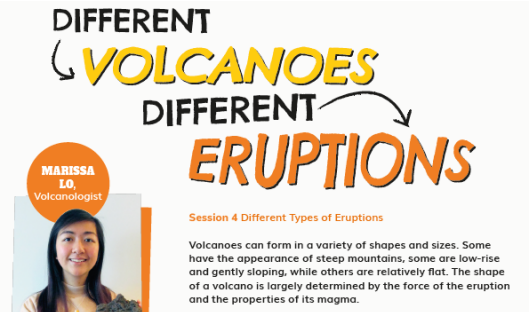
Which of the four locations are volcanoes? Use your model to describe how the landscapes were formed. Be sure to include:

- How the landscapes changed at different scales, from the atomic to the very large, and over time
- How energy drove their formation
- How matter was cycled.

Claim	Bougainville Island, Auckland, and Yogyakarta are all in volcanic areas. Kathmandu is not.
Evidence	We identified the Bougainville Island and Yogyakarta rock samples as andesite, which is an extrusive igneous rock. We identified the Auckland rock sample as basalt, which is also an extrusive igneous rock. We identified the Kathmandu samples as limestone and shale, which are both sedimentary rocks.
Reasoning	Different pressures and temperatures will result in the formation of different rocks. Extrusive igneous rocks like andesite and basalt found

L1 S8 Summative Assessment, TJ pp. 58–59

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	These examples show how students have opportunities to develop and use elements of the CCCs over the course of the module.	Investigate Lava Types Divide students into teams of four and distribute materials. Have teams read the instructions on pages 65–66 in their Twig Journals. Then have them complete the three investigations into the effects of viscosity, tephra, and slope on lava flow, and record their observations on pages 65–66 in their Twig Journals. Confirm that *viscosity* refers to how easily a liquid flows, and affects how quickly the liquid moves. *Tephra* refers to any solid material erupted from a volcano. **L2 S2 Investigate Lava Types, TE p. 61** **What Makes Eruptions Explosive?** 25 min Explore Explosivity with the Digital Interactive Have students meet in small teams and explore the **Volcano Builder Level 2 digital interactive**. Prompt them to select different amounts of gas for their eruptions.  Ask students to record their observations on page 67 in their Twig Journals. **L2 S3 Explore Explosivity with the Digital Interactive, TE p. 65**  **L2 S4 Different Volcanoes Different Eruptions, TJ p. 69**

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CROSSCUTTING CONCEPT: Patterns

What **question** are you investigating, or what **design problem** are you solving?

Think about:

- Patterns can be used to identify cause and effect relationships.
- A *pattern* is something that is repeated or happens in a regular, predictable way.
- Visual representations (such as charts, images, and graphs) can be used to identify patterns in data.
- Patterns observed at the macroscopic (large) scale relate to the microscopic or atomic scale in the same system.
- Patterns in relationships expressed in numbers (such as how quickly changes occur) can give us information about natural systems.

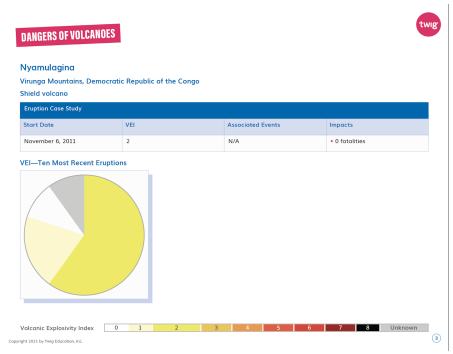
Patterns handout

Obtain Information • Complete the graphic organizer using information from the "Mount St. Helens Erupts: Washington, May 1980" article.

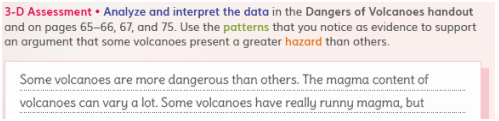
Mount St. Helens Eruption	Characteristics
What were the impacts of the eruption?	Fifty-seven people died and many more were injured. Ash and dust were spread over large parts of the United States. People could not travel due to the disruption. Smaller disasters, like mudslides, continued to happen after the eruption. The surrounding forests and rivers were altered significantly, resulting in large losses of timber and fish. A lot of money was lost due to the damage. The government invested more money in the USGS, creating opportunities to expand the study of volcanoes. More money went into researching and monitoring active sites, like Mount Hood and other volcanoes in the Cascades.

L2 S5 Obtain Information, TJ p. 83

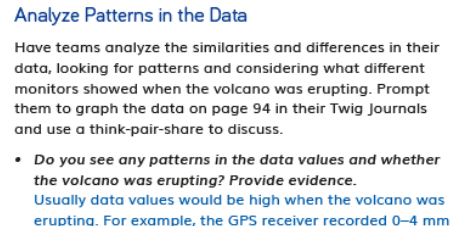
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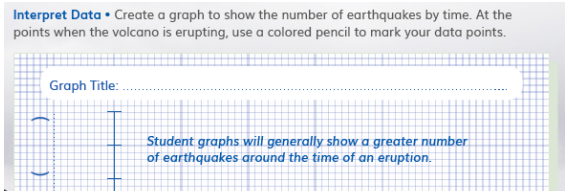
Dangers of Volcanoes handout



L2 S6 3-D Assessment, TE p. 78



L3 S1 Analyze Patterns in the Data, TE p. 85



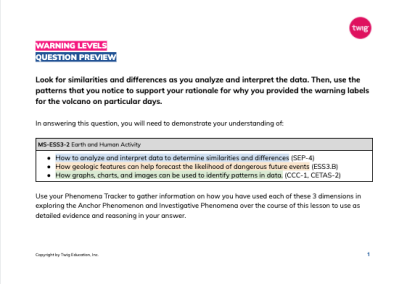
L3 S1 Interpret Data, TJ p. 94

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3-D Assessment • Look for **similarities and differences as you analyze and interpret the data**. Then, use the **patterns** that you notice to support your rationale for why you provided the **warning labels for the volcano** on particular days.

Warning Level	Days	Argument
Warning	Day 1 to 7	I didn't assign this level to the volcano as the data didn't start to rapidly increase at any point from day

L3 S4 3-D Assessment, TJ p. 110



WARNING LEVELS
QUESTION PREVIEW

Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days.

In answering this question, you will need to demonstrate your understanding of:

MS-ESS3-2 Earth and Human Activity

- How to analyze and interpret data to determine similarities and differences (SEP-4)
- How geologic features can help forecast the likelihood of dangerous future events (ESS3.B)
- How graphs, charts, and images can be used to identify patterns in data. (CCC-1, CETAS-2)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

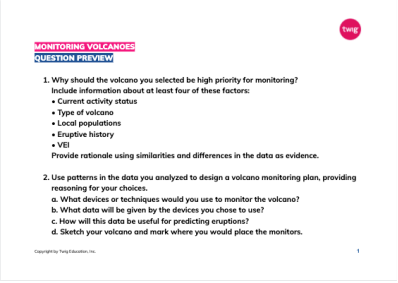
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Warning Levels Teacher Rubric

Identify Patterns • Choose one volcano from the **Undermonitored Volcanoes handout** that you think should be closely monitored, then fill out the graphic organizer.

Name and Location	Alayta, Ethiopia	*Student answers will vary depending on which volcano they choose from the dataset.*
Type of Volcano	Shield	
Activity Status	Active	
Population	70,513	
Last Known Eruption	1915	
Frequency of Eruptions	2	
Average VEI	2	

L3 S5 Identify Patterns, TJ p. 112



MONITORING VOLCANOES
QUESTION PREVIEW

1. **Why should the volcano you selected be high priority for monitoring?**
   Include information about at least four of these factors:
   - **Current activity status**
   - **Type of volcano**
   - **Local populations**
   - **Eruptive history**
   - **VEI**

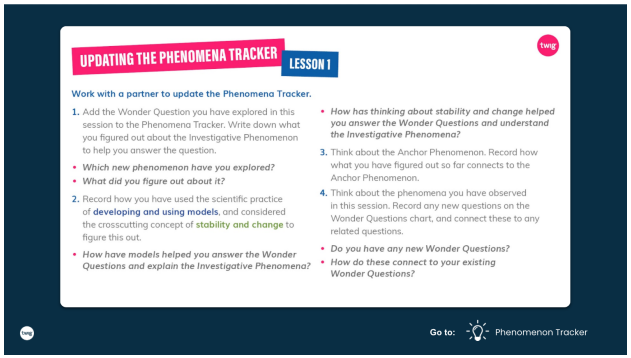
   Provide rationale using similarities and differences in the data as evidence.

2. **Use patterns in the data you analyzed to design a volcano monitoring plan, providing reasoning for your choices.**
   a. **What devices or techniques would you use to monitor the volcano?**
   b. **What data will be given by the devices you chose to use?**
   c. **How will this data be useful for predicting eruptions?**
   d. **Sketch your volcano and mark where you would place the monitors.**

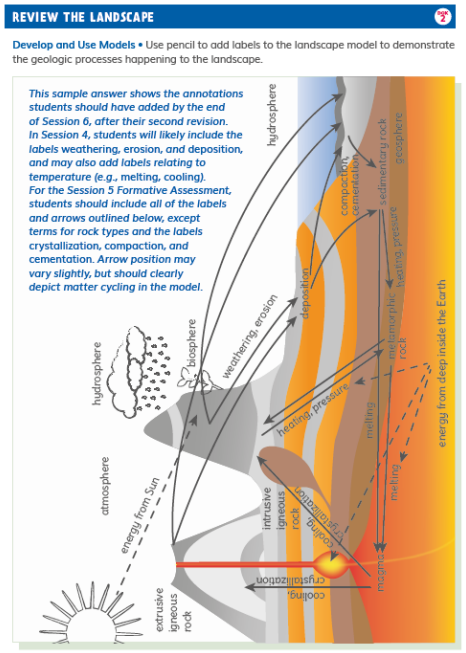
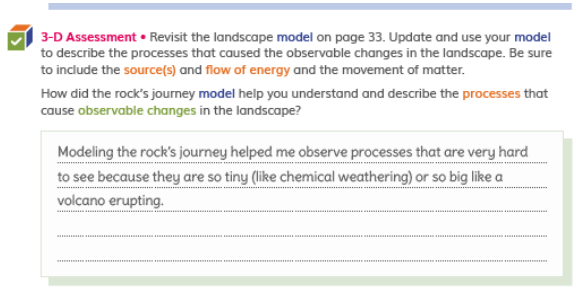
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Monitoring Volcanoes Teacher Rubric

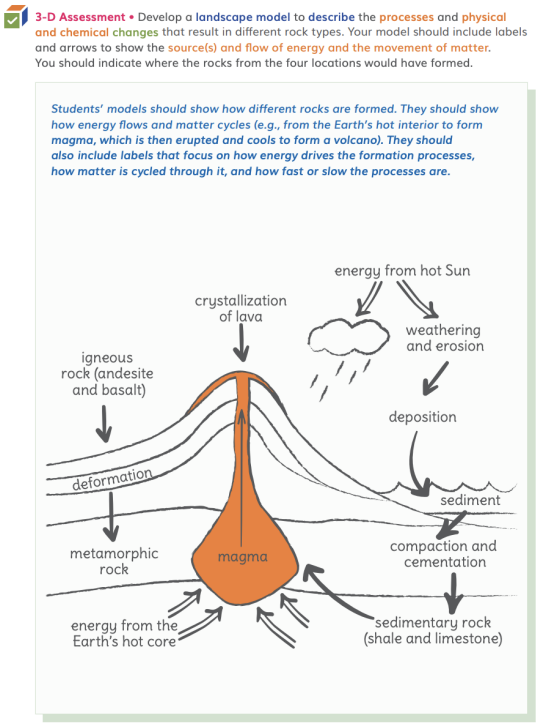
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C. **Integrating the Three Dimensions:** Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.	**Evidence of C. Integrating the Three Dimensions:** Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs. **Anchor Phenomenon** Making sense of the **Anchor Phenomenon** requires students to use the elements of the SEPs, DCIs, and CCCs as specified in the targeted **Performance Expectations** for the module. They track their sense-making using the targeted DCIs, SEPs, and CCCs whenever they are prompted to update the **Phenomena Tracker** using the **Phenomena Tracker Routine visual**. This visual specifically encourages students to record their use of the targeted SEPs and CCCs in developing their understanding. In Volcano Hunters Lesson 1 students begin the module narrative, in which they determine whether particular landforms are volcanic and are a threat to local residents. First, they make observations of the landscape features and predict whether they are volcanic, based on the patterns they identify (SEP-8, SEP-4, ESS2.A, CCC-1). They gather information about and develop models of how a landscape (including volcanoes) can change over time (SEP-8, SEP-2, ESS2.A, ESS3.B, CCC-7), and create models of the changes rocks undergo in the rock cycle (SEP-2, CCC-7, ESS2.A). Finally, they analyze rock samples from the **Anchor Phenomenon** locations and determine whether the locations are volcanic	**Evidence of C. Integrating the Three Dimensions:** Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.  **Phenomena Tracker Routine, Lesson Presentation slides**

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	(SEP-4, ESS2.A). In the **Formative Assessment** in **L1 S5**, students revise their landscape models to describe the processes that caused observable changes in the landscape. They include the sources and flow of energy and the movement of matter. They write how the kinesthetic model from the session helped them understand and describe the processes that cause observable changes in the landscape (SEP-2, ESS2.A, CCC-7). In the **Summative Assessment** in **L1 S8**, students use a visual to identify rock samples and determine if they are volcanic or not. They draw a model to show how the rocks were formed and explain their reasoning using a CER chart. They are divided into teams and, using rock sample bags and the **Rock Samples ID Chart visual**, record their observations of the samples in their Twig Journals. They then develop a model to demonstrate how the rocks found at the four different sites could have formed and finally, use their model to argue which of the locations are volcanic by completing the CER chart on page 59 in their Twig Journals (SEP-2, CCC-7, ESS2.A). In Volcano Hunters Lesson 2 students investigate whether all volcanoes are equally dangerous to communities. First, they observe models of different types of volcanoes and ask questions about explosivity (SEP-2, CCC-3, SEP-1, ESS2.A, PS1.A, PS3.A). They carry out investigations to distinguish between potential types of volcanoes	 **L1 S5 Formative Assessment, TJ p. 33**  **L1 S5 Formative Assessment, TJ p. 37**

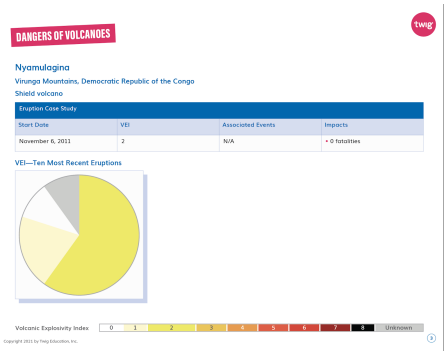
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	and eruptions (SEP-3, CCC-1, ESS3.B, PS1.A, PS3.A) and conduct hands-on and digital investigations on how different viscosity liquids and gas affect the explosivity of volcanoes (SEP-3, CCC-2, ESS2.A, ESS3.B). They obtain information from text to determine if patterns in data indicate that some volcanoes are more dangerous (SEP-8, CCC-1, ESS3.B) and, finally, use those patterns to argue that some volcanoes are more dangerous than others (CCC-1, SEP-6, ESS3.B, CETAS-2). In the **Summative Assessment** in **L2 S6**, students write a scientific argument in response to the claim: Some volcanoes are more dangerous than others. They use evidence from the module and analyze data (identifying patterns) from the **Dangers of Volcanoes handout** to support their argument. They use the **Meta-Think-Aloud language routine** to verbalize their thinking as they collect evidence, record their research in their graphic organizers, use a think-pair-share to compare their evidence, and finally write their scientific arguments in their Twig Journals (SEP-6, ESS3.B, CCC-2, SEP-4, CCC-1). In Volcano Hunters Lesson 3 students explore whether analyzing volcanic data can help scientists predict eruptions and therefore protect communities. First, they analyze data collected during a video lab to identify patterns and predict when eruptions could occur (SEP-4, CCC-1, ESS3.B). They obtain information from text about different monitoring techniques and the drive	

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	behind the development of new technology (SEP-8, ESS3.B, CETAS-2). They analyze different types of data to identify increasing volcanic activity (SEP-4, CCC-1, ESS3.B) and use this knowledge to argue when specific warning levels should be applied to a particular volcano (SEP-7, ESS3.B, CCC-1, CCC-7). Finally, they analyze a dataset of undermonitored volcanoes, use patterns to identify one they think should have increased monitoring, and develop a monitoring plan (SEP-4, CCC-1, CCC-7, ESS3.B, SEP-6). In the **Formative Assessment** in **L3 S4**, students analyze datasets from a volcano and determine danger level by evaluating changes in the data over time. They construct an argument, using the patterns they identified as evidence, about when specific warning levels should be applied to the volcano (SEP-4, ESS3.B, CCC-1, CCC-7, SEP-7). In the **Summative Assessment** in **L3 S5**, students look at a dataset of undermonitored volcanoes and, considering patterns in a number of variables, identify one they think should be monitored more. They create a monitoring plan for their chosen volcano, identifying hazards and monitoring techniques (ESS3.B, CCC-1, CCC-7, SEP-6). As students construct their explanations of the **Anchor Phenomenon** at the end of each lesson, they are again prompted to reflect on and incorporate the specific elements of the SEPs and CCCs into their explanations.	 Which of the four locations are volcanoes? **Use your model to describe** how the landscapes were formed. Be sure to include: • How the landscapes **changed at different scales, from the atomic to the very large, and over time** • How **energy** drove their formation • How matter was **cycled**. **Claim**: Bougainville Island, Auckland, and Yogyakarta are all in volcanic areas. Kathmandu is not. **Evidence**: We identified the Bougainville Island and Yogyakarta rock samples as andesite, which is an extrusive igneous rock. We identified the Auckland rock sample as basalt, which is also an extrusive igneous rock. We identified the Kathmandu samples as limestone and shale, which are both sedimentary rocks. **Reasoning**: Different pressures and temperatures will result in the formation of different rocks. Extrusive igneous rocks like andesite and basalt found at Bougainville Island, Yogyakarta, and Auckland are formed by cooled lava. Magma forms when parts of the Earth's mantle are melted by the energy from the Earth's hot core over thousands of years. Magma chambers form and magma erupts at the surface as lava. As it cools, atoms in the magma can rearrange themselves to form crystals. If magma cools outside a volcano, it becomes extrusive igneous rock. Eruptions can quickly change a landscape. When these rocks are present, it's likely to be a volcanic area. Sedimentary rocks are formed when weathering breaks down existing rocks to smaller pieces and erosion carries these pieces to another place on the landscape. In chemical weathering, there is a change in the rocks at the atomic level. Deposition layers these sediments. Then, the layers are squeezed together through compaction and cementation, transforming them into sedimentary rocks. This takes thousands of years, and some rock fragments can be carried huge distances. Inside the Earth, sedimentary and igneous rocks can deform and, due to pressure and high temperatures, transform into metamorphic rocks. Sedimentary rocks are not necessarily formed near volcanoes. In both these rock types, the matter is transformed and cycled over time because the rocks go through different processes in the landscape. Summative Assessment 59 **L1 S8 3-D Assessment, TJ pp. 58–59**

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Dangers of Volcanoes handout

Think Talk—Meta-Think-Aloud

Use the Meta-Think Aloud language routine to encourage students to engage in metacognition and to use this as a strategy when they engage in complex tasks. Clearly model your thinking around evidence and reasoning relating to the danger posed by different types of volcanoes so that students can follow your thought process.

- Pick a piece of evidence. Have students evaluate whether the evidence makes sense in addressing the claim.
- Use a think-aloud to go over and interpret the evidence. Then, provide a piece of reasoning for the analyzed piece of evidence. Have students evaluate and support why the reasoning is strong, and then practice this skill independently.

If time allows, encourage small groups of students to practice this strategy with each other, verbalizing their thinking as they collect their evidence.

L2 S6 Think Talk—Meta-Think-Aloud, TE p. 77

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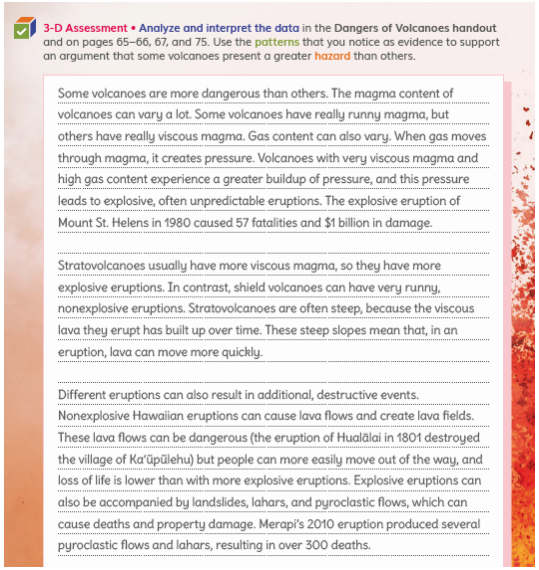
Share Graphic Organizers

Invite pairs to share and compare their graphic organizers.

- ***What evidence did you use to support the claim that some volcanoes are more dangerous than others?***
- ***What is your reasoning?***

Prompt them to revise their graphic organizers based on the think-pair-share.

L2 S6 Share Graphic Organizers, TE p. 77



3-D Assessment • **Analyze and interpret the data** in the **Dangers of Volcanoes handout** and on pages 65–66, 67, and 75. Use the **patterns** that you notice as evidence to support an argument that some volcanoes present a greater **hazard** than others.

Some volcanoes are more dangerous than others. The magma content of volcanoes can vary a lot. Some volcanoes have really runny magma, but others have really viscous magma. Gas content can also vary. When gas moves through magma, it creates pressure. Volcanoes with very viscous magma and high gas content experience a greater buildup of pressure, and this pressure leads to explosive, often unpredictable eruptions. The explosive eruption of Mount St. Helens in 1980 caused 57 fatalities and $1 billion in damage.

Stratovolcanoes usually have more viscous magma, so they have more explosive eruptions. In contrast, shield volcanoes can have very runny, nonexplosive eruptions. Stratovolcanoes are often steep, because the viscous lava they erupt has built up over time. These steep slopes mean that, in an eruption, lava can move more quickly.

Different eruptions can also result in additional, destructive events. Nonexplosive Hawaiian eruptions can cause lava flows and create lava fields. These lava flows can be dangerous (the eruption of Hualālai in 1801 destroyed the village of Ka'ūpūlehu) but people can more easily move out of the way, and loss of life is lower than with more explosive eruptions. Explosive eruptions can also be accompanied by landslides, lahars, and pyroclastic flows, which can cause deaths and property damage. Merapi's 2010 eruption produced several pyroclastic flows and lahars, resulting in over 300 deaths.

L2 S6 Summative Assessment, TJ p. 88

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3-D Assessment • Look for **similarities and differences as you analyze and interpret the data**. Then, use the **patterns** that you notice to support your rationale for why you provided the **warning labels for the volcano** on particular days.

Warning Level	Days	Argument
Warning	Day 1 to 7	I didn't assign this level to the volcano as the data didn't start to rapidly increase at any point from day 7 onward.
Watch	Day 9 to Day 19	A Watch level should be assigned for days 9–19. There are a few overlapping peaks in data, like the three data types on Day 11, which might mean a lot of volcanic activity. Values are high in all four data types. For example, COSPEC readings are over 300 metric tons, even over 400 at the beginning, and the temperature is in the upper 30s and lower 40s. Readings are high, but they are not high enough to need a Warning label anymore. The readings are also dropping. The historic data for the Warning period showed that COSPEC readings were close to or above 1,000 metric tons. The current data matches the historic Watch data, with temperatures from 36°C to 43°C and COSPEC from 159 to 487 metric tons/day.

L3 S4 Formative Assessment, TJ p. 110

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3-D Assessment • Why should the volcano you selected be high priority for monitoring? Include information about at least four of these factors:

- Current activity status
- Type of volcano
- Local populations
- Eruptive history
- VEI.

Provide rationale using **similarities and differences in the data** as evidence.

Students may note that dormant volcanoes are not expected to erupt soon but could erupt again in the future, and that extinct volcanoes are unlikely to erupt again.

They should identify specific features of the volcano's eruptive history that indicate its dangerousness. For example, they might mention that it has had several eruptions in a short time period, or that it tends to have explosive eruptions.

They should refer to the potential explosivity of the volcano and how this might affect the landscape. For example, a low VEI eruption might result in lava flows that cover the surrounding area, and a high VEI eruption might cause large parts of the volcano to be destroyed. They should also consider how many people might be affected by eruptions.

Students' predictions should rely on both eruptive frequency and last known eruption. Their VEI predictions may be based on one of a range of factors, such as average VEI, last known VEI, or highest ever VEI.

L3 S6 Summative Assessment, TJ p. 113

Connecting to the Anchor Phenomenon

10 min

Review the Anchor Phenomenon

Display the Class Wonder Questions chart and review the Anchor Phenomenon. Summarize the Wonder Questions that have been looked at in the module and ask students to discuss which new aspects of the Anchor Phenomenon they can now explain. Have students complete their explanations on page 3 in their Twig Journals.

Remind them to include information about how they used the scientific practice of analyzing and interpreting data, and thought about the phenomena through the lens of patterns.

Review the Anchor Phenomenon, TE p. 107

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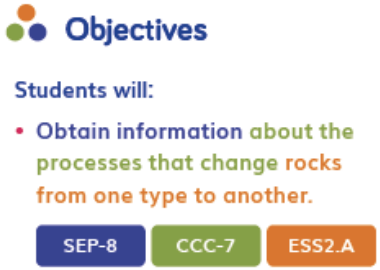
Investigative Phenomena
Every Investigative Phenomenon is explored through student experiences that integrate elements of the SEPs, DCIs, and CCCs. These can be easily identified from the Objectives for each session. Examples from Volcano Hunters include:

- L1 S6
  Investigative Phenomenon:
  - The features of a landscape change over time.

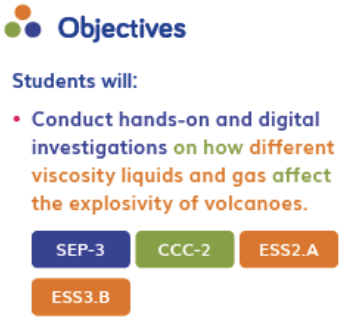
  Objectives:
  - Obtain information about the processes that change rocks from one type to another. (elements of SEP-8, CCC-7, and ESS2.A)
- L2 S3
  Investigative Phenomenon:
  - Gas moves differently through different lava viscosities.

  Objectives:
  - Conduct hands-on and digital investigations on how different viscosity liquids and gas affect the explosivity of volcanoes. (elements of SEP-3, CCC-2, ESS2.A, and ESS3.B)
- L3 S1
  Investigative Phenomenon:
  - Volcanoes change in observable ways before an eruption.

  Objectives:
  - Analyze and interpret various sources of data to identify

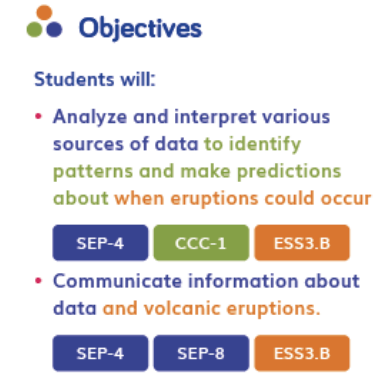
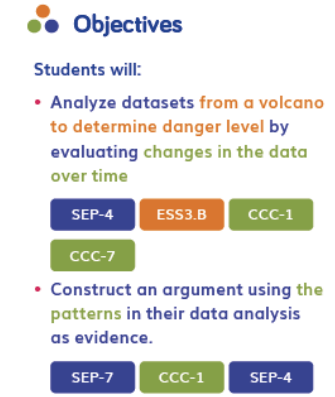


L1 S6 Objectives, TE p. 37



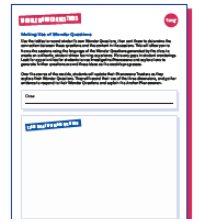
L2 S3 Objectives, TE p. 63

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	patterns and make predictions about when eruptions could occur (elements of SEP-4, CCC-1, and ESS3.B) • Communicate information about data and volcanic eruptions. (elements of SEP-4, SEP-8, and ESS3.B) • **L3 S4** Investigative Phenomenon: • Volcanoes change in measurable ways before an eruption. Objectives: • Analyze datasets from a volcano to determine danger level by evaluating changes in the data over time (elements of SEP-4, ESS3.B, CCC-1, and CCC-7) • Construct an argument using the patterns in their data analysis as evidence. (elements of SEP-7, CCC-1, and SEP-4) Students make sense of the **Investigative Phenomena** and record their explanations in the **Phenomena Tracker** when prompted by the teacher (**Phenomena Tracker Routine**).	 L3 S1 Objectives, TE p. 82  L3 S4 Objectives, TE p. 96

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Category I: NGSS 3D Design (Additional Criteria for Units Only)

Unit Criteria A unit or longer lesson designed for the NGSS will also include clear and compelling evidence of the following:	Specific evidence from materials and reviewers' reasoning	Evidence of Quality
D. **Unit Coherence:** Lessons fit together to target a set of performance expectations. i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences. ii. The lessons help students develop toward proficiency in a targeted set of performance expectations.	Evidence of i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences. In the first session of the module, students use the **Co-Craft Questions language routine** to ask scientific questions about the **Anchor Phenomenon**, which they experience through visual media, datasets, maps, and hands-on exploration. These are recorded on a **Wonder Questions chart**. The teacher then uses these questions to identify the sessions in the program that can help students answer them. After using the **Co-Craft Questions language routine** to generate **Wonder Questions** in the first session, students return to these questions as each lesson progresses. The first session of each subsequent lesson has an opportunity for students to generate and add to their **Wonder Questions Chart** using the **Co-Craft Questions language routine**. After generating **Wonder Questions**, students are invited to suggest which questions they want to	Evidence of i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences. **Think Talk—Co-Craft Questions** Use the Co-Craft Questions language routine to generate Wonder Questions about the Anchor Phenomenon. Have students work individually and then in small groups and record their questions on scratch paper. Prompt groups to share their Wonder Questions, and record them on the board. Have the class reframe the questions as investigable questions. Discuss ways of grouping questions together, and whether there are any missing questions. Based on the discussion, develop a physical or digital Class Wonder Questions chart. Guide students to group questions that consider: • How and why an area might change as a result of geoscience processes associated with volcanic activity (Lesson 1) • What makes volcanoes dangerous to human populations (Lesson 2) • How we can predict eruptions and protect communities from the risks they pose (Lesson 3). Share with students the group of questions they will be investigating this lesson. Have students record the questions in their Wonder Questions charts on pages 4–5 in their Twig Journals. During or after the session, use the **Module Wonder Questions** to create a map that connects student questions to the sessions.  **L1 S1 Think Talk—Co Craft Questions, TE p. 14**

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answer first, and discuss what they already know about the questions and how they might answer them.

At the start of the next session, students review the Wonder Question that they will be exploring using either the Class Wonder Questions Chart or the Lesson Presentation slides. They are asked to share what they already know that can help them answer the question, and how they might answer the question.

Toward the end of a session, students update their Phenomena Trackers to record their sense-making about the Investigative and Anchor Phenomena, and respond to any Wonder Questions they can answer. They then suggest any new Wonder Questions, and they are invited to determine which questions they want to answer next. They discuss what they already know about the question and how they might answer it.

This process is repeated as students progress through the module.

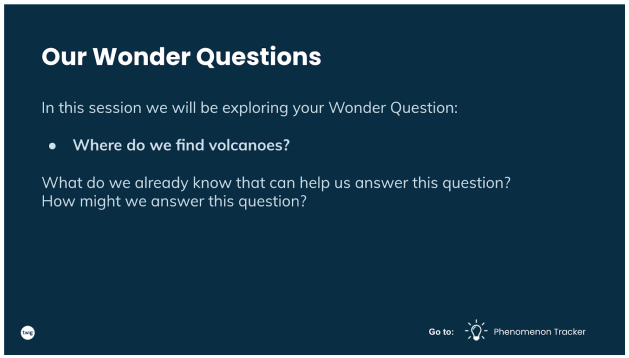
In Volcano Hunters, the way each session is connected to, and builds on, previous sessions is described in the Volcano Hunters Storyline on pages 3–5 of this document.

The Co-Craft Questions language routine, Wonder Questions Chart Routine, and Phenomena Tracker Routine appear in these

Pedagogical Support—
Wonder Questions Chart Routine

At the start of each session, display the Class Wonder Questions chart and highlight the Wonder Questions that students will be exploring today.

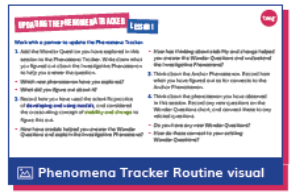
L1 S2 Wonder Questions Chart Routine, TE p. 16



Wonder Questions Chart Routine, Lesson Presentation slides

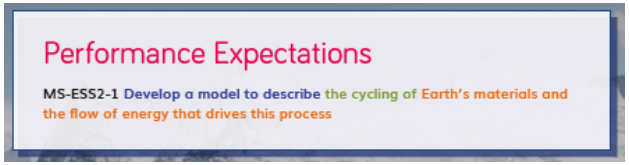
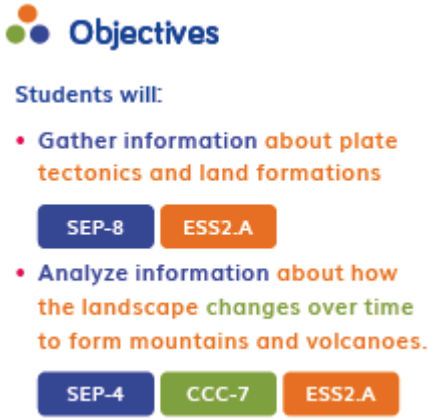
Update the Phenomena Tracker

Display the **Phenomena Tracker Routine visual**. Invite students to use the routine to make sense of their Wonder Questions and connect to the Anchor Phenomenon. Have students share ideas and add new Wonder Questions to the Class Wonder Questions chart. Take note of the Wonder Questions you will be exploring in the next session and highlight these.

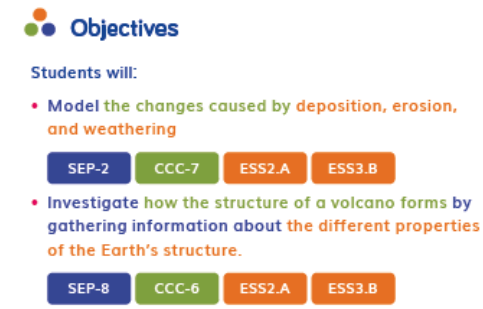
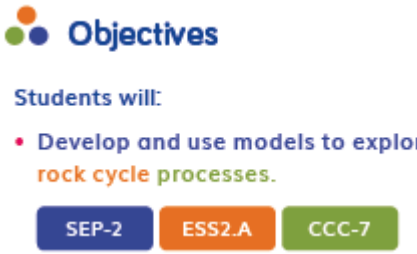
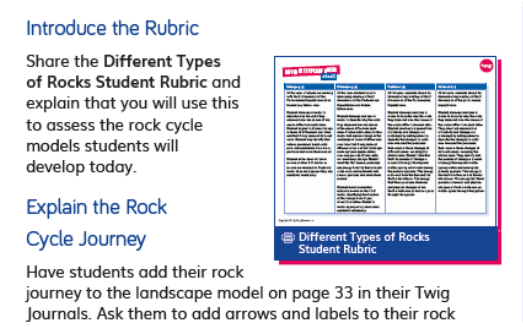


L2 S1 Update the Phenomena Tracker, TE p. 57

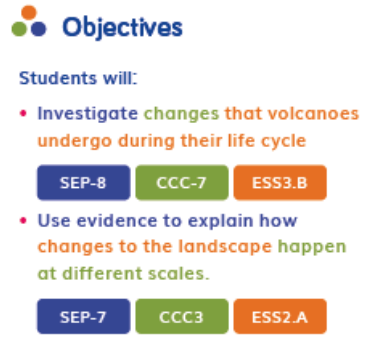
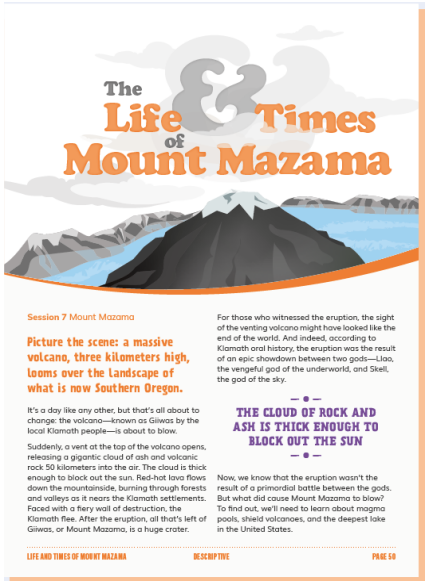
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	sessions: • Co-Craft Questions language routine: L1 S1, L2 S1, L3 S1 • Wonder Questions Chart Routine: L1 S2–8, L2 S1–6, L3 S1–6 • Phenomena Tracker Routine: L1 S2–4, L1 S6–7, L2 S1–5, L3 S1–5 Evidence of ii. The lessons help students develop toward proficiency in a targeted set of performance expectations. All of the materials in the lessons and sessions help students develop toward proficiency in the targeted set of Performance Expectations. The online Performance Expectation Progressions identifies students' progress toward mastering the different dimensions of the Performance Expectations as they move through the module. L1 targets the following Performance Expectation: • **MS-ESS2-1** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process This Performance Expectation comprises these dimensions: • **SEP-2:** Develop and use a model to describe phenomena. • **ESS2.A:** All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and	Evidence of ii. The lessons help students develop toward proficiency in a targeted set of performance expectations.  Lesson 1 Performance Expectations, TE p. 10  L1 S2 Objectives, TE p. 17

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	Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. • **CCC-7:** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. In **L1 S2**, objectives include analyzing information about how the landscape changes over time to form mountains and volcanoes (CCC-7, ESS2.A). Students read a scientific text about plate tectonics and use the information to construct an explanation about where volcanoes are found. They build on this in **L1 S3** as they investigate how the structure of a volcano forms by gathering information about the different properties of the Earth's structure (ESS2.A) and modeling the changes caused by deposition, erosion, and weathering (SEP-2, CCC-7, ESS2.A). In **L1 S4–6**, students develop and use models to explore rock cycle processes (SEP-2, ESS2.A, CCC-7). They use crayon models to explore different geologic processes, ride the rock cycle, and develop 2-D models of the rock cycle, completing a **Formative Assessment** that assesses their developing mastery of MS-ESS2-1. In **L1 S7**, objectives include investigating changes that volcanoes undergo during their life cycle	 L1 S3 Objectives, TE p. 21  L1 S4 Objectives, TE p. 27  L1 S5 Formative Assessment, TE p. 35

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	(CCC-7). Students read a scientific text about the history of Mount Mazama and use a **Stronger and Clearer Each Time language routine** to explain the processes involved in Mount Mazama's history, and whether these were fast or slow changes. Finally, in **L1 S8**, students complete objectives including developing a model that shows how different geologic processes change the landscape to form mountains or volcanoes (SEP-2, CCC-7, ESS2.A). They complete a **Summative Assessment** that assesses their mastery of MS-ESS2-1 as they develop a landscape model showing the processes and physical and chemical changes that result in different rock types, and the source(s) and flow of energy and the movement of matter. They use their models to describe how the **Anchor Phenomenon** landscapes were formed. **L2** and **L3** target the following **Performance Expectation**: • **MS-ESS3-2** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects This **Performance Expectation** comprises these dimensions: • **SEP-4:** Analyze and interpret data to determine similarities and differences in findings.	 L1 S7 Objectives, TE p. 42  L1 S7 "The Life and Times of Mount Mazama" article, TJ pp. 50–52

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	• **ESS3.B:** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. • **CCC-1:** Graphs, charts, and images can be used to identify patterns in data. • **CETAS-2:** The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. In L2 S2, students investigate the effects of viscosity, tephra, and slope on the behavior of lava, with the objective to use their findings from the investigation to develop predictions (CCC-1, ESS3.B, SEP-4). They use a **Productive Discussion language routine** to connect how different properties affect lava's behavior. Students build on this in L2 S3, where the objective is to conduct hands-on and digital investigations on how different viscosity liquids and gas affect the explosivity of volcanoes (ESS3.B). They consolidate their ideas about the relationship between viscosity, gas content, and explosivity using a **Stronger and Clearer Each Time language routine**. In L2 S4–5, students obtain information from case	**Think Talk—Stronger and Clearer Each Time** Use the Stronger and Clearer Each Time language routine to provide students with an opportunity to revise and refine their verbal and written output. Optional: Distribute copies of the **Stronger and Clearer Graphic Organizer handout.** • **Discussion Prompt**: How did Mount Mazama change over its lifetime? When was it relatively stable? Explain the processes involved, and whether the changes were fast or slow.  Stronger and Clearer Graphic Organizer handout Invite students to individually answer the prompt on page 55 in their Twig Journals. Explain that they can also draw L1 S7 Stronger and Clearer Each Time language routine, TE p. 44 **Objectives** Students will: • Develop a model that shows how different geologic processes change the landscape to form mountains or volcanoes SEP-2 CCC-7 ESS2.A • Analyze physical evidence and use observations about volcanoes and their locations to determine changes over time. SEP-4 SEP-7 ESS2.A CCC-7 L1 S8 Objectives, TE p. 46

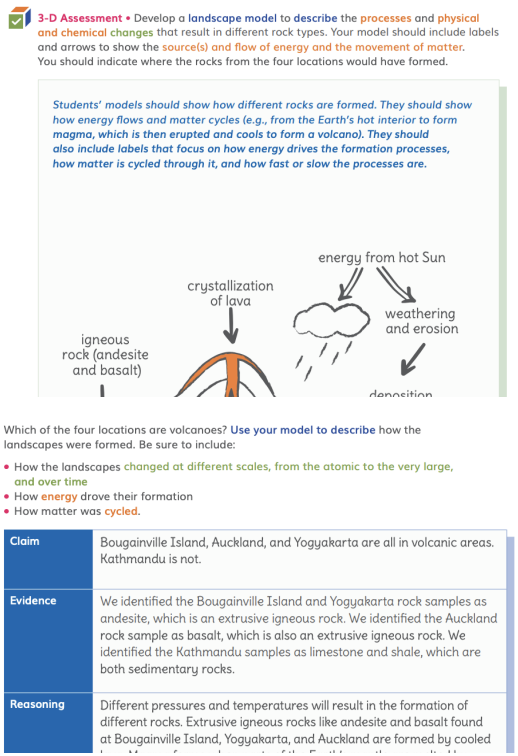
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studies, determining if patterns in data indicate that some volcanoes are more dangerous (CCC-1, ESS3.B). After reading scientific texts, they compare and contrast features of the most and least dangerous volcanoes and identify the physical hazards and societal impacts of the 1980 eruption of Mount St. Helens.

In L2 S6, students complete a Summative Assessment that assesses their mastery of MS-ESS3-2, with the objective to analyze patterns in data and develop an argument using evidence that indicates that some volcanoes are more dangerous than others (SEP-4, CCC-1, ESS3.B, CETAS-2). They analyze data on the **Dangers of Volcanoes handout** and write a scientific argument in response to the claim: *Some volcanoes are more dangerous than others.*

In L3 S1, the objective is to analyze and interpret various sources of data to identify patterns and make predictions about when eruptions could occur (SEP-4, CCC-1, ESS3.B). Students gather, analyze, and interpret data from a fictional volcano and share their findings with the class. They engage with the data collection table using the Meta-Think-Aloud language routine, and the teacher is guided to model the activity. After data collection, students analyze their findings in groups, and the teacher summarizes at the end of the session.

In L3 S3, students analyze and interpret different types of data to identify increasing volcanic



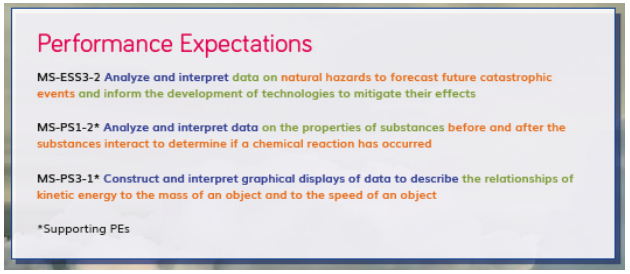
L1 S8 3-D Assessment, TJ pp. 58–59

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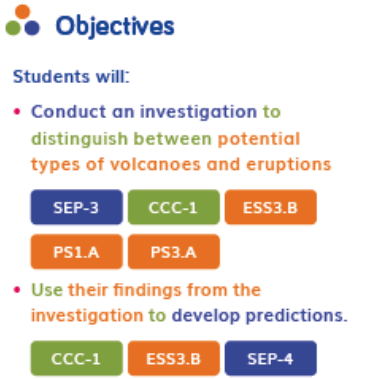
activity (SEP-4, CCC-1, ESS3.B). They are introduced to the **Historic Dataset handout** which they analyze in teams, although this time without the support of the Meta-Think-Aloud language routine. They individually graph their data, showing increasing mastery of MS-ESS3-2, as they now rely less on peer assistance to analyze their data patterns.

In L3 S4, students complete the Formative Assessment. They analyze datasets to determine volcanic danger level by evaluating changes in the data over time (SEP-4, ESS3.B, CCC-7). They assign warning levels, write a scientific argument to support their choices, and are assessed on their growing mastery of MS-ESS3-2 with the **Warning Levels Rubric**. In this session, they receive less peer and teacher support as they should now be able to independently analyze their data patterns to predict warning levels.

Finally, in L3 S5-6, students complete the Summative Assessment, which assesses their mastery of MS-ESS3-2. They work toward objectives including designing a volcano-monitoring plan for undermonitored volcanoes around the world based on their analysis of patterns in the data and changes over time (ESS3.B, SEP-4, CCC-1). They look at a dataset of undermonitored volcanoes and, considering patterns in a number of variables, identify one they think should be monitored more. They create a monitoring plan for their chosen volcano, identifying hazards and monitoring



Lesson 2 Performance Expectations, TE p. 52



L2 S2 Objectives, TE p. 58

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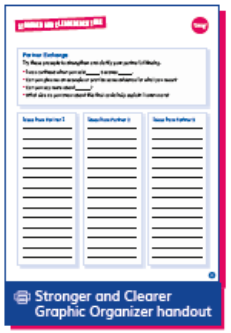
	techniques.	**Think Talk—Productive Discussion** Use the Productive Discussion language routine with pairs or small groups of students. • **Discussion Goal:** Students connect how different properties affect lava's behavior. • ***What differences in flow rate (the amount of time it takes for a liquid to move) did you observe? How might a liquid's flow rate connect to its viscosity?*** The oil moves fastest because it is much runnier than the other liquids (it is less viscous). The ketchup moves slowest because it is heavier and thicker (it is more viscous). • ***Would the shape of a volcano have an effect on the speed of its lava flow?*** Yes. Lava travels more quickly down a steep slope than a shallow one. • ***How does tephra affect how quickly or slowly a liquid moves down the slope of a volcano?*** The tephra make the lava move more slowly. The more tephra (or debris) in lava, the slower it moves. **L2 S2 Productive Discussion, TE p. 61** **Objectives** **Students will:** • Conduct hands-on and digital investigations on how different viscosity liquids and gas affect the explosivity of volcanoes. SEP-3 CCC-2 ESS2.A ESS3.B **L2 S3 Objectives, TE p. 63**

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Think Talk—Stronger and Clearer Each Time

Use the Stronger and Clearer Each Time language routine to provide students with an opportunity to revise and refine their verbal and written output. Optional: Distribute copies of the **Stronger and Clearer Graphic Organizer handout.**

- Discussion Prompt: What is the relationship between viscosity, gas content, and explosivity? Use evidence to justify your answer.



Invite students to individually answer the prompt on page 68 in their Twig Journals before working

L2 S3 Stronger and Clearer Each Time, TE p. 65

Objectives

Students will:

- Obtain information and collect evidence to determine if patterns in data indicate that some volcanoes are more dangerous and their eruptions are explosive.

SEP-8 CCC-1 ESS3.B

L2 S4 Objectives, TE p. 67

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Compare and Contrast Volcanoes

Have a few students share their graphic organizers. Create a T-chart with the headings Most Dangerous Volcanoes and Least Dangerous Volcanoes. Have the class fill out the chart. Elicit answers by connecting to students' learning from earlier in Lesson 2.

- ***How do liquids with different viscosities travel down a volcano? How much debris do they collect?***
- ***What can you say about the relationship between gas content and viscosity?***

Most Dangerous Volcanoes	Least Dangerous Volcanoes
• Steep slopes	• Shallow slopes
• Stratovolcanoes	• Shield volcanoes
• High viscosity magma	• Low viscosity magma
• High gas content	• Low gas content

L2 S4 Compare and Contrast Volcanoes, TE p. 70

Chart Hazards and Impacts

Create a T-chart with the headings Physical Hazards and Impacts. Invite students to share information that should be added to either category.

Physical Hazards	Impacts
• Landslides and mudslides	• 57 fatalities
• Nine hour explosion of magma and hot ash	• Over $1 billion in damages
• Hot ash, magma, sand, and rocks shot into the air	• Ash and debris reached as far as Oklahoma
• Burning everything in its path	• 10,000 km of roads were impassable, and air travel in the area had to stop
	• Changes to nearby landforms, like shrinking lakes and rivers and destruction of forests

L2 S5 Chart Hazards and Impacts, TE p. 73

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Objectives

Students will:

- Analyze patterns in data and develop an argument using evidence that indicates that some volcanoes are more dangerous than others.

SEP-4 CCC-1 SEP-6
ESS3.B CETAS-2

L2 S6 Objectives, TE p. 75

Think Talk—Meta-Think-Aloud

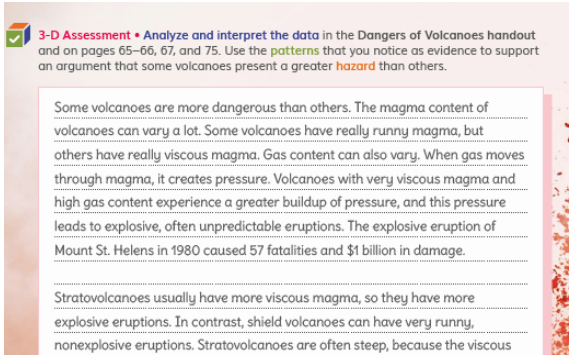
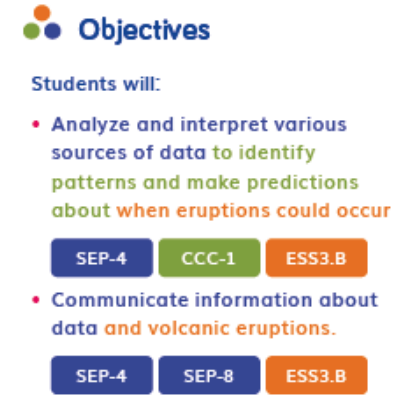
Use the Meta-Think Aloud language routine to encourage students to engage in metacognition and to use this as a strategy when they engage in complex tasks. Clearly model your thinking around evidence and reasoning relating to the danger posed by different types of volcanoes so that students can follow your thought process.

- Pick a piece of evidence. Have students evaluate whether the evidence makes sense in addressing the claim.
- Use a think-aloud to go over and interpret the evidence. Then, provide a piece of reasoning for the analyzed piece of evidence. Have students evaluate and support why the reasoning is strong, and then practice this skill independently.

If time allows, encourage small groups of students to practice this strategy with each other, verbalizing their thinking as they collect their evidence.

L2 S6 Meta-Think-Aloud language routine, TE p. 76

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		 3-D Assessment • Analyze and interpret the data in the Dangers of Volcanoes handout and on pages 65–66, 67, and 75. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others. Some volcanoes are more dangerous than others. The magma content of volcanoes can vary a lot. Some volcanoes have really runny magma, but others have really viscous magma. Gas content can also vary. When gas moves through magma, it creates pressure. Volcanoes with very viscous magma and high gas content experience a greater buildup of pressure, and this pressure leads to explosive, often unpredictable eruptions. The explosive eruption of Mount St. Helens in 1980 caused 57 fatalities and $1 billion in damage. Stratovolcanoes usually have more viscous magma, so they have more explosive eruptions. In contrast, shield volcanoes can have very runny, nonexplosive eruptions. Stratovolcanoes are often steep, because the viscous L2 S6 Summative Assessment, TJ p. 88  Objectives Students will: • Analyze and interpret various sources of data to identify patterns and make predictions about when eruptions could occur SEP-4 CCC-1 ESS3.B • Communicate information about data and volcanic eruptions. SEP-4 SEP-8 ESS3.B L3 S1 Objectives, TE p. 82

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Think Talk—Meta-Think-Aloud

Prompt students to turn to the data collection table on page 93 in their Twig Journals. Play the first minute of the **Our Volcano Erupts—Part 1 video.**



Use the Meta-Think Aloud language routine to encourage students to engage in metacognition. Clearly model your thinking so that students can follow your thought process.

- The GPS receiver read 0 mm at 0:01, and it still reads 0 mm at the 01:00 time stamp. It has not moved at all, so we write 0 in the GPS column. If it had moved up or down, we would

L3 S1 Think Talk—Meta-Think-Aloud, TE p. 84

Discuss Observations and Data

Invite students to share their findings with the class.

- ***What patterns did you notice?***
  Eruptions were more likely when lots of values were high—a greater number of earthquakes, more gas being released, and more ground movement being recorded.
- ***How easy or difficult would it be to forecast an eruption?***
  We could get a good idea of an approaching eruption, but the data does not always match up precisely. The gas levels were usually very high (over 300 metric tons) when the volcano was erupting, but at one point it was under 100 metric tons.
- ***What might have caused the pattern in increased seismic activity that led to an eruption?***
  As magma moved through the volcano, maybe it caused the Earth to shake.

Summarize students' findings:

- It can be possible to predict an eruption by monitoring changes in the surrounding area.
- When there is more activity in an area than normal (e.g., more ground movement, more seismic activity), this suggests an eruption may occur.
- When several types of monitors record increased activity at the same time, this also suggests an eruption may occur.

L3 S1 Discuss Observations and Data, TE p. 86

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Objectives

Students will:

- Analyze and interpret different type of data to identify increasing volcanic activity

SEP-4 | CCC-1 | ESS3.B

- Communicate information about quantitative models documenting volcanic activity before an eruption

SEP-2 | SEP-4 | ESS3.B

- Graph different datasets and predict how volcanic activity increases over a period of time.

SEP-2 | SEP-4 | ESS3.B | CCC-7

L3 S3 Objectives, TE p. 91

Introduce the Historic Dataset

Organize students into teams of four. Give each team a **Historic Dataset handout**. Explain that:

- Each page contains a dataset of activity at the fictional volcano from Session 1
- Each dataset covers a 10-day period, but from different times before an eruption: ten days, two months, six months, or several years before.


Historic Dataset handout

Ask teams to divide their datasets so each team member has one page.

Note: The goal of the activity is to determine which monitor readings indicate a potential upcoming eruption at the volcano. Don't share this with students yet.

- ***What can we do to make it easier for us to look for patterns in this data?***
  We can create graphs so the patterns in the data are easier to observe.

Graph Data

Have students individually graph their assigned data on pages 101–103 in their Twig Journals. Ask them to create one graph for each type of data. Prompt them to add time stamp information along their *x*-axes and help them identify suitable scales for their *y*-axes.

L3 S3 Introduce the Historic Dataset, TE p. 93

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HISTORIC DATASET—PAGE 1

Timestamp	GPS Receiver (change in distance, mm)	Seismometer (no. of earthquakes)	COSPEC (gas levels, metric tons)	Temperature (°C)
Day 1 12:00 AM	3	32	404	40
Day 1 12:00 PM	6	38	671	41
Day 2 12:00 AM	8	46	418	43
Day 2 12:00 PM	3	25	326	41
Day 3 12:00 AM	2	33	319	44
Day 3 12:00 PM	3	42	460	44
Day 4 12:00 AM	1	42	712	43
Day 4 12:00 PM	4	47	718	43
Day 5 12:00 AM	4	33	463	44
Day 5 12:00 PM	6	48	570	44
Day 6 12:00 AM	5	39	455	43
Day 6 12:00 PM	1	36	543	45
Day 7 12:00 AM	1	39	854	45
Day 7 12:00 PM	0	41	705	47
Day 8 12:00 AM	7	49	934	44
Day 8 12:00 PM	4	38	907	43
Day 9 12:00 AM	3	65	1,187	46
Day 9 12:00 PM	6	47	886	46
Day 10 12:00 AM	4	55	1,018	47
Day 10 12:00 PM	9	67	1,140	47

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Historic Dataset handout

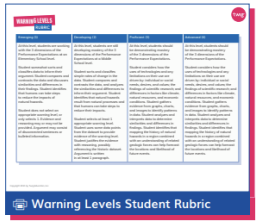
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Formative Assessment: Categorizing Volcanic Activity

30 min

Introduce the Rubric

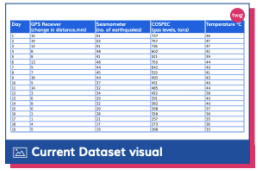
Share the **Warning Levels Student Rubric** and explain that you will use this to assess the analyses and scientific arguments students will develop today.



Warning Levels Student Rubric

Construct Scientific Arguments

Display the **Current Dataset visual**. Explain that this shows new data from the volcano they looked at in the last session. Point out that students can also find the dataset on pages 108–109 in their Twig Journals.



Current Dataset visual

Display the **Warning Levels visual**. Explain that students will assign a warning level to different points in the current dataset and write a scientific argument to support their choice.

Have students complete the table on pages 108–109 in their Twig Journal for Days 9 to 38. They should assign a warning level based on a comparison of the readings for the day with the preceding days' levels.

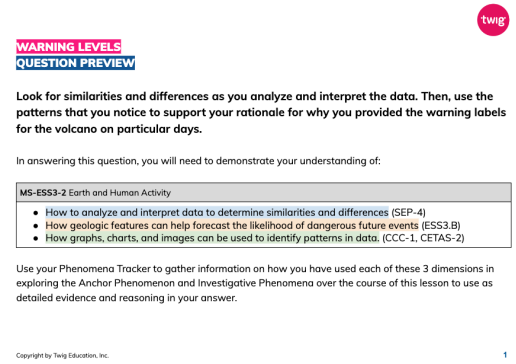
Have students use their graphic organizer to write a scientific argument on pages 110–111 in their Twig Journals, justifying why they assigned certain warning levels at particular times.

Clarify that students should:

- Identify which days they assign with each warning level
- Explain why they assigned the warning levels to their selected days
- Include references to each of the data types
- Cite evidence from the data they have looked at this lesson.

L3 S4 Formative Assessment: Categorizing Volcanic Activity, TE p. 98

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WARNING LEVELS
QUESTION PREVIEW

Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days.

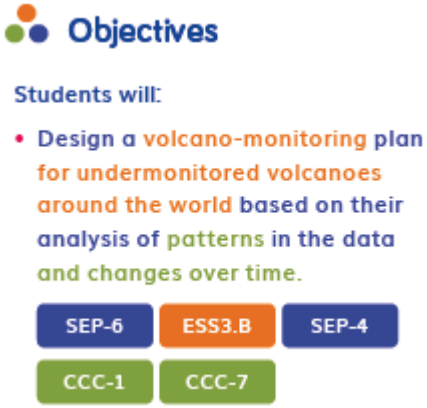
In answering this question, you will need to demonstrate your understanding of:

MS-ESS3-2 Earth and Human Activity
• How to analyze and interpret data to determine similarities and differences (SEP-4) • How geologic features can help forecast the likelihood of dangerous future events (ESS3.B) • How graphs, charts, and images can be used to identify patterns in data. (CCC-1, CETAS-2)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

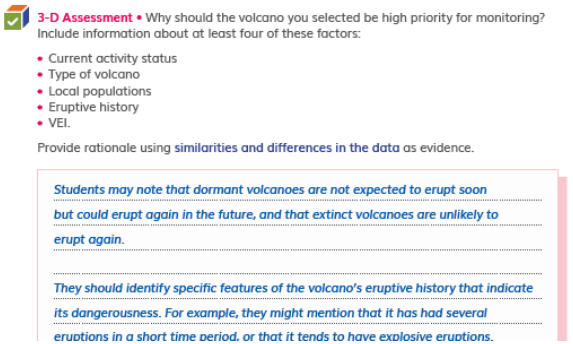
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Warning Levels Teacher Rubric



L3 S5 Objectives, TE p. 101

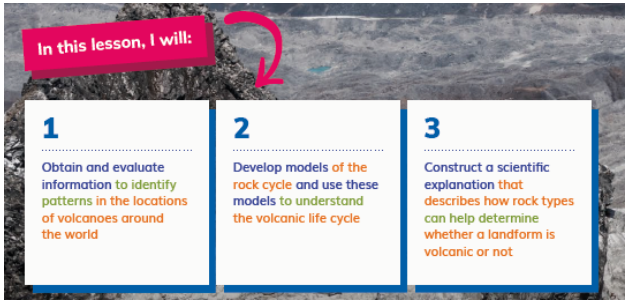
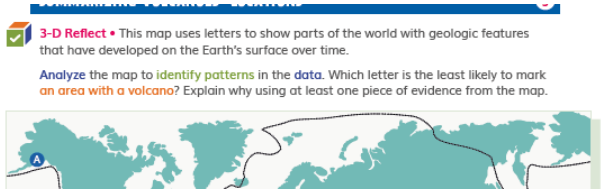
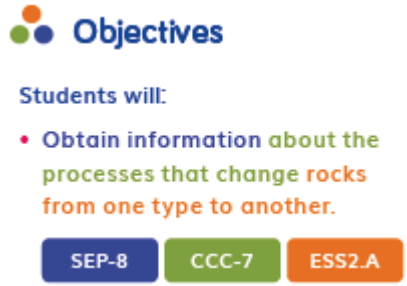
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		 3-D Assessment • Why should the volcano you selected be high priority for monitoring? Include information about at least four of these factors: • Current activity status • Type of volcano • Local populations • Eruptive history • VEI. Provide rationale using similarities and differences in the data as evidence. *Students may note that dormant volcanoes are not expected to erupt soon but could erupt again in the future, and that extinct volcanoes are unlikely to erupt again.* *They should identify specific features of the volcano's eruptive history that indicate its dangerousness. For example, they might mention that it has had several eruptions in a short time period, or that it tends to have explosive eruptions.* **L3 S5 Summative Assessment, TJ p. 113**
E. **Multiple Science Domains:** When appropriate, links are made across the science domains of life science, physical science and Earth and space science. i. Disciplinary core ideas from different disciplines are used together to explain phenomena. ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.	Evidence of i. Disciplinary core ideas from different disciplines are used together to explain phenomena. In this module, students use a blend of DCIs from different disciplines to make sense of **Investigative Phenomena** and the **Anchor Phenomenon**. For example, the **Investigative Phenomenon** in **L2 S1** is: • Volcanoes erupt in lots of different ways. To make sense of this phenomenon, students use elements both from a focal Earth and Space Science DCI (ESS2.A) and from complementary Physical Science DCIs (PS1.A, PS3.A). During the session, students observe footage of different eruptions (**Observing Volcanoes video**) and observe two 3-D eruption models. They identify differences between the eruptions, including properties (PS1.A) of the model lava, explosivity	Evidence of i. Disciplinary core ideas from different disciplines are used together to explain phenomena. **Investigative Phenomenon** Volcanoes erupt in lots of different ways. **L2 S1 Investigative Phenomenon, TE p. 54** **Investigative Phenomenon** Lava from different volcanoes is different. **L2 S2 Investigative Phenomenon, TE p. 58**

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	(PS3.A) of the resulting eruptions, and which eruption (ESS2.A) is likely to be more dangerous. Students continue to use both Earth and Space Science and Physical Science DCIs in **L2 S2** as they explore the **Investigative Phenomenon**: • Lava from different volcanoes is different. To make sense of this phenomenon, students continue to use elements of PS1.A and PS3.A, and additionally use the focal Earth and Space Science DCI ESS3.B. During the session, students conduct an investigation into the properties (PS1.A) of lava types, studying the effects of viscosity, tephra, and slope on lava flow (PS3.A, ESS3.B). Twig Science Next Gen Middle School is available in Discipline-Specific or Integrated volumes. Each Integrated volume contains at least two modules and an **Integrated 3-D Challenge** that is designed to help students forge cross-discipline connections. For example, Volcano Hunters is presented in the same volume as the Dinosaur Trail module. The **Integrated 3-D Challenge**, Supereruptions, connects to the narratives from the associated modules but is centered around its own phenomenon. To make sense of the phenomenon, students use elements from both Earth and Space Science (MS-ESS2-1, MS-ESS2-2) and Physical Science (MS-PS3-5).	

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	Evidence of ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted. Twig Science Next Gen Teacher Editions highlight the CCCs at the point of use, and the connections to multiple science domains. This tends to occur in (but is not exclusive to) the objectives, and in the **"I Will" statements** and colored exercise text in the Twig Journal. Student sense making is achieved by applying a crosscutting concept lens to a phenomena or design problem. For example, in **L1 S6**, the objective is to obtain information about the processes that change rocks from one type to another, linking to CCC-7 (Stability and Change). In the session, the teacher is directed to connect students' learning to CCC-7 by having them answer questions about the time span of geologic processes and stability and change in a landscape before filling out their graphic organizers. This shows the CCC being highlighted at point of use for the teacher. On top of this, using the CCC to develop their ideas also helps students make sense of the **Investigative Phenomenon**: *The features of a landscape change over time.* as students consider the stability of and changes in the rock cycle over time.	Evidence of ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.  **Lesson 1 "I Will" statements, TJ p. 6**  **L1 S2 colored exercise text, TJ p. 24**  **L1 S6 Objectives, TE p. 37**

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Connect to CCC-7—Stability and Change

Have students think about time spans and how these connect to stability and change in the investigation of phenomena.

- ***How does the time span of a geologic process relate to its observability?***
  Some processes happen over a very long period of time and cannot be easily observed, like the weathering and eroding of a mountain, or the deposition of material. Some processes, such as a volcano erupting, or lava cooling, are observable because they happen quickly and are big changes that can be easily seen.
- ***How does observability affect how we understand stability and change in the landscape?***
  Things that happen over a very long period of time, like weathering and erosion, might appear to be stable, or unchanging, even though they are just changing very gradually.

Have students complete the graphic organizer on pages 46–47 in their Twig Journals. Then, have students share their responses with the class.

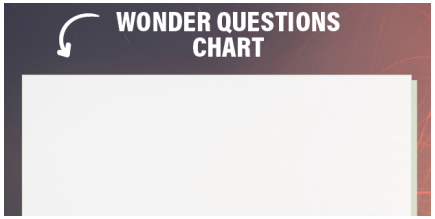
L1 S6 Connect to CCC-7—Stability and Change, TE p. 40

Investigative Phenomenon

The features of a landscape change over time.

L1 S6, Investigative Phenomenon, TE p. 37

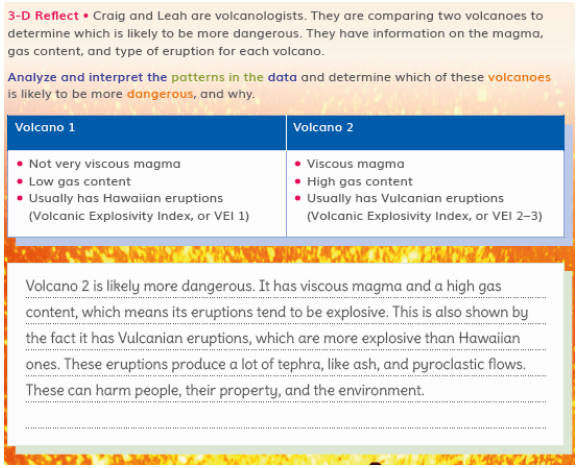
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F. **Math and ELA:** Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.	**Evidence of F. Math and ELA:** Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects. Grade-appropriate connections to the NGSS standards for Math and ELA are highlighted in the **Module Standards**. In Volcano Hunters, students use the following Math standards as they make sense of phenomena: • MP1 Make sense of problems and persevere in solving them • MP2 Reason abstractly and quantitatively • MP3 Construct viable arguments and critique the reasoning of others • MP4 Model with mathematics • MP7 Look for and make use of structure • MP8 Look for and express regularity in repeated reasoning Students use MP1 across the module as they work across multiple tasks to resolve the questions they have relating to phenomena, completing the **Wonder Questions Chart**. Students use MP2 in Lesson 2 as they use quantitative evidence to reason that some volcanoes are more dangerous than others. They additionally use MP2 and MP4 in Lesson 3 as they gather quantitative data and create tables and	**Evidence of F. Math and ELA:** Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects. Module Standards Standards indicated in **bold** are part of the module Performance Expectations. Students are expected to develop mastery of these standards at middle school level over the course of this module. Standards indicated in ***bold italics*** are part of the module Performance Expectations, but are only partially mastered at middle school level over the course of this module. Standards with an asterisk are applied at the level of student prior knowledge from Grades 3–5.  **Module Standards, TE p. 4**  **Wonder Questions Chart, TJ p. 4**

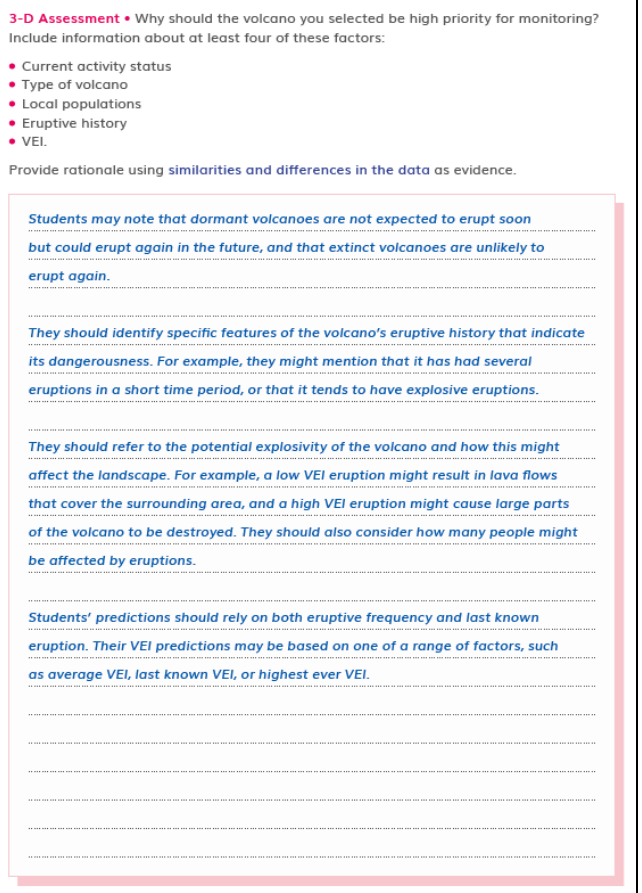
	Standards		Lesson 1	Lesson 2	Lesson 3
SEP	SEP-1*	Asking Questions and Defining Problems		✓	
	SEP-2	Developing and Using Models	✓	✓	✓
	SEP-3*	Planning and Carrying Out Investigations		✓	
	SEP-4	Analyzing and Interpreting Data	✓	✓	✓
	SEP-6*	Constructing Explanations and Designing Solutions		✓	✓
	SEP-7*	Engaging in Argument from Evidence	✓		✓
	SEP-8*	Obtaining, Evaluating, and Communicating Information	✓	✓	✓
DCI	*ESS2.A**	*Earth's Materials and Systems*	✓	✓	
	ESS3.B	Natural Hazards	✓	✓	✓
	PS1.A*	Structures and Properties of Matter		✓	
	PS3.A*	Definitions of Energy		✓	
CCC	CCC-1	Patterns	✓	✓	✓
	CCC-2*	Cause and Effect		✓	
	CCC-3*	Scale, Proportion, and Quantity	✓	✓	
	CCC-6*	Structure and Function	✓		✓
	CCC-7	Stability and Change	✓		✓
CETAS	CETAS-2	Influence of Engineering, Technology, and Science on Society and the Natural World			✓
EPCI	Principle V	Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors		✓	✓

	Standards		Lesson 1	Lesson 2	Lesson 3
Math	MP1	Make sense of problems and persevere in solving them	✓	✓	✓
	MP2	Reason abstractly and quantitatively		✓	✓
	MP3	Construct viable arguments and critique the reasoning of others	✓	✓	✓
	MP4	Model with mathematics			✓
	MP7	Look for and make use of structure	✓	✓	✓
	MP8	Look for and express regularity in repeated reasoning	✓	✓	✓
ELA	RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.	✓	✓	
	RST.6-8.2	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.	✓		✓
	RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.	✓	✓	
	RST.6-8.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.	✓		✓
	RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	✓	✓	✓

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	graphical models of volcanic systems to reason when eruptions may occur. Students use MP3 in Lessons 2 and 3 as they construct arguments to support a scientific claim about the risks from volcanoes, which should be monitored, and how. Students use MP7 and MP8 across the module as they look for, express, and make use of patterns and relationships in data on the locations of volcanoes, the behavior and structure of different volcanoes, and the warning signs of an eruption. Students also use the following ELA standards as they make sense of phenomena: • RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. • RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. • RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. • RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.	 3-D Reflect • Craig and Leah are volcanologists. They are comparing two volcanoes to determine which is likely to be more dangerous. They have information on the magma, gas content, and type of eruption for each volcano. Analyze and interpret the patterns in the data and determine which of these volcanoes is likely to be more dangerous, and why. Volcano 1 • Not very viscous magma • Low gas content • Usually has Hawaiian eruptions (Volcanic Explosivity Index, or VEI 1) Volcano 2 • Viscous magma • High gas content • Usually has Vulcanian eruptions (Volcanic Explosivity Index, or VEI 2–3) Volcano 2 is likely more dangerous. It has viscous magma and a high gas content, which means its eruptions tend to be explosive. This is also shown by the fact it has Vulcanian eruptions, which are more explosive than Hawaiian ones. These eruptions produce a lot of tephra, like ash, and pyroclastic flows. These can harm people, their property, and the environment. L2 S4 3-D Reflect, TJ p. 76

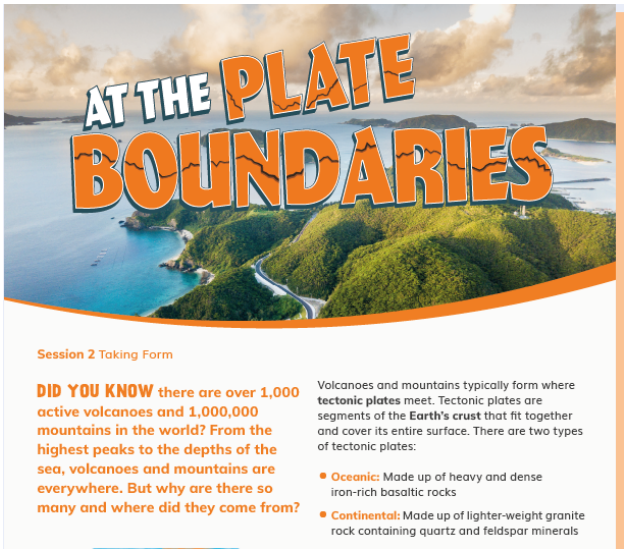
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	• RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). • RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. • RST.6-8.10 By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently. • WHST.6-8.1 Write arguments focused on discipline-specific content. • WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. • WHST.6-8.5 With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. • WHST.6-8.7 Conduct short research projects to answer a question (including a	 L3 S5 3-D Assessment, TJ p. 113

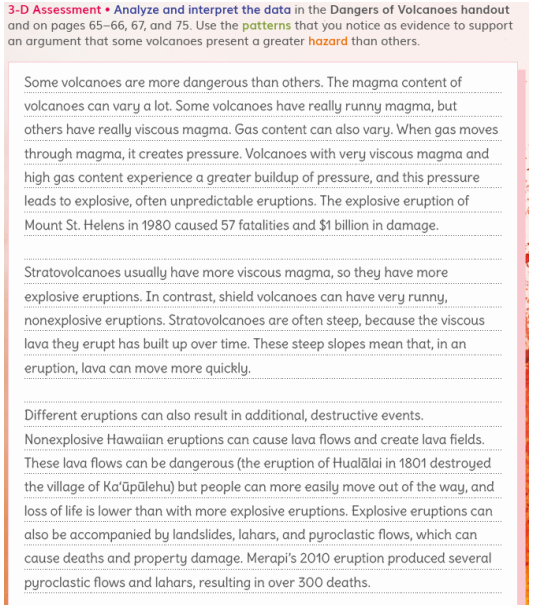
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	self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. • WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. • WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. • WHST.6-8.10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. Students are provided with opportunities throughout the module to demonstrate these skills. For example, in L1 S2, students use **RST.6-8.1**, **RST.6-8.2**, **RST.6-8.4**, **RST.6-8.7**, **RST.6-8.10**, **WHST.6-8.2**, **WHST.6-8.9**, and **WHST.6-8.10** as they read an article about different types of plate boundaries and the effect that plate interactions can have on the Earth's landscape. They identify information from the text that can be used to explain the patterns in where volcanoes form, integrate this information with evidence from the **Volcano Explorer digital**	Analyze Patterns in the Data Have teams analyze the similarities and differences in their data, looking for patterns and considering what different monitors showed when the volcano was erupting. Prompt them to graph the data on page 94 in their Twig Journals and use a think-pair-share to discuss. • ***Do you see any patterns in the data values and whether the volcano was erupting? Provide evidence.*** Usually data values would be high when the volcano was erupting. For example, the GPS receiver recorded 0–4 mm of ground movement when the volcano was not erupting, but 4–8 mm when it was erupting. **L3 S1 Analyze Patterns in the Data, TE p. 85** **Where Volcanoes Form** 25 min Critically Read the Scientific Text Ask students to read the "At the Plate Boundaries" article on pages 17–22 in their Twig Journals. Prompt them to think about where volcanoes are located are they read. **L1 S2 Critically Read a Scientific Text, TE p. 19**

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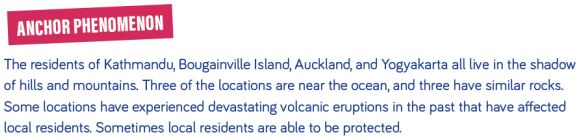
	interactive, and construct an explanation that shows their sense-making of the **Investigative Phenomenon**: There is a pattern in where volcanoes form. In L2 S6, students use **RST.6-8.1**, **RST.6-8.7**, **RST.6-8.9**, **WHST.6-8.1**, **WHST.6-8.9**, and **WHST.6-8.10** as they analyze data (including graphs), draw on evidence from informational texts, and integrate that evidence with results from hands-on and digital investigations to write an argument that supports the claim: Some volcanoes are more dangerous than others.	 L1 S2 At the Plate Boundaries, TJ p. 17 Write Scientific Arguments Prompt students to write their scientific arguments on pages 88–89 in their Twig Journals. They should write at least two paragraphs, with an introduction and conclusion. L2 S6 Write Scientific Arguments, TE p. 77

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		 3-D Assessment • Analyze and interpret the data in the Dangers of Volcanoes handout and on pages 65–66, 67, and 75. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others. Some volcanoes are more dangerous than others. The magma content of volcanoes can vary a lot. Some volcanoes have really runny magma, but others have really viscous magma. Gas content can also vary. When gas moves through magma, it creates pressure. Volcanoes with very viscous magma and high gas content experience a greater buildup of pressure, and this pressure leads to explosive, often unpredictable eruptions. The explosive eruption of Mount St. Helens in 1980 caused 57 fatalities and $1 billion in damage. Stratovolcanoes usually have more viscous magma, so they have more explosive eruptions. In contrast, shield volcanoes can have very runny, nonexplosive eruptions. Stratovolcanoes are often steep, because the viscous lava they erupt has built up over time. These steep slopes mean that, in an eruption, lava can move more quickly. Different eruptions can also result in additional, destructive events. Nonexplosive Hawaiian eruptions can cause lava flows and create lava fields. These lava flows can be dangerous (the eruption of Hualālai in 1801 destroyed the village of Ka'ūpūlehu) but people can more easily move out of the way, and loss of life is lower than with more explosive eruptions. Explosive eruptions can also be accompanied by landslides, lahars, and pyroclastic flows, which can cause deaths and property damage. Merapi's 2010 eruption produced several pyroclastic flows and lahars, resulting in over 300 deaths. **L2 S6 3-D Assessment, TJ p. 88**
Rating for Category I. NGSS 3D Designed—units After carefully weighing the evidence, reasoning, and suggestions for improvement, rate the degree to which the criteria are met across the unit.	Unit Rating Scale for Category I (Criteria A–F): 3: At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C 2: At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C 1: Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C 0: Inadequate (or no) evidence to meet any criteria in Category I (A–F)	**Unit Rating Scale for Category I (Criteria A–F): 3**

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Category II: NGSS Instructional Supports (lessons and units)

Lesson and Unit Criteria *Lessons and units designed for the NGSS include clear and compelling evidence of the following:*	**Specific evidence from materials and reviewers' reasoning**	**Evidence of Quality**
A. **Relevance and Authenticity:** Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world. i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations). ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate. iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.	Evidence of i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations). Students directly experience the **Anchor Phenomenon** in **L1 S1** through the multimodal task in the "Volcano Hunters Anchor Phenomenon" section of the session. The description of this phenomenon is presented to students after they have discussed their observations. Students experience **Investigative Phenomena** throughout the subsequent sessions. Each **Investigative Phenomenon** is directly experienced through visual media, films, interactive simulations, guided investigations, or data sets. The tasks can be identified in the Teacher Edition through the headings "[Observe the/Discuss the] Investigative Phenomenon (Session X)". The description of this phenomenon is presented to students after they have discussed their observations. Examples from Volcano Hunters include: • **L1 S2**: Students explore the **Volcano Explorer digital interactive**, which allows	Evidence of i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).  **Anchor Phenomenon, TE p. 6**

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them to construct a global map showing volcano locations, plate boundaries, and historic earthquakes. They discuss observed patterns about the locations of volcanoes, and are introduced to the Investigative Phenomenon: There is a pattern in where volcanoes form.

- L1 S4: Students make observations about the **Rock Models visual**, which shows rocks found at different locations. The teacher distributes crayon models of the three rock types on the visual. Students make further observations and match the crayon models with the rocks on the visual, identifying the location each crayon model would be associated with. They are introduced to the Investigative Phenomenon: Rocks have different observable properties depending on where they are found.
- L3 S5: Students review the monitoring techniques they've learned about and how these help predict eruptions. They watch the **Undermonitored Volcanoes video**, which uses visual and verbal information to introduce them to the Investigative Phenomenon: Not all volcanoes are monitored to the same extent.

Volcano Hunters Anchor Phenomenon 30 min

Observe the Volcano Data

Arrange students into teams of four. Invite students to observe the images and statements on pages 8–10, and the map on page 11 in their Twig Journals. Prompt students to make a note of any observations on page 11.

Distribute a set of rock samples and a hand lens to each team. Explain that the numbered bags of rock samples correspond with the four locations shown on pages 8–11 in their Twig Journals. Prompt students to make a note of any observations on page 11 in their Twig Journals.

Distribute the envelopes with the slips from the **Volcano Headlines handout,** which show historic data on eruptions and impacts in each area. Prompt students to read and sort the data on the slips, and make a note of any observations on page 11 in their Twig Journals.



Describe the Anchor Phenomenon

Invite students to summarize their observations as a class. Synthesize their observations and reframe them as the Anchor Phenomenon on page 2 in their Twig Journals. Share that they will complete the explanation section at the end of the module.

L1 S1 Volcano Hunters Anchor Phenomenon, TE p. 13

Investigative Phenomenon

There is a pattern in where volcanoes form.

L1 S2 Investigative Phenomenon, TE p. 17

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Observe the Investigative Phenomenon (Session 2)

Have students explore the **Volcano Explorer digital interactive**. Ask them to record their observations on page 16 in their Twig Journals.



- ***What did you notice about the locations of volcanoes?***
  They can be on land or underwater.
  They are often clustered together.
  There are very few volcanoes on the US East Coast but lots on the West Coast.
  The Hawaiian Islands are all volcanoes.
- ***Where are most of these volcanoes located? Why could that be?***
  They are located near plate boundaries.
  They are located on the edges of oceans and countries/continents (on the edges of plates).
  I know there are often earthquakes at faults, so maybe the same processes also create volcanoes.

L1 S2 Observe the Investigative Phenomenon, TE p. 18

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Describe the Investigative Phenomenon (Session 4)

Display the **Rock Models visual**. Explain that each of the rocks were found at a different location.



- ***What do you observe about these rocks?***
  They all look different
  Some contain different colors or materials.
- ***How might these rocks have been formed? What makes you think that?***
  The rock at Location 1 looks like it's made up of lots of different pieces. Maybe this was formed by pushing different materials together.
  The rock at Location 3 is all the same color and smoother. This could have been melted.

Distribute the prepared 3-D crayon rock models throughout the class. Hold up or pass around the sedimentary, metamorphic, and igneous rock samples. **Note:** Students don't need to know the different rock types at this stage.

- ***What do you observe about these rocks? What do you observe about the crayon models?***
  The crayon models look like models of the different types of rock.
- ***Match the crayon models to each of the three locations in the visual. Explain your reasoning.***
  The crayon model with all the pieces matched the rock at Location 1. (Sedimentary rock model)
  The crayon model that has melted pieces looks like the rock at Location 2. (Metamorphic rock model)
  The crayon model that looks most melted matches the smooth rock at Location 3. (Igneous rock model)

Let students know that the 3-D models were formed using a particular process, just like the real rocks they are models of. Have students share their observations and ideas about formation.

L1 S4 Describe the Investigative Phenomenon (Session 4), TE p. 29

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	Evidence of ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate. **Cultural Connection sidebars**, included in all Twig Science Next Gen products, offer teachers strategies to link student instruction to their home, neighborhood, and community. Some **Honors and Advanced Extension** tasks also provide opportunities for connecting instruction to student experience. For example, in **L1 S8**, the **Honors and Advanced Extension** task invites students to research the topography and geology of their local area, considering how they	**Observe the Investigative Phenomenon (Session 5)** Review that students have been learning about monitoring techniques. • ***How does data help us monitor volcanoes?*** It helps us determine if and when an eruption is likely to occur. • ***What kinds of data have we been analyzing?*** Seismic activity, GPS movement, temperature, gas levels • ***Are all volcanoes monitored in the same way? Why or why not?*** No, monitors can be put in different places. Not all monitors are used on all volcanoes. • ***Do you think some volcanoes are monitored more than others? Why do you think so?*** Probably, yes. Not all volcanoes are active or dangerous. No. They're all monitored the same so we can predict eruptions. **L3 S5 Observe the Investigative Phenomenena (Session 5), TE p. 102** Evidence of ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate. **Cultural Connection** Be aware that the article reports details of some of the fatalities that occurred as a result of the eruption, which some students may find upsetting. **L2 S5 Cultural Connection, TE p. 72**

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might identify volcanoes, and make a claim about the likelihood of volcanoes in their area.

Twig Science Next Gen features scientists from a wide range of cultural and ethnic backgrounds, giving all students the opportunity to see themselves represented within the program. For example, in L2 S4, students are introduced to the concept of different types of eruptions through the eyes of real-life volcanologist Marissa Lo, providing students with a positive role model in a STEAM career.

The Teacher Background Knowledge documents provide connections between the instruction in the module, and careers that community members may have, or students may wish to pursue themselves. For example, the Volcano Hunters Teacher Background Knowledge provides details about careers including volcanologist, tour guide, engineering geologist, emergency management specialist, and engineering technician and assistant.

In Volcano Hunters, students also engage with the societal considerations and constraints in volcanology and hazard mitigation. For example, in L3 S5, students study several volcanoes and discuss reasons why these volcanoes are undermonitored, considering real-life causes for undermonitoring such as financial constraints, political issues, and cultural concerns.

Honors and Advanced Extension:
Are There Any Volcanoes Near Me?

Introduce the Activity

Explain that students will find out if there is any evidence for the existence of volcanoes near them, either now or in the past. They will use geologic and topographic maps.

- ***What do geologic maps show?***
  Rock types
- ***What do topographic maps show?***
  Elevations in an area, contour lines

Remind students that the closer the contour lines, the steeper the elevation.

Research Local Geology and Topography

Have students use digital topographic and geologic maps to research the topography and geology of their local area. Ask them to record their observations on page 60 in their Twig Journals and discuss these with a think-pair-share.

- ***How will you decide which locations are most likely to have volcanoes, or have had volcanoes in the past? Explain your reasoning.***
  I will look in locations that had igneous rocks, like we saw on the geologic map. I will look at the elevations in those areas to identify places where lava may have built up into rock formations.
- ***Were there any elevations on the map that suggest it might be a volcano? Share your evidence.***

Make Claims

Ask students to write a claim with evidence and reasoning on page 61 in their Twig Journals.

L1 S8 Honors and Advanced Extension, TE p. 50

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Extension

ARE THERE ANY VOLCANOES NEAR ME?

Collect Data • Use the internet to investigate the question: Are there any volcanoes near you? Record data and your observations.

Location	Rock Type	Observations (e.g., elevation)
Students should gather information on the types of rocks from geologic maps and record observations on elevation from the topographic maps.		

L1 S8 Extension, TJ p. 60

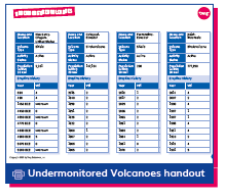
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L2 S4 Different Volcanoes Different Eruptions, TJ p. 69

Analyze Hazard Risks

Have students meet in small teams. Distribute the **Undermonitored Volcanoes handout**.



Ask teams to identify one volcano from the dataset they think should be prioritized for monitoring. They should consider:

- The activity status of the volcano
- The type of volcano
- The local population
- The eruptive history.

Have teams complete the graphic organizer and support their choice on pages 112–113 in their Twig Journals.



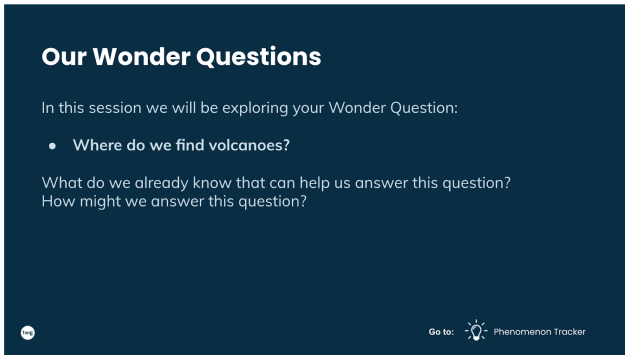
Provide support with reading the eruptive histories and help teams calculate the average VEI of each

L2 S5 Analyze Hazard Risks, TE p. 103

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	Evidence of iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience. In the first session of the module, students use the **Co-Craft Questions language routine** to ask scientific questions based on their own experiences of the **Anchor Phenomenon**. These are recorded on a **Wonder Questions chart**. The teacher then uses these questions to identify the sessions in the program that can help students answer them. After using the **Co-Craft Questions language routine** to generate **Wonder Questions** in the first session, students return to these questions as each lesson progresses. The first session of each subsequent lesson has an opportunity for students to generate and add to their **Wonder Questions Chart** using the **Co-Craft Questions language routine**. After generating **Wonder Questions**, students are invited to suggest which questions they want to answer first, and discuss what they already know about the questions and how they might answer them. At the start of the next session, students review the **Wonder Question** that they will be exploring using either the **Class Wonder Questions Chart** or the **Lesson Presentation slides**. They are asked	Evidence of iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience. **Think Talk—Co-Craft Questions** Use the Co-Craft Questions language routine to generate Wonder Questions about the Anchor Phenomenon. Have students work individually and then in small groups and record their questions on scratch paper. Prompt groups to share their Wonder Questions, and record them on the board. Have the class reframe the questions as investigable questions. Discuss ways of grouping questions together, and whether there are any missing questions. Based on the discussion, develop a physical or digital Class Wonder Questions chart. Guide students to group questions that consider: • How and why an area might change as a result of geoscience processes associated with volcanic activity (Lesson 1) • What makes volcanoes dangerous to human populations (Lesson 2) • How we can predict eruptions and protect communities from the risks they pose (Lesson 3). Share with students the group of questions they will be investigating this lesson. Have students record the questions in their Wonder Questions charts on pages 4–5 in their Twig Journals. During or after the session, use the **Module Wonder Questions** to create a map that connects student questions to the sessions.  **L1 S1 Think Talk—Co-Craft Questions, TE p. 14**

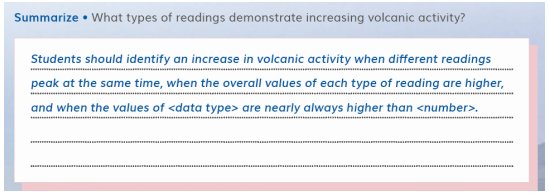
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	to share what they already know that can help them answer the question, and how they might answer the question. Module-specific introductory tasks also allow students to recall and recap prior experiences from within or outside the classroom. For example, in Volcano Hunters, students are encouraged to use prior knowledge from outside the classroom to describe a volcano (L1 S1) and to use information from Lesson 2 to discuss what signs might indicate a volcano is about to erupt (L3 S1). Toward the end of a session, students update their Phenomena Trackers to record their sense-making about the Investigative and Anchor Phenomena, and respond to any Wonder Questions they can answer. They then suggest any new Wonder Questions, and they are invited to determine which questions they want to answer next. They discuss what they already know about the question and how they might answer it. This process is repeated as students progress through the module. In Volcano Hunters, the Co-Craft Questions language routine, Wonder Questions Chart Routine, and Phenomena Tracker Routine appear in these sessions: • Co-Craft Questions language routine: L1 S1, L2 S1, L3 S1 • Wonder Questions Chart Routine: L1	 Wonder Questions Chart Routine, Lesson Presentation slides **What Is a Volcano?** 10 min Activate Prior Knowledge About Volcanoes Ask students to imagine a volcano. Have them turn to a partner and describe their volcano. Invite students to share their descriptions. Write their ideas on the board to create a class description. L1 S1 Activate Prior Knowledge About Volcanoes, TE p. 13

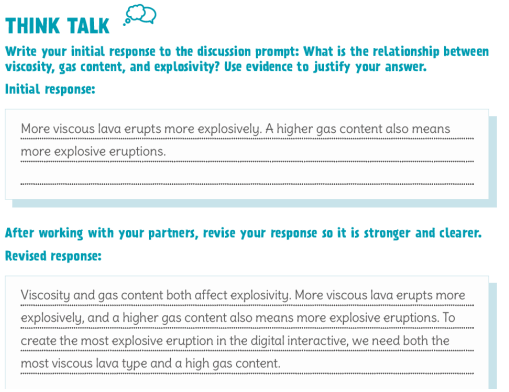
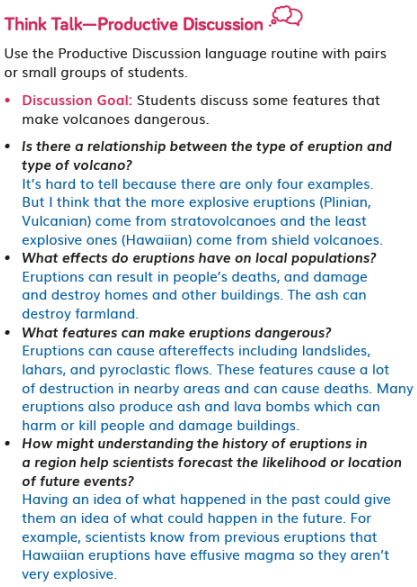
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	S2–8, L2 S1–6, L3 S1–6 • Phenomena Tracker Routine: L1 S2–4, L1 S6–7, L2 S1–5, L3 S1–5	**Discuss Observations and Data** Invite students to share their findings with the class. • ***What patterns did you notice?*** Eruptions were more likely when lots of values were high—a greater number of earthquakes, more gas being released, and more ground movement being recorded. • ***How easy or difficult would it be to forecast an eruption?*** We could get a good idea of an approaching eruption, but the data does not always match up precisely. The gas levels were usually very high (over 300 metric tons) when the volcano was erupting, but at one point it was under 100 metric tons. • ***What might have caused the pattern in increased seismic activity that led to an eruption?*** As magma moved through the volcano, maybe it caused the Earth to shake. Summarize students' findings: • It can be possible to predict an eruption by monitoring changes in the surrounding area. • When there is more activity in an area than normal (e.g., more ground movement, more seismic activity), this suggests an eruption may occur. • When several types of monitors record increased activity at the same time, this also suggests an eruption may occur. L3 S1 Discuss Observations and Data, TE p. 86

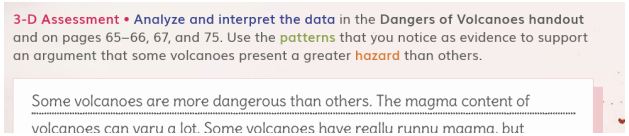
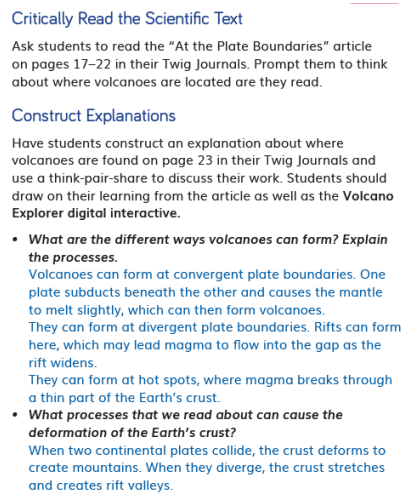
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B. **Student Ideas:** Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and to respond to peer and teacher feedback orally and/or in written form as appropriate.	**Evidence of B. Student Ideas:** Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and to respond to peer and teacher feedback orally and/or in written form as appropriate. Twig Science Next Gen sessions provide opportunities for students to express, clarify, justify, interpret, and represent their ideas and to respond to feedback. This expression takes many forms. Class discussion and language routines provide opportunities for students to express themselves with equity, while grade-appropriate writing and drawing tasks encourage students to communicate their ideas. Students revisit their work and previous conceptions over the course of the module, using feedback and learning to revise and improve their ideas. Students have opportunities for targeted specific oral questioning throughout the module. For example, in **L1 S2**, during the guided investigation, the teacher prompts students to communicate their observations about the **Volcano Explorer digital interactive**. Students also have many opportunities throughout the module to provide written answers to questioning. For example, in **L3 S3**, students are supported to express their ideas about the relationship between volcanic activity and quantitative data with a written answer to the question: *What types of readings demonstrate increasing volcanic activity?* This provides them with an opportunity to express their ideas about	**Evidence of B. Student Ideas:** Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and to respond to peer and teacher feedback orally and/or in written form as appropriate. Observe the Investigative Phenomenon (Session 2) Have students explore the **Volcano Explorer digital interactive**. Ask them to record their observations on page 16 in their Twig Journals.  • ***What did you notice about the locations of volcanoes?*** They can be on land or underwater. They are often clustered together. There are very few volcanoes on the US East Coast but lots on the West Coast. The Hawaiian Islands are all volcanoes. • ***Where are most of these volcanoes located? Why could that be?*** They are located near plate boundaries. They are located on the edges of oceans and countries/ continents (on the edges of plates). I know there are often earthquakes at faults, so maybe the same processes also create volcanoes. **L1 S2 Observe the Investigative Phenomenon (Session 2), TE p. 18**  Summarize • What types of readings demonstrate increasing volcanic activity? *Students should identify an increase in volcanic activity when different readings peak at the same time, when the overall values of each type of reading are higher, and when the values of <data type> are nearly always higher than <number>.* **L3 S3 Summarize, TJ p. 105**

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	the data they've been analyzing and how it relates to volcanic activity. Students are able to both clarify and justify their thinking and ideas with the use of language routines throughout the module. For example, in L2 S3, students use the Stronger and Clearer Each Time language routine, as they respond to the prompt: • *What is the relationship between viscosity, gas content, and explosivity? Use evidence to justify your answer.* They write an individual answer to the prompt in their Twig Journals, before pairing up with other students. Students share their own thinking, and ask for clarity, reasoning, details, and examples to help support the ideas of other students. They then revise their responses in a way that is clearer and more strongly supported by evidence and reasoning. Teachers are recommended to provide the **Stronger and Clearer Graphic Organizer handout** to help students with their revised responses. In L2 S4, students engage in a Productive Discussion language routine when synthesizing their understanding of features that make volcanoes dangerous. Students are also prompted to justify their thinking when responding to Summative Assessment tasks. For example, in L2 S6, students construct arguments about the comparative dangers of volcanoes and are prompted to provide evidence that justifies their ideas.	 THINK TALK Write your initial response to the discussion prompt: What is the relationship between viscosity, gas content, and explosivity? Use evidence to justify your answer. Initial response: More viscous lava erupts more explosively. A higher gas content also means more explosive eruptions. After working with your partners, revise your response so it is stronger and clearer. Revised response: Viscosity and gas content both affect explosivity. More viscous lava erupts more explosively, and a higher gas content also means more explosive eruptions. To create the most explosive eruption in the digital interactive, we need both the most viscous lava type and a high gas content. L2 S3 Stronger and Clearer Each Time language routine, TJ p. 68  Think Talk—Productive Discussion Use the Productive Discussion language routine with pairs or small groups of students. • Discussion Goal: Students discuss some features that make volcanoes dangerous. • ***Is there a relationship between the type of eruption and type of volcano?*** It's hard to tell because there are only four examples. But I think that the more explosive eruptions (Plinian, Vulcanian) come from stratovolcanoes and the least explosive ones (Hawaiian) come from shield volcanoes. • ***What effects do eruptions have on local populations?*** Eruptions can result in people's deaths, and damage and destroy homes and other buildings. The ash can destroy farmland. • ***What features can make eruptions dangerous?*** Eruptions can cause aftereffects including landslides, lahars, and pyroclastic flows. These features cause a lot of destruction in nearby areas and can cause deaths. Many eruptions also produce ash and lava bombs which can harm or kill people and damage buildings. • ***How might understanding the history of eruptions in a region help scientists forecast the likelihood or location of future events?*** Having an idea of what happened in the past could give them an idea of what could happen in the future. For example, scientists know from previous eruptions that Hawaiian eruptions have effusive magma so they aren't very explosive. L2 S4 Productive Discussion language routine, TE p. 69

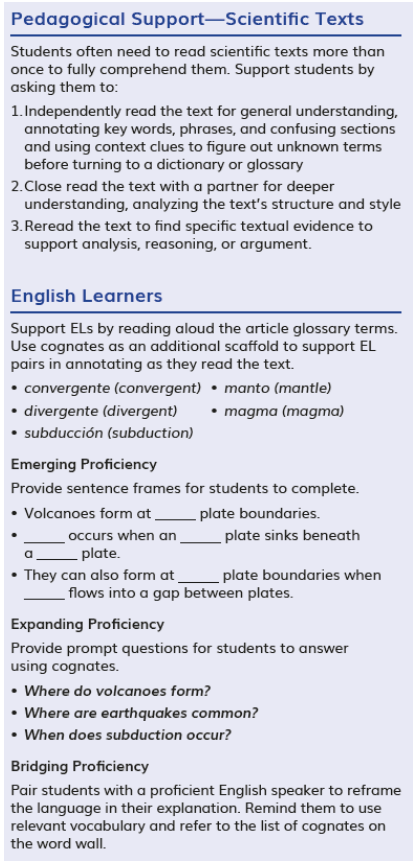
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	Students are often prompted to consider how they have interpreted information and to interpret information provided by others. For example, after using the **Volcano Explorer digital interactive** and reading the "At the Plate Boundaries" article in **L1 S2**, students use a think-pair-share to discuss their ideas about where volcanoes are found. This allows them to have a prompted discussion, and share their impressions and understanding of what they have just read. Teachers are prompted to help with the reading (**Pedagogical Support—Scientific Texts sidebar**, **English Learners sidebar**). Throughout the module, students communicate their thinking and ideas in different ways. For example, in **L1 S7**, after reading the "Life and Times of Mount Mazama" article, students develop models, write descriptions, and construct arguments in their Twig Journals. They additionally have other opportunities to visually show their thinking, for example, in **L1 S3**, when they draw models to distinguish between the processes of weathering and erosion. Students also present their thinking in written explanations throughout the module, for example, in **L1 S2**, when they develop written explanations about the locations of volcanoes, or when they provide a written response to the **Anchor Phenomenon** at the end of the module. Finally, students also communicate their thinking orally, for example, in **L2 S2**, when they engage in a **Productive Discussion Language Routine** to connect how	 3-D Assessment • Analyze and interpret the data in the Dangers of Volcanoes handout and on pages 65–66, 67, and 75. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others. Some volcanoes are more dangerous than others. The magma content of volcanoes can vary a lot. Some volcanoes have really runny magma, but **L2 S6 Summative Assessment, TJ p. 88**  Critically Read the Scientific Text Ask students to read the "At the Plate Boundaries" article on pages 17–22 in their Twig Journals. Prompt them to think about where volcanoes are located are they read. Construct Explanations Have students construct an explanation about where volcanoes are found on page 23 in their Twig Journals and use a think-pair-share to discuss their work. Students should draw on their learning from the article as well as the **Volcano Explorer digital interactive.** • ***What are the different ways volcanoes can form? Explain the processes.*** Volcanoes can form at convergent plate boundaries. One plate subducts beneath the other and causes the mantle to melt slightly, which can then form volcanoes. They can form at divergent plate boundaries. Rifts can form here, which may lead magma to flow into the gap as the rift widens. They can form at hot spots, where magma breaks through a thin part of the Earth's crust. • ***What processes that we read about can cause the deformation of the Earth's crust?*** When two continental plates collide, the crust deforms to create mountains. When they diverge, the crust stretches and creates rift valleys. **L1 S2 Critically Read the Scientific Text, TE p. 19**

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different properties affect lava's behavior. This allows them to share and discuss their ideas in pairs, or small groups.

Students are prompted to provide peer feedback when appropriate. For example, in **L1 S7**, students use a **Stronger and Clearer Each Time language routine** when they explain how Mount Mazama has changed over its lifetime. After constructing an individual response to the prompt, students discuss their thinking with another student. Students listen to one another's thinking, and then respond with suggestions for reasoning, evidence, and clarification. This is a collaborative approach that allows students to support each other in revising and strengthening their ideas. Teachers are also given opportunities throughout the module to scaffold students ideas, and to give feedback when appropriate. For example, in **L1 S3**, while students are taking part in a **Productive Discussion language routine**, teachers are encouraged to circulate amongst the student groups and use talk moves to help expand and clarify student thinking and deepen their reasoning.



Pedagogical Support—Scientific Texts

Students often need to read scientific texts more than once to fully comprehend them. Support students by asking them to:

1. Independently read the text for general understanding, annotating key words, phrases, and confusing sections and using context clues to figure out unknown terms before turning to a dictionary or glossary
2. Close read the text with a partner for deeper understanding, analyzing the text's structure and style
3. Reread the text to find specific textual evidence to support analysis, reasoning, or argument.

English Learners

Support ELs by reading aloud the article glossary terms. Use cognates as an additional scaffold to support EL pairs in annotating as they read the text.

- *convergente (convergent)*
- *divergente (divergent)*
- *subducción (subduction)*
- *manto (mantle)*
- *magma (magma)*

Emerging Proficiency

Provide sentence frames for students to complete.

- Volcanoes form at _____ plate boundaries.
- _____ occurs when an _____ plate sinks beneath a _____ plate.
- They can also form at _____ plate boundaries when _____ flows into a gap between plates.

Expanding Proficiency

Provide prompt questions for students to answer using cognates.

- ***Where do volcanoes form?***
- ***Where are earthquakes common?***
- ***When does subduction occur?***

Bridging Proficiency

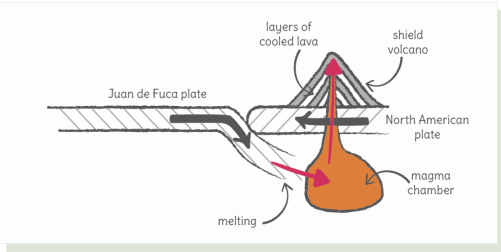
Pair students with a proficient English speaker to reframe the language in their explanation. Remind them to use relevant vocabulary and refer to the list of cognates on the word wall.

L1 S2 Pedagogical Support—Scientific Texts sidebar, English Learners sidebar, TE p. 19

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Develop Models • Mount Mazama was once on the boundary between the Juan de Fuca plate and the North American plate. The Juan de Fuca plate moved beneath the North American plate in a process called subduction.

Draw the steps that occurred at the plate boundary during Phase 1 of Mount Mazama's formation. Use arrows to show how the materials are cycling.



L1 S7 Develop Models, TJ p. 53

Obtain Scientific Information • Based on the reading, write descriptions of each of the changes and periods of stability Mount Mazama underwent over its lifetime.

Phase	Changes or Periods of Stability	Cause	Timescale
1	Two plates collided, which resulted in plate subduction. One plate was pushed down into the mantle, which started to melt into magma. Over thousands of years a magma chamber formed. The volcano erupted over thousands of years, and layers of magma cooled to form volcanic rock. It was a broad and gently sloped volcano, which lay dormant for thousands more years.	Plate collision Volcanic eruptions	Slow Fast
2	A new magma chamber formed with thicker and more explosive magma. It erupted, coating the landscape with magma and volcanic ash. Mount Mazama grew steeper and higher to become a 2,500 m high stratovolcano. Wind and glacial erosion shortened the volcano to 2,000 m. Then, 250,000 years ago, a massive eruption emptied the magma chamber.	New magma chamber full of thick and explosive magma Wind and glacial erosion Volcanic eruptions	Slow Slow Fast
3	Mount Mazama's last violent eruption was 7,000 years ago. It was so big that it hollowed out the volcano, causing it to collapse. This formed a massive crater called a caldera. Rainwater and melting snow turned the crater into a lake and minor eruptions have caused small islands to form.	Volcanic eruptions Rainwater and melting ice	Fast Slow

L1 S7 Obtain Scientific Information, TJ p. 54

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THINK TALK

Write your initial response to the discussion prompt:

How did Mount Mazama change over its lifetime? When was it relatively stable? Explain the processes involved, and whether the changes were fast or slow.

Initial response:

Mount Mazama changed from a shield volcano to a stratovolcano to a caldera. This happened over thousands of years. Some of these changes were faster than others.

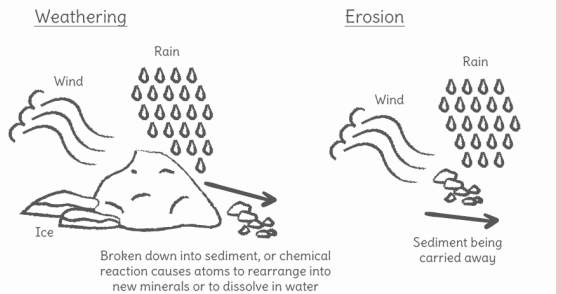
After working with your partners, revise your response so it is stronger and clearer.

Revised response:

Over thousands of years, Mount Mazama moved through three phases in its life cycle. During the first phase, two tectonic plates collided, forcing one to move under the other in a process called subduction. It took thousands of years for a magma chamber to form and erupt magma onto the surface, creating a shield volcano, which lay dormant for thousands of years. In the second phase, the shield volcano erupted thicker and more explosive magma, causing it to change shape. Over thousands of years it became a steep stratovolcano. In the third phase, a massive eruption caused the volcano to collapse, forming a huge crater or caldera. This change happened quickly, only two days after the eruption.

L1 S7 Stronger and Clearer Each Time language routine, TJ p. 55

Draw 2-D models to distinguish the processes of weathering and erosion.



L1 S3 Develop and Use Models, TJ p. 29

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		Construct Explanations • Where are volcanoes found? Write an explanation using evidence gathered from the "At the Plate Boundaries" article and the **Volcano Explorer digital interactive**. Volcanoes are found in areas where the mantle is partially melted and magma can emerge from the Earth. We saw in the digital interactive and in the text that volcanoes often occur over plate boundaries where plates converge and diverge. For example, they often appear at oceanic–continental convergent plate boundaries, where the oceanic plate moves under the continental plate. This process is called subduction. Volcanoes also occur in underwater rift valleys, where plates diverge, and at hot spots, which can be in the middle of tectonic plates. **L1 S2 Construct Explanations, TJ p. 23** Review the Anchor Phenomenon Display the Class Wonder Questions chart and review the Anchor Phenomenon. Summarize the Wonder Questions that have been looked at in the module and ask students to discuss which new aspects of the Anchor Phenomenon they can now explain. Have students complete their explanations on page 3 in their Twig Journals. Remind them to include information about how they used the scientific practice of analyzing and interpreting data, and thought about the phenomena through the lens of patterns. **L3 S6 Review the Anchor Phenomenon, TE p. 107**

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EXPLANATION:

Bougainville Island, Yogyakarta, and Auckland are all volcanic areas, but Kathmandu is not volcanic. We can identify which landforms are volcanic by analyzing their location, and using rock samples. Models show how the rocks in these areas have been changed as a result of the cycling of energy and matter. The lava from eruptions forms igneous rock. Igneous rock is physically changed by energy from the Earth's core, and changes from other rock as chemicals mix together in the molten rock. Sedimentary rock is formed when erosion and weathering break down other rock into fragments, and transport it to rivers and lakes, where pressure and chemical reactions cause it to cement together.

By comparing eruption data to identify patterns, it is clear that not all volcanoes pose a risk though. Only two are active, while one is dormant. The Auckland volcanic field is dormant. This means that an eruption is unlikely in this location. The residents of Bougainville Island and Yogyakarta have active volcanoes that have explosive eruptions. This means they are more dangerous than active volcanoes with non-explosive eruptions. Also as these volcanoes are near where people live, they pose a larger risk than those far away from communities.

Volcanoes have patterns of behavior that can be used to predict when they might erupt. Volcanologists can monitor volcanoes and analyze the data they collect about the eruptive history, gas content, earthquake levels, and magma thickness. This can be used to predict an eruption and alert people, such as the residents of Bougainville Island and Yogyakarta, to any possible risk.

Anchor Phenomenon, TJ p. 3

Think Talk—Productive Discussion

Use the Productive Discussion language routine with pairs or small groups of students.

- **Discussion Goal:** Students connect how different properties affect lava's behavior.
- ***What differences in flow rate (the amount of time it takes for a liquid to move) did you observe? How might a liquid's flow rate connect to its viscosity?***
  The oil moves fastest because it is much runnier than the other liquids (it is less viscous). The ketchup moves slowest because it is heavier and thicker (it is more viscous).
- ***Would the shape of a volcano have an effect on the speed of its lava flow?***
  Yes. Lava travels more quickly down a steep slope than a shallow one.
- ***How does tephra affect how quickly or slowly a liquid moves down the slope of a volcano?***
  The tephra make the lava move more slowly. The more tephra (or debris) in lava, the slower it moves.

L2 S2 Productive Discussion language routine, TE p. 61

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Think Talk—Stronger and Clearer Each Time

Use the Stronger and Clearer Each Time language routine to provide students with an opportunity to revise and refine their verbal and written output. Optional: Distribute copies of the **Stronger and Clearer Graphic Organizer handout.**

- Discussion Prompt: How did Mount Mazama change over its lifetime? When was it relatively stable? Explain the processes involved, and whether the changes were fast or slow.



Invite students to individually answer the prompt on page 55 in their Twig Journals. Explain that they can also draw diagrams or other visuals to help them organize their thinking.

Ask students to pair up to verbally share their thinking. As Student 1 shares, Student 2 should listen carefully and ask for clarity, reasoning, details, and examples that support Student 1's thinking. Students then switch roles.

Have students repeat the routine with two to three partners. When they finish, prompt students to use the **Stronger and Clearer Graphic Organizer handout** to revise their written responses on page 55 in their Twig Journals. Give students time to compare their two responses.

L1 S7 Stronger and Clearer Each Time language routine, TE p. 44

Think Talk—Productive Discussion

Use the Productive Discussion language routine with pairs or small groups of students. Circulate to support scientific discussion, using talk moves to help expand and clarify student thinking and deepen their reasoning.

Collect and display key student language that aligns to the discussion goal, as appropriate. Listen for how students are using the three dimensions for sense-making. Use this as a visual reference to bridge to module vocabulary.

- Discussion Goal: Students discuss the life cycle of a volcano, and describe what causes volcanoes to change over time.
- ***How do different-shaped volcanoes form?***
  Volcanoes form when magma from the Earth's mantle erupts to the surface. The thickness of the lava determines what a volcano looks like after it erupts.

L1 S3 Productive Discussion language routine, TE p. 26

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C. **Building Progressions:** Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers:

i. Explicitly identifying prior student learning expected for all three dimensions
ii. Clearly explaining how the prior learning will be built upon

Evidence of i.
Explicitly identifying prior student learning expected for all three dimensions

Teaching materials clearly identify prior student learning expected for all three dimensions. The **online Performance Expectation Progressions** specify students' prior knowledge from Grades 3–5 for each dimension, and identify the sessions where students are working with prior knowledge of each dimension. For example, the **online Performance Expectation Progressions** for Volcano Hunters indicate that, when working toward mastery of MS-ESS2-3, students are working with prior knowledge of SEP-4 in **L2 S1** and **L3 S1**, ESS3.B in **L2 S1** and **L3 S1–2**, CCC-1 in **L2 S1** and **L3 S1**, and CETAS-2 in **L2 S5**.

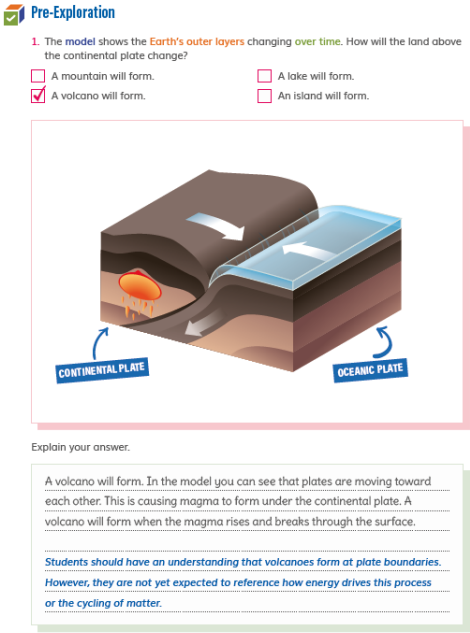
The module **Pre-Assessment** in **L1 S1** is designed to check student prior knowledge, ensuring students have an appropriate level of understanding before they work toward the targeted dimensions. The example answers provided in the student answer Twig Journal clarify what students are expected to know from earlier grades. For example, in Volcano Hunters, the answer to Q1 states that:

- Students should have an understanding that volcanoes form at plate boundaries. However, they are not yet expected to reference how energy drives this process or the cycling of matter.

Evidence of i.
Explicitly identifying prior student learning expected for all three dimensions

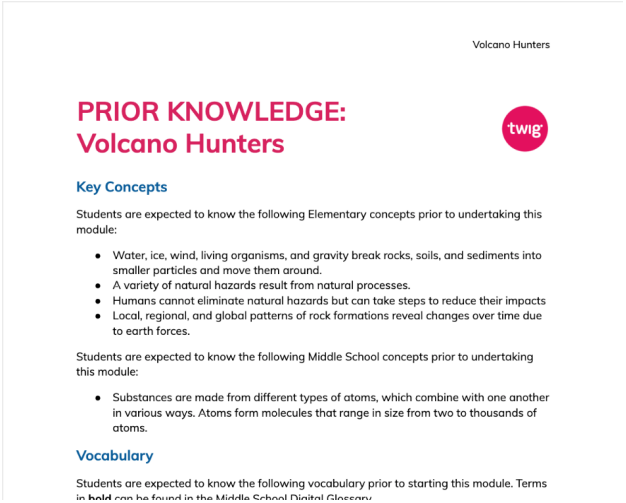
	Working with Prior Knowledge	Working Toward Mastery	Demonstrating Mastery
MS-ESS2-1 Earth's Systems			
SEP-2	Lesson 1 Session 2	Lesson 1 Session 4 Lesson 1 Session 5	Lesson 1 Session 6 Lesson 1 Session 8
ESS2.A[a]	Lesson 1 Session 2 Lesson 1 Session 3	Lesson 1 Session 4 Lesson 1 Session 5	Lesson 1 Session 6 Lesson 1 Session 7 Lesson 1 Session 8

Online Performance Expectation Progressions



L1 S1 Pre-Assessment, TJ p. 12

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	The teacher-facing **Prior Knowledge** document outlines expected prior knowledge that relates to the module DCIs, including key concepts and vocabulary, and provides video supports to help students recap key terms and concepts they need for the module. For example, the **Prior Knowledge** for Volcano Hunters specifies that students should know these concepts before undertaking the module: **Concepts from Elementary** ● Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. ● A variety of natural hazards result from natural processes. ● Humans cannot eliminate natural hazards but can take steps to reduce their impacts. ● Local, regional, and global patterns of rock formations reveal changes over time due to earth forces. **Concepts from Middle School** ● Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Evidence of ii. Clearly explaining how the prior learning will be built upon Teacher materials clearly explain how students' prior knowledge for all three dimensions will be	 Volcano Hunters PRIOR KNOWLEDGE: Volcano Hunters Key Concepts Students are expected to know the following Elementary concepts prior to undertaking this module: ● Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. ● A variety of natural hazards result from natural processes. ● Humans cannot eliminate natural hazards but can take steps to reduce their impacts ● Local, regional, and global patterns of rock formations reveal changes over time due to earth forces. Students are expected to know the following Middle School concepts prior to undertaking this module: ● Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Vocabulary Students are expected to know the following vocabulary prior to starting this module. Terms Prior Knowledge Evidence of ii. Clearly explaining how the prior learning will be built upon

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built on as they progress through the module. The **online Performance Expectation Progressions** indicate the sessions where students are working with prior knowledge, working toward grade-level, and working at grade-level for each dimension. For example, the **online Performance Expectation Progressions** for Volcano Hunters indicate that students are working with prior knowledge of SEP-4 in L3 S1, working toward grade level mastery in L3 S3, and working at grade level (demonstrating mastery) in L3 S4–6.

In every Teacher Edition (pp. 6–7), there is a completed **Phenomena Tracker** that includes suggested student answers and helps show how student understanding develops over the module. These answers are color-coded to highlight the dimensions students are using to make sense of the phenomenon. For example, the completed **Phenomena Tracker** for Volcano Hunters includes the following student responses:

- L3 S1: Patterns show that volcanoes change before they erupt, becoming taller, releasing more carbon dioxide, and producing small earthquakes.
- L3 S2: Volcanologists gather data using rock sampling, GPS, gas detectors, seismometers, and other detectors to measure changes in volcanoes over long periods of time to determine trends.
- L3 S3–4: Long-term trends in data from volcanoes show that volcanoes change before they erupt, becoming taller, releasing more carbon dioxide, and

	Working with Prior Knowledge	Working Toward Mastery	Demonstrating Mastery
MS-ESS2-1 Earth's Systems			
SEP-2	Lesson 1 Session 2	Lesson 1 Session 4 Lesson 1 Session 5	Lesson 1 Session 6 Lesson 1 Session 8
ESS2.A[a]	Lesson 1 Session 2 Lesson 1 Session 3	Lesson 1 Session 4 Lesson 1 Session 5	Lesson 1 Session 6 Lesson 1 Session 7 Lesson 1 Session 8

Online Performance Expectation Progressions

Phenomena Tracker

Session	Wonder Question	Investigative Phenomenon	Outcome of Sense-Making
Lesson 1 | Driving Question *Can we identify volcanoes in the landscape surrounding Kathmandu, Bougainville Island, Auckland, and Yogyakarta?*			
1.2	*Where do we find volcanoes?*	There is a pattern in where volcanoes form.	Patterns show that volcanoes tend to occur at the boundaries between tectonic plates and at hot spots, but not all interactions at plate boundaries result in volcanoes.
1.3	*Do volcanoes always look the same?*	Volcanoes form at tectonic boundaries, changing landscapes.	Energy from the Earth's center causes rocks to melt into magma, which breaks through the Earth's crust as a volcano. Volcanoes change over long and short periods of time as lava erupts and cools, building up rock peaks which are also eroded by wind and rain.
1.4	*Why are rocks different from each other?*	Rocks have different observable properties depending on where they are found.	Processes such as heating, cooling, compression, and abrasion cause rocks to have different observable properties.
1.5	*What are the processes that cause rocks to change in a volcanic landscape?*	The features of a landscape change over time.	Matter in the Earth cycles; physical and chemical processes cause rocks to change into different types: sedimentary, metamorphic, and igneous. These changes can happen quickly or slowly. Sometimes the conditions do not cause rocks to change, and they appear stable for very long periods of time.
1.6	*What are the processes that cause rocks to change in a volcanic landscape?*	The features of a landscape change over time.	Matter in the Earth cycles; physical and chemical processes cause rocks to change into different types: sedimentary, metamorphic, and igneous. These changes can happen quickly or slowly. Sometimes the conditions do not cause rocks to change, and they appear stable for very long periods of time.
1.7	*How does a volcano change over its lifetime?*	Volcanoes change over time.	Mount Mazama has had periods of stability, and periods of change over its lifetime. It has formed peaks of igneous rock as magma solidified, been eroded via physical and chemical processes, slowly over time, and through fast changes such as landslides and collapse. It is now extinct, and can be seen as a huge caldera.

Phenomena Tracker, TE pp. 6

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	producing small earthquakes. • L3 S5: The threat to communities from volcanoes can be assessed using historic data about volcanoes, and details about the location, as well as ongoing monitoring. Solutions can be designed and evaluated to minimize the impact of eruptions to communities. These color-coded answers show the development of student use of the dimensions across the lesson. For example, students build on their understanding of the DCI as they progress from observing that volcanoes change before they erupt, to thinking about how change can be measured over time, to assessing the potential threat to communities indicated by these changes.	
D. **Scientific Accuracy:** Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.	**Evidence of D. Scientific Accuracy:** Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning. Developed in partnership with scientists at Imperial College London, Twig Science Next Gen sessions and materials use grade-appropriate scientific information and phenomena in guiding students to make sense of phenomena. Module learning materials that feature verbal or written text (i.e., scientific texts, videos) are assessed using ATOS to determine reading level, and are matched against specific grade-band DCI	**Evidence of D. Scientific Accuracy:** Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning. ANCHOR PHENOMENON The residents of Kathmandu, Bougainville Island, Auckland, and Yogyakarta all live in the shadow of hills and mountains. Three of the locations are near the ocean, and three have similar rocks. Some locations have experienced devastating volcanic eruptions in the past that have affected local residents. Sometimes local residents are able to be protected. **Anchor Phenomenon, TE pp. 6**

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requirements.

Representations of phenomena are grade-appropriate, because they can be explored and explained using elements of the grade-band appropriate SEP, CCC, and DCIs.

For example, the Anchor Phenomenon for Volcano Hunters is:

- *The residents of Kathmandu, Bougainville Island, Auckland, and Yogyakarta all live in the shadow of hills and mountains. Three of the locations are near the ocean, and three have similar rocks. Some locations have experienced devastating volcanic eruptions in the past that have affected local residents. Sometimes local residents are able to be protected.*

To explore and make sense of the phenomenon, students use elements of grade-band SEP-2, SEP-4, ESS2.A, ESS3.B, CCC-1, and CCC-7. The three dimensions are highlighted for the teacher in the example student answer in the Twig Journal.

Individual NGSS standards are applied at a grade-appropriate level. For example, at Grades 6–8 of the NGSS, students are expected to show increasing mastery of SEP-3 (Planning and Carrying Out Investigations). They should "progress to include investigations that use multiple variables and provide evidence to

Investigative Phenomenon

Lava from different volcanoes is different.

L2 S2 Investigative Phenomenon, TE p. 58

Plan and Carry Out Investigations • Follow these steps to investigate how lava behaves.

Investigation 1: Steepness of Slope

1. Place the plastic table cover on your work area. Use books and a flat surface to set up a shallow slope on top of the cover.
2. Pour 1 tbsp of your assigned liquid from the top of the slope.
   a. Time how long it takes for the liquid to reach the bottom of the slope.
   b. Use a ruler to measure how far the liquid travels.
   c. Record the time and distance in the Measurements column.
3. Add books to raise the height of your slope, creating a medium slope.
4. Repeat Step 2.
5. Add books to raise the height of your slope, creating a steep slope.
6. Repeat Step 2.

Liquid: Corn syrup

Steepness of Slope	Measurements	
Shallow	5 min to travel 32 cm	*Student results will vary depending on the liquid tested and the angle of their slopes. Oil will move farther and take less time, dish soap will move roughly the same distance and in the same time, and ketchup won't move as far and will take a long time to move.*
Medium	2 min 50 s to travel 50 cm	
Steep	1 min 46 s to travel 50 cm	

L2 S2 Plan and Carry Out Investigations, TJ p. 65

Investigative Phenomenon

Volcanoes change in measurable ways before an eruption.

L3 S4 Investigative Phenomenon, TE p. 96

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support explanations or solutions." In L2 S2, students discuss predictions about lava and complete the Lava Types investigation as they explore and make sense of the Investigative Phenomenon:

- Lava from different volcanoes is different.

They test the impact of several variables on the behavior of lava, including steepness of slope, viscosity of liquid, and whether or not there is tephra (debris). They also choose different liquids to perform the investigations with, and come together as a class to share findings. This shows students making clear, grade-appropriate use of SEP-3 as they test multiple variables to find evidence to support their hypotheses.

Students are also expected to show increased mastery of CCC-7 (Stability and Change). They should "explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time." In L3 S4, students are working toward making sense of the Investigative Phenomenon:

- Volcanoes change in measurable ways

Day	GPS Receiver (change in distance,mm)	Seismometer (no. of earthquakes)	COSPEC (gas levels, tons)	Temperature °C
1	10	51	737	46
2	19	53	757	47
3	12	51	716	47
4	8	48	602	42
5	8	41	521	39
6	13	46	750	44
7	9	44	642	40
8	7	45	519	41
9	16	44	493	43
10	9	37	451	40
11	14	32	485	44
12	3	34	432	38
13	6	29	391	40
14	8	32	382	40
15	6	29	398	37
16	2	28	338	38
17	1	21	257	35
18	4	17	273	36
19	5	19	268	33

Current Dataset visual

Collect Evidence • Complete the table by assigning warning levels to each day.

Day	GPS receiver (change in distance, mm)	Seismometer (no. of earthquakes)	COSPEC (gas levels, metric tons)	Temperature (°C)	Warning Level
1	10	51	737	46	Warning
2	19	35	757	47	Warning
3	12	51	716	47	Warning
4	8	48	602	42	Warning
5	8	41	521	39	Warning
6	13	46	750	44	Warning
7	9	44	642	40	Warning
8	7	45	519	41	Warning
9	16	44	493	43	Watch
10	9	37	451	40	Watch
11	14	32	485	44	Watch
12	3	34	432	38	Watch
13	6	29	391	40	Watch
14	8	32	382	40	Watch

L3 S4 Collect Evidence, TJ p. 108

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	before an eruption. To do this, students analyze datasets from a volcano to determine danger level by evaluating changes in the data over time. They study the **Current Dataset visual** for a fictional volcano and analyze how changes in the data over time might correlate to a higher risk of volcanic eruption. They assign warning levels based on their data to specify the degree of threat of eruption and explain their choices in a scientific argument. This shows clear use of CCC-7 at grade appropriate level as they are explaining changes in natural systems over time and considering how changes in one part of the data could affect other parts of the volcanic system.	
E. **Differentiated Instruction:** Provides guidance for teachers to support differentiated instruction by including: i. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers, etc.) for students who are English language learners, have special needs, or read well below the grade level. ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations. iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.	**Evidence of E. Differentiated Instruction:** Provides guidance for teachers to support differentiated instruction by including: Twig Science Next Gen sessions offer teachers support in differentiating activities at the point of use. English Learners, Special Needs, Below-Level Learners, and Above-Level Learners sidebars provide effective strategies that teachers can apply to support students of all abilities, and ensure equity in the classroom. Special Needs sidebars offer strategies for students with specific educational needs. The strategies include Executive Functioning, Expressive and Receptive Language,	**Evidence of E. Differentiated Instruction:** Provides guidance for teachers to support differentiated instruction by including: **Special Needs** **Fine Motor Skills** Encourage students who struggle with fine motor skills to take on an instructional role while those tools are being used, and ensure students are engaged in modeling geologic processes. **L1 S4, Special Needs, TE p. 30**

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Social-Emotional Functioning, Memory, Conceptual Processing, Fine Motor Skills, and Physical Disability. Accommodations are provided so that teachers can ensure equity of experience and learning for all students. For example, in L1 S4, support is provided for learners who may struggle with fine motor skills when completing an investigation. It is recommended that these students take on an instructional role to ensure they are engaged in the session. This also builds confidence by putting them in a leadership role within the group.

English Learners sidebars offer varying levels of support for students with Emerging, Expanding, and Bridging Proficiency. These strategies include connecting cognates, providing sentence frames, and cloze activities. In L2 S2, English learners are supported in various ways to make observations about lava types. Firstly, the teacher shares cognates, and models sentences students could use. Teachers are also given suggested sentence frames at the three differentiated levels of Emerging, Expanding, and Bridging Proficiency.

Below-Level Learners sidebars offer strategies and scaffolds for helping students struggling to apply the three dimensions of NGSS or with other cross-curricular aspects. In the Below-Level Learners sidebar in L2 S4, help is provided for students struggling to identify features that make volcanoes dangerous. It is suggested that teachers revisit how the Volcano Explosivity Index relates to some of the characteristics of explosive

English Learners

Support ELs by adding relevant vocabulary and terms to their list of cognates. Focus on language they will need to describe their observations, for example:

- *diferencia (difference)*
- *lava (lava)*
- *flujo de lava (lava flow)*
- *viscoso/a (viscous)*
- *líquido (liquid)*
- *moverse (to move)*
- *movimiento (movement)*
- *materiales (materials)*

Before ELs share their observations, model using cognates in a think-aloud. Use gestures and visuals as necessary.

- I observed that one liquid (ketchup) is thicker than the other liquid. The ketchup is thicker than oil.

Extend the activity: use sentences that include cognates and explain comparative and superlative forms in context (e.g., *faster/fastest, slower/slowest, more/less slowly, most/least slowly, quicker/quickest, more/less quickly, most/least quickly, runnier/runniest, heavier/heaviest, thicker/thickest*).

Offer proficiency-leveled sentence frames to help students use comparative and superlative forms to discuss their observations.

Emerging Proficiency

- _____ liquids flow <quicker/slower>.

Expanding Proficiency

- _____ liquids don't travel as far as _____ liquids.

Bridging Proficiency

- Adding materials makes the lava move _____. The _____ debris, the _____ it moves.

L2 S2 English Learners, TE p. 60

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volcanoes and that they model for students by selecting several different **Extreme Eruptions Cards** and asking the class to categorize them as dangerous or not dangerous. The teacher can also use the **Patterns handout** to consolidate learning and help students contribute to the class discussion.

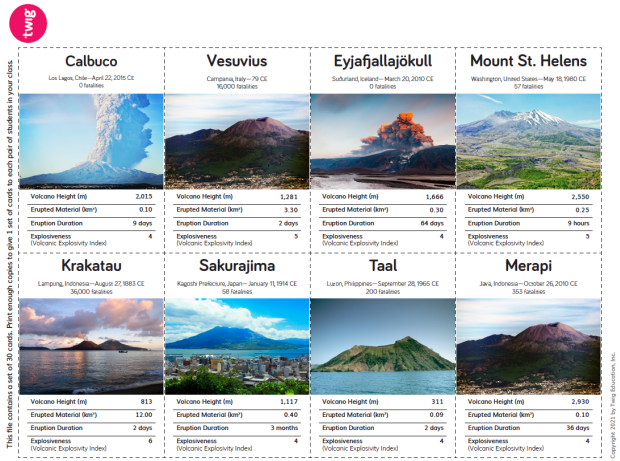
Above-Level Learners sidebars provide extra or more challenging activities for GATE students. In L3 S2, it is recommended in the sidebar that above-level learners are challenged to complete the investigation independently, rather than working in teams, using the **Volcano Blog Posts handout** or the internet. This provides these students with the opportunity to expand their learning and challenge themselves.

Below-Level Learners

Follow up with students who struggle to identify features that make volcanoes dangerous. Revisit how the Volcano Explosivity Index relates to some of the characteristics of explosive volcanoes, such as lahars, pyroclastic flows, and viscous magma. Model by selecting several different Extreme Eruptions Cards and asking the class to categorize them as dangerous or not dangerous.

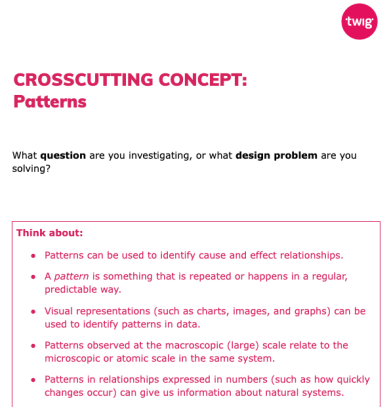
For students who struggle to identify common criteria following the language routine, use the **Patterns handout** to consolidate learning and help them contribute to the class discussion.

L2 S4 Below-Level Learners, TE p. 70



Extreme Eruptions Cards

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CROSSCUTTING CONCEPT:
Patterns

What **question** are you investigating, or what **design problem** are you solving?

Think about:

- Patterns can be used to identify cause and effect relationships.
- A *pattern* is something that is repeated or happens in a regular, predictable way.
- Visual representations (such as charts, images, and graphs) can be used to identify patterns in data.
- Patterns observed at the macroscopic (large) scale relate to the microscopic or atomic scale in the same system.
- Patterns in relationships expressed in numbers (such as how quickly changes occur) can give us information about natural systems.

Patterns handout



Above-Level Learners

Challenge students to complete the task independently, either using the **Volcano Blog Posts handout** or internet research.

L3 S2 Above-Level Learners, TE p. 89

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	Evidence of i. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers, etc.) for students who are English language learners, have special needs, or read well below the grade level. Every digital Twig Science Next Gen session has a Text-to-Speech function that can be used to support students who find it easier to comprehend aural text. Alternative methods for terminology acquisition are provided throughout the module. The digital glossary provides picture support for all terms to aid student comprehension, and glossary videos for key terms are provided in the Teacher Edition	 VolcanoBlog Home Recent About Contact Using and Positioning a Seismometer Latest Posts Using and Positioning a Seismometer Using and Positioning GPS Using and Taking Rock Core Samples Temperature Monitoring Gas Emissions 3-D Mapping **Volcano Blog Posts handout** Evidence of i. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers, etc.) for students who are English language learners, have special needs, or read well below the grade level. **Below-Level Learners** Scaffold the discussion for students by playing the **Energy Glossary video.** **L1 S4 Below-Level Learners, TE p. 28**

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at appropriate points. The following glossary videos are included in Volcano Hunters:

- **Energy Glossary video** (L1 S4)
- **Sedimentary Rock Glossary video** (L1 S6)
- **Igneous Rock Glossary video** (L1 S6)
- **Metamorphic Rock Glossary video** (L1 S6)

Sidebars are included throughout the Teacher Edition, providing scaffolds and alternatives for English language learners, students with special educational needs, or students who read below grade level.

Students who are English learners are catered for in the English Learners sidebars throughout the module with appropriate scaffolding and alternatives. For example, in L1 S3, after completing the Volcano Life Cycle investigation, students are expected to share their findings with the class. The English Learners sidebar suggests differentiated scaffolds for students with Emerging, Expanding, and Bridging Proficiency. It suggests that at Emerging Proficiency level, students be allowed to read their notes aloud from their Twig Journals. At Expanding Proficiency level, they can read from their notes but are encouraged to report in their own words. At Bridging Proficiency level, it is suggested that ELs present alongside proficient speakers who can support them, and they are encouraged to recast their answers using academic language.

English Learners

To include ELs in the discussion, have them present their responses alongside native speaker students, and provide appropriate scaffolds.

Emerging Proficiency

Allow ELs to read their notes directly from their Twig Journals.

Expanding Proficiency

Allow ELs to read their notes directly from their Twig Journals, but encourage them to answer in their own words. Have their teams support them with essential vocabulary and pronunciation.

Bridging Proficiency

Have ELs present alongside proficient English speakers who can support them in answering the questions in their own words. Encourage them to recast some answers using relevant vocabulary.

L1 S3 English Learners, TE p. 25

Special Needs

Visual–Spatial Processing, Conceptual Processing

If students are struggling with comprehension of geographical locations, provide them with a map of Washington and locate the following places on the map:

- Mount St. Helens
- Mount Adams
- Yakima
- Spokane
- Vancouver
- Toutle River

L2 S5 Special Needs, TE p. 72

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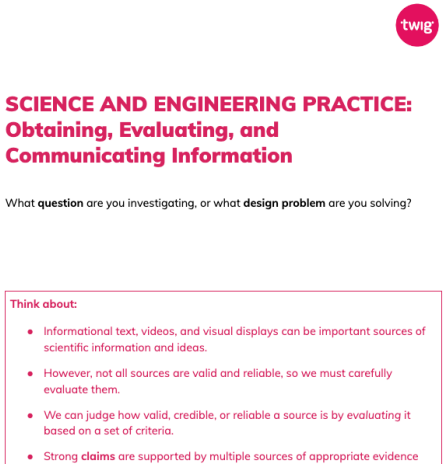
Alternative learning methods are also given for students with special educational needs in the Special Needs sidebars. In L2 S5 the Special Needs sidebar provides support for students who may struggle with Visual-Spatial Processing and Conceptual Processing. Students are required to critically read a scientific text about the Mount St. Helens' eruption. For students who may struggle to comprehend the geographical locations referenced, teachers are recommended to provide a map and help students locate the key areas from the article. This deepens their comprehension of the far-reaching impacts of the eruption.

In L3 S5, students who are working below the grade level are supported in the Below-Level Learners sidebar. In the session, students develop a plan to monitor currently undermonitored volcanoes by identifying those with the greatest hazard risks. For students who struggle to identify and communicate the information they need, it is recommended that teachers provide the **Obtaining, Evaluating, and Communicating Information handout** to help them develop their monitoring plans.

Below-Level Learners

For students who struggle to identify and communicate relevant information, use the **Obtaining, Evaluating, and Communicating Information handout** to help them develop their monitoring plans.

L3 S5 Below-Level Learners, TE p. 103



SCIENCE AND ENGINEERING PRACTICE: Obtaining, Evaluating, and Communicating Information

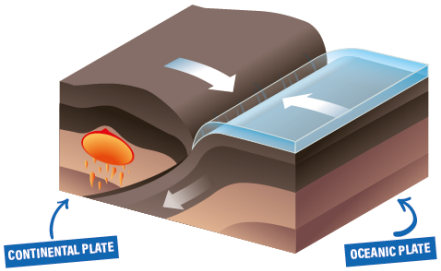
What **question** are you investigating, or what **design problem** are you solving?

Think about:

- Informational text, videos, and visual displays can be important sources of scientific information and ideas.
- However, not all sources are valid and reliable, so we must carefully evaluate them.
- We can judge how valid, credible, or reliable a source is by evaluating it based on a set of criteria.
- Strong **claims** are supported by multiple sources of appropriate evidence

Obtaining, Evaluating, and Communicating Information handout

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	Evidence of ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations. Students are offered extra support when teachers identify them as struggling to meet targeted expectations. **Pre-Assessment tables**, **rubrics**, and **Formative Assessments** offer strategies for teachers to support these students. In **L1 S1**, students complete the **Pre-Assessment**/**Pre-Exploration** for the module. This allows the teachers to have sight of any students who may not be performing on level. The TE also provides scaffolds to help teachers to support learners who may be struggling. In **L2 S6**, in order to complete the **Summative Assessment**, students construct a scientific argument to support the claim "Some volcanoes are more dangerous than others." Before they start the task, they view the **Dangerous Volcanoes Student Rubric**, which includes student-friendly descriptions of the assessed dimensions, a summary of what the teacher will be looking for in their responses, a checklist of items students should make sure to include in their responses, and the differences between the four levels of attainment. These student-facing rubrics allow students to visually engage with the factors that they will be assessed on and improve students' understanding of what their answers need to include. Students' responses are then assessed using the teacher-facing **Dangerous**	Evidence of ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations. **Pre-Exploration** 1. The model shows the Earth's outer layers changing over time. How will the land above the continental plate change? ☐ A mountain will form. ☐ A lake will form. ☑ A volcano will form. ☐ An island will form.  Explain your answer. A volcano will form. In the model you can see that plates are moving toward each other. This is causing magma to form under the continental plate. A volcano will form when the magma rises and breaks through the surface. *Students should have an understanding that volcanoes form at plate boundaries. However, they are not yet expected to reference how energy drives this process or the cycling of matter.* **L1 S1 Pre-Exploration, TJ p. 12**

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Volcanoes Teacher Rubric.

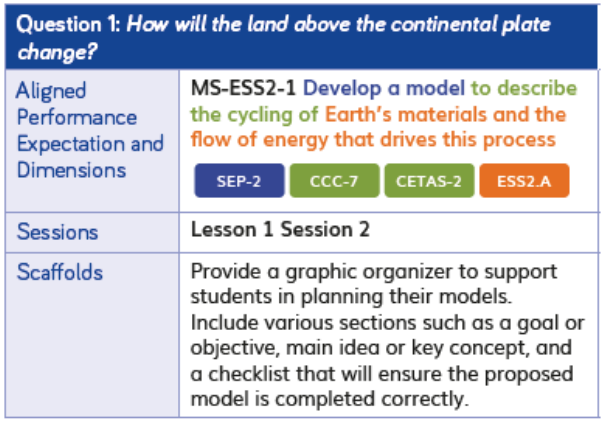
There are also a variety of extra support options available for students who are struggling in the sidebars of the Teacher Edition.

Supplementary video supports that the teacher can use to scaffold various activities are provided throughout the module in the **Below-Level Learners sidebars**. Examples in Volcano Hunters include:

- **Erosion and Weathering video** (L1 S3)
- **Rock Cycles video** (L1 S6)
- **What Is a Volcano? video** (L2 S6)
- **Volcanic Eruptions video** (L3 S1)
- **Predicting Volcanic Eruptions video** (L3 S5)
- **Volcanoes: LEDC Response video** (L3 S6)
- **Volcanoes: MEDC Response video** (L3 S6)

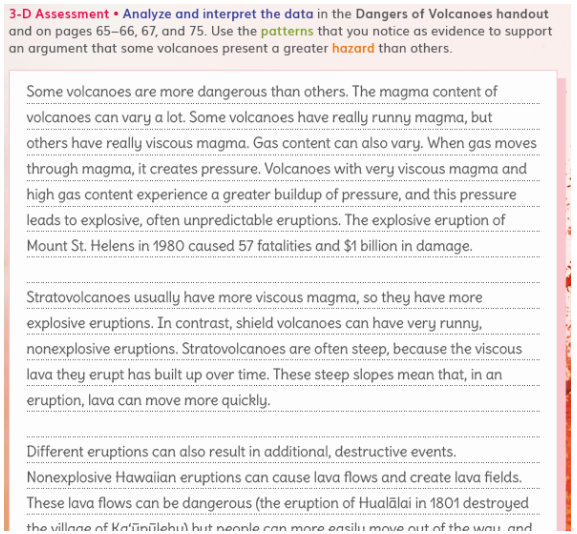
Supplementary handouts are provided at appropriate points to scaffold students' use of elements of the targeted SEPs and CCCs. Volcano Hunters includes the following handouts:

- **Developing and Using Models handout**, targeting SEP-2 (L1 S5)
- **Analyzing and Interpreting Data handout**, targeting SEP-4 (L3 S3)
- **Patterns handout**, targeting CCC-1 (L1 S2, L2 S4, L3 S3)
- **Stability and Change handout**, targeting CCC-7 (L1 S3)



Question 1: *How will the land above the continental plate change?*	
Aligned Performance Expectation and Dimensions	MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process SEP-2 CCC-7 CETAS-2 ESS2.A
Sessions	Lesson 1 Session 2
Scaffolds	Provide a graphic organizer to support students in planning their models. Include various sections such as a goal or objective, main idea or key concept, and a checklist that will ensure the proposed model is completed correctly.

L1 S1 Pre-Assessment table, TE p. 15



3-D Assessment • Analyze and interpret the data in the Dangers of Volcanoes handout and on pages 65–66, 67, and 75. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others.

Some volcanoes are more dangerous than others. The magma content of volcanoes can vary a lot. Some volcanoes have really runny magma, but others have really viscous magma. Gas content can also vary. When gas moves through magma, it creates pressure. Volcanoes with very viscous magma and high gas content experience a greater buildup of pressure, and this pressure leads to explosive, often unpredictable eruptions. The explosive eruption of Mount St. Helens in 1980 caused 57 fatalities and $1 billion in damage.

Stratovolcanoes usually have more viscous magma, so they have more explosive eruptions. In contrast, shield volcanoes can have very runny, nonexplosive eruptions. Stratovolcanoes are often steep, because the viscous lava they erupt has built up over time. These steep slopes mean that, in an eruption, lava can move more quickly.

Different eruptions can also result in additional, destructive events. Nonexplosive Hawaiian eruptions can cause lava flows and create lava fields. These lava flows can be dangerous (the eruption of Hualālai in 1801 destroyed

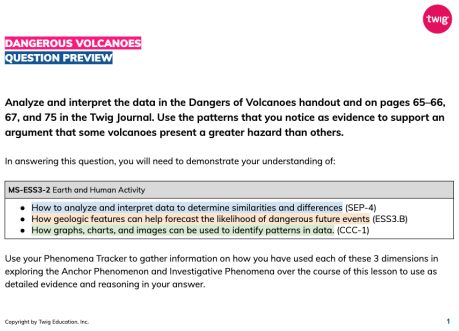
L2 S6 3-D Assessment, TJ p. 88

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Pedagogical Support sidebars clarify how the module content aligns with the targeted expectations and offer additional strategies for the teacher to support students.

In **L1 S6**, pedagogical support for the Disciplinary Core Ideas is offered in the **Pedagogical Support—Disciplinary Core Ideas sidebar**. It recommends that as students critically read the scientific text and complete their graphic organizers, they consider how energy transfers from the Sun and matter cycles in the Earth's hot interior drive the transformations of the rock cycle. This supports students to embed understanding of **ESS2.A**, which is a core learning target for the module.

In **L2 S3**, pedagogical support for the Crosscutting Concepts is offered in the **Pedagogical Support—Crosscutting Concepts sidebar**. It clarifies that students will need to refer to patterns identified in their investigations as they participate in the **Stronger and Clearer Each Time language routine**, and prompts teachers to check students understand that identifying relationships is one way scientists use patterns to understand phenomena. This supports students to embed understanding of **CCC-1**, which is a core learning target for the module.



DANGEROUS VOLCANOES
QUESTION PREVIEW

Analyze and interpret the data in the Dangers of Volcanoes handout and on pages 65–66, 67, and 75 in the Twig Journal. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others.

In answering this question, you will need to demonstrate your understanding of:

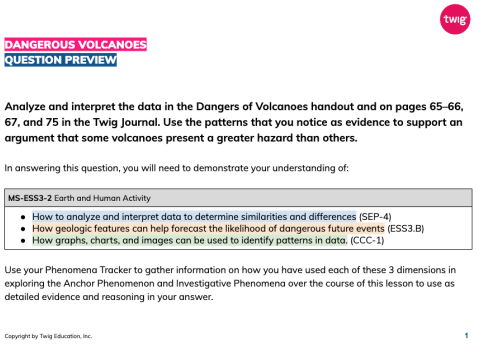
MS-ESS3-2 Earth and Human Activity

- How to analyze and interpret data to determine similarities and differences (SEP-4)
- How geologic features can help forecast the likelihood of dangerous future events (ESS3.B)
- How graphs, charts, and images can be used to identify patterns in data. (CCC-1)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

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Dangerous Volcanoes Student Rubric



DANGEROUS VOLCANOES
QUESTION PREVIEW

Analyze and interpret the data in the Dangers of Volcanoes handout and on pages 65–66, 67, and 75 in the Twig Journal. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others.

In answering this question, you will need to demonstrate your understanding of:

MS-ESS3-2 Earth and Human Activity

- How to analyze and interpret data to determine similarities and differences (SEP-4)
- How geologic features can help forecast the likelihood of dangerous future events (ESS3.B)
- How graphs, charts, and images can be used to identify patterns in data. (CCC-1)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

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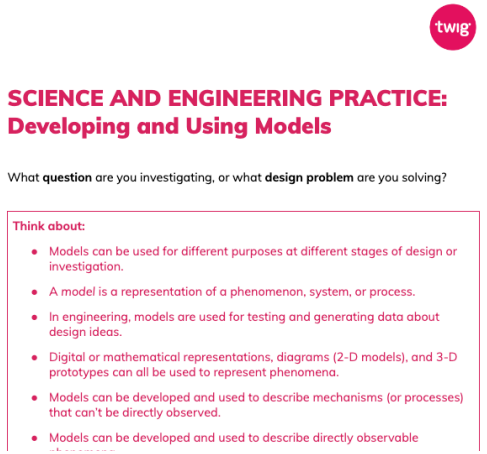
Dangerous Volcanoes Teacher Rubric

Below-Level Learners

Support students by playing the **Volcanic Eruptions video** before they observe the visual.

L3 S1 Volcanic Eruptions video, TE p. 83

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SCIENCE AND ENGINEERING PRACTICE: Developing and Using Models

What **question** are you investigating, or what **design problem** are you solving?

Think about:

- Models can be used for different purposes at different stages of design or investigation.
- A model is a representation of a phenomenon, system, or process.
- In engineering, models are used for testing and generating data about design ideas.
- Digital or mathematical representations, diagrams (2-D models), and 3-D prototypes can all be used to represent phenomena.
- Models can be developed and used to describe mechanisms (or processes) that can't be directly observed.
- Models can be developed and used to describe directly observable

Developing and Using Models handout

Pedagogical Support—Disciplinary Core Ideas

Earth's Materials and Systems

As students read the text and complete the graphic organizer, they should consider how energy transfers from the Sun and matter cycles in the Earth's hot interior drive the transformations of the rock cycle.

L1 S6 Pedagogical Support—Disciplinary Core Ideas, TE p. 38

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	Evidence of iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts. GATE students and students who have already met the Performance Expectations are encouraged to complete **Honors and Advanced Extension activities**. These activities are provided at regular intervals throughout the module, at the end of sessions. They promote a deeper understanding of the SEPs, DCIs and CCCs. For example, in **L1 S6**, students can complete the Honors and Advanced Extension: Applying Rock Cycle Knowledge activity, in which they complete a Venn diagram to compare and contrast two rock cycle models, understanding the benefits and limitations of the different types. They also use the internet to research the rock type of rock samples on the **Rock Samples from Around the**	**Pedagogical Support—Crosscutting Concepts** **Patterns** As students participate in the language routine, they will need to refer to the patterns they've uncovered in their investigations in order to identify relationships between the three properties. If needed, clarify that identifying relationships is one way that scientists use patterns to understand phenomena. **L2 S3 Pedagogical Support—Crosscutting Concepts, TE p. 65** Evidence of iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.

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	World handout and answer questions. This learning can provide them with a deeper understanding of the lesson objective, which is to obtain information about the processes that change rocks from one type to another (SEP-8, CCC-7, ESS2.A). In L2 S5, students can complete the Honors and Advanced Extension: Topographic Effects of Volcanic Eruptions activity, in which they access a topography website and compare pre- and post-eruption maps of the area around Mount St. Helens. They then share how they think the eruption affected the shape of the volcano. This extra learning can provide them with a deeper understanding of the lesson objective, which is to analyze and interpret a case study of Mount St. Helens to understand the impacts of an eruption (SEP-4, CCC-2, ESS3.B).	**Honors and Advanced Extension:** **Applying Rock Cycle Knowledge** Evaluate Models Have students look at the classic rock cycle model on page 48 in their Twig Journals. Prompt them to fill out the Venn diagram on page 49. **Think Talk—Productive Discussion** Use the Productive Discussion language routine with pairs or small groups of students. • **Discussion Goal:** Students compare and contrast the models. • ***What are the limitations of the two models? Draw on evidence from your Venn diagram.*** You cannot see where in the landscape each step occurs. The landscape model shows you the areas of the Earth where the processes would occur. The landscape model is more complicated and harder to interpret at a glance. The rock cycle model is clearer in showing the cycle. • ***Which model is more accurate, and why?*** The landscape model is more accurate because it shows where each step occurs and connects how the steps happen visually. The rock cycle model summarizes the steps but does not tell you where everything happens. Research Different Rock Samples Have students use the internet to research the rock type of the 10 rock samples on the **Rock Samples from Around the World handout**. • ***Are the rocks sedimentary, metamorphic, or igneous?*** • ***Could they be from a volcano?***  Rock Samples from Around the World handout **L1 S6 Honors and Advanced Extension: Applying Rock Cycle Knowledge, TE p. 41**

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ROCK SAMPLES FROM AROUND THE WORLD

1	Location:	Kutkhiny Baty, Kamchatka Peninsula, Russia
	Rock Type:	Pumice
2	Location:	Mauna Loa, Hawaii, United States
	Rock Type:	Basalt
3	Location:	Marble Rocks, Madhya Pradesh, India
	Rock Type:	Marble
4	Location:	Bacuit Bay, Palawan, Philippines
	Rock Type:	Limestone
5	Location:	Coyote Buttes, Utah, United States
	Rock Type:	Sandstone
6	Location:	Old Harry Rocks, Dorset, United Kingdom
	Rock Type:	Chalk
7	Location:	Prestahnúkur, Highlands of Iceland
	Rock Type:	Rhyolite
8	Location:	Aniakchak, Alaska, United States
	Rock Type:	Basaltic andesite
9	Location:	Petra tou Romiou, Paphos, Cyprus
	Rock Type:	Brecciated limestone
10	Location:	Flatirons, Colorado, United States
	Rock Type:	Sandstone, conglomerate

Rock Samples from Around the World handout

Honors and Advanced Extension: Topographic Effects of Volcanic Eruptions

Analyze Eruption Effects

Prompt students to access a topography website and compare this eruption to the 1980 and 1983 maps of Mount St. Helens. Have them record their observations and answer the prompt on page 85 in their Twig Journals.

Share Explanations

Ask students to share how they think Mount St. Helens's eruption affected its shape. Give students time to revise their answers, if applicable.

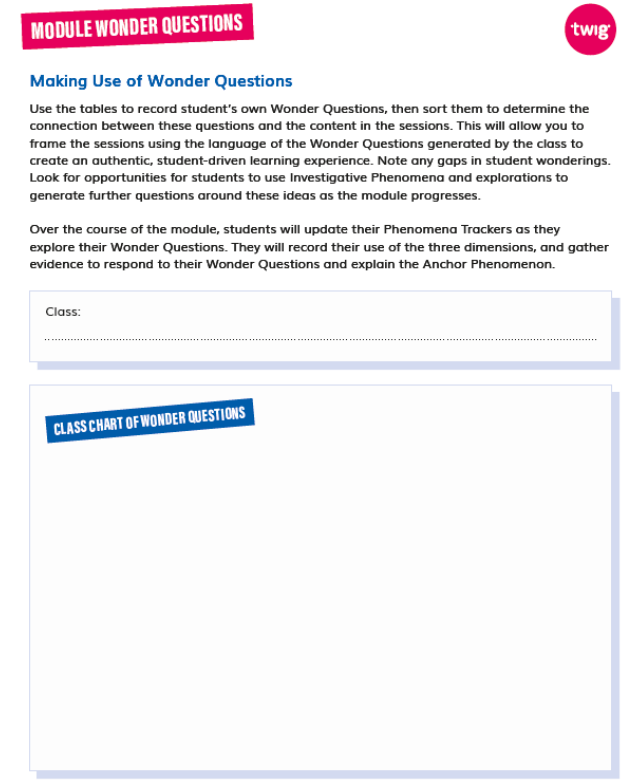
L2 S5 Honors and Advanced Extension: Topographic Effects of Volcanic Eruptions, TE p. 74

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Category II: NGSS Instructional Supports (additional criteria for units only)

Unit Criteria A unit or longer lesson designed for the NGSS will also include clear and compelling evidence of the following:	Specific evidence from materials and reviewers' reasoning	Evidence of Quality
F. **Teacher Support for Unit Coherence:** Supports teachers in facilitating coherent student learning experiences over time by: i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.). ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions.	Evidence of i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.). Several teaching strategies are used and embedded within the program to link student engagement across lessons. Teachers use the **Co-Craft Questions language routine** to cultivate students' initial questions about the **Anchor Phenomenon**, find connections between questions, and initially order their explorations in future lessons. Teachers then use the **Module Wonder Questions handout** to develop an initial learning journey based on student questions. They use the **Wonder Questions routine** to return to the student generated questions at the start of each session, and the **Phenomena Tracker Routine** at the end of each session to generate further questions. Teachers are supported in applying these strategies through use of documentation including: • **Making Sense of Phenomena**: This document explains the role of phenomena	Evidence of i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.). **Think Talk—Co-Craft Questions** Use the Co-Craft Questions language routine to generate Wonder Questions about the Anchor Phenomenon. Have students work individually and then in small groups and record their questions on scratch paper. Prompt groups to share their Wonder Questions, and record them on the board. Have the class reframe the questions as investigable questions. Discuss ways of grouping questions together, and whether there are any missing questions. Based on the discussion, develop a physical or digital Class Wonder Questions chart. Guide students to group questions that consider: • How and why an area might change as a result of geoscience processes associated with volcanic activity (Lesson 1) • What makes volcanoes dangerous to human populations (Lesson 2) • How we can predict eruptions and protect communities from the risks they pose (Lesson 3). Share with students the group of questions they will be investigating this lesson. Have students record the questions in their Wonder Questions charts on pages 4–5 in their Twig Journals. During or after the session, use the **Module Wonder Questions** to create a map that connects student questions to the sessions.  **L1 S1 Think Talk—Co-Ccraft Questions, TE p. 14**

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	in Twig Science Next Gen and outlines the Phenomena Tracker Routine. • **Language Routines Guide**: This document clarifies how language routines can support students in building understanding, and provides guidance for routines including the Co-Craft Questions language routine. • **Module Wonder Questions handout**: This document outlines the Wonder Questions Routine and provides a table that supports teachers to connect students' Wonder Questions to specific sessions within the module.	 Module Wonder Questions handout

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Evidence ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions.

The **Phenomena Tracker Routine** is used throughout the module to ensure that sense-making and/or problem-solving is linked to learning in all three dimensions.

Throughout the module, students use their **Phenomena Tracker** to track their progress making sense of the **Investigative Phenomena**. They record their explanation for each phenomenon and how they used the three dimensions to figure it out.

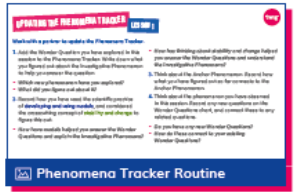
For example, students complete the **Phenomena Tracker Routine** in **L1 S2–4**, **S6–7**. They are prompted to record how they used the scientific practice of developing and using models (SEP-2) and considered the crosscutting concept of stability and change (CCC-7) to figure out the **Investigative Phenomena**, which support students to consider how matter cycles and energy flows within and among the Earth's systems (ESS2.A).

The Teacher Edition contains an exemplar completed **Phenomena Tracker** so the teacher can support students to connect their **Wonder Questions**, the **Investigative Phenomena**, and the three dimensions.

Student Rubrics

Evidence ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions

Update the Phenomena Tracker



Display the **Phenomena Tracker Routine visual**. Invite students to use the routine to make sense of their Wonder Questions and connect to the Anchor Phenomenon. Have students share ideas and add new Wonder Questions to the Class Wonder Questions chart. Take note of the Wonder Questions you will be exploring in the next session and highlight these.

L1 S2 Update the Phenomena Tracker, TE p. 20

Phenomena Tracker

Session	Wonder Question	Investigative Phenomenon	Outcome of Sense-Making
Lesson 1 | Driving Question *Can we identify volcanoes in the landscape surrounding Kathmandu, Bougainville Island, Auckland, and Yogyakarta?*			
1.2	*Where do we find volcanoes?*	There is a pattern in where volcanoes form.	Patterns show that volcanoes tend to occur at the boundaries between tectonic plates and at hot spots, but not all interactions at plate boundaries result in volcanoes.
1.3	*Do volcanoes always look the same?*	Volcanoes form at tectonic boundaries, changing landscapes.	Energy from the Earth's center causes rocks to melt into magma, which breaks through the Earth's crust as a volcano. Volcanoes change over long and short periods of time as lava erupts and cools, building up rock peaks which are also eroded by wind and rain.
1.4	*Why are rocks different from each other?*	Rocks have different observable properties depending on where they are found.	Processes such as heating, cooling, compression, and abrasion cause rocks to have different observable properties.
1.5	*What are the processes that cause rocks to change in a volcanic landscape?*	The features of a landscape change over time.	Matter in the Earth cycles; physical and chemical processes cause rocks to change into different types: sedimentary, metamorphic, and igneous. These changes can happen quickly or slowly. Sometimes the conditions do not cause rocks to change, and they appear stable for very long periods of time.
1.6	*What are the processes that cause rocks to change in a volcanic landscape?*	The features of a landscape change over time.	Matter in the Earth cycles; physical and chemical processes cause rocks to change into different types: sedimentary, metamorphic, and igneous. These changes can happen quickly or slowly. Sometimes the conditions do not cause rocks to change, and they appear stable for very long periods of time.
1.7	*How does a volcano change over its lifetime?*	Volcanoes change over time.	Mount Mazama has had periods of stability, and periods of change over its lifetime. It has formed peaks of igneous rock as magma solidified, been eroded via physical and chemical processes, slowly over time, and through fast changes such as landslides and collapse. It is now extinct, and can be seen as a huge caldera.

Phenomena Tracker exemplar, TE p. 6

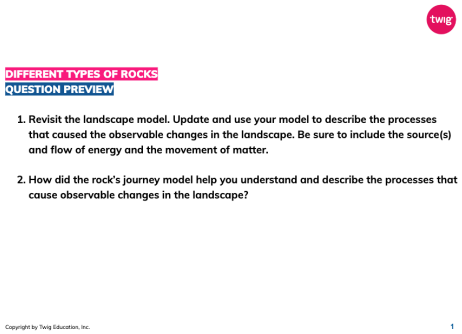
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Student Rubrics provide students with a way to understand how they will be assessed on their application of the three dimensions while working through **Summative** and **Formative Assessments**.

Each **Student Rubric** includes student-friendly descriptions of the assessed dimensions, a summary of what the teacher will be looking for in their responses, a checklist of items students should make sure to include in their responses, and the differences between the four levels of attainment. These student-facing rubrics allow students to visually engage with the factors that they will be assessed on and improve students' understanding of what their answers need to include.

In **L1 S5**, as part of the Riding the Rock Cycle Formative Assessment, students are introduced to the **Different Types of Rocks Student Rubric**. This helps them successfully apply the three dimensions while they use their learning to create a 2-D model of a rock journey which they add to the landscape model in their Twig Journal. This task assesses their growing mastery of **MS-ESS2-1** Earth's Systems.

In **L1 S8**, as part of the Volcanic and Nonvolcanic Rocks Summative Assessment, students are introduced to the **Hills and Mountains, or Volcanoes? Student Rubric**. This helps them successfully apply the three dimensions as they develop models that demonstrate how certain rocks could have formed and create CER charts



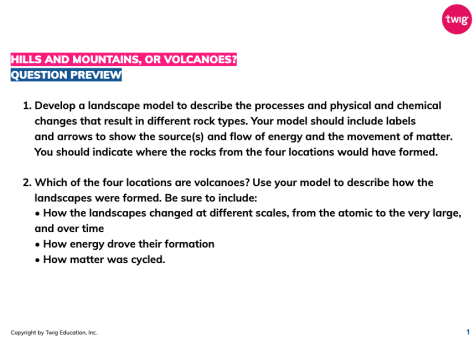
DIFFERENT TYPES OF ROCKS
QUESTION PREVIEW

1. Revisit the landscape model. Update and use your model to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter.

2. How did the rock's journey model help you understand and describe the processes that cause observable changes in the landscape?

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Different Types of Rocks Student Rubric



HILLS AND MOUNTAINS, OR VOLCANOES?
QUESTION PREVIEW

1. Develop a landscape model to describe the processes and physical and chemical changes that result in different rock types. Your model should include labels and arrows to show the source(s) and flow of energy and the movement of matter. You should indicate where the rocks from the four locations would have formed.

2. Which of the four locations are volcanoes? Use your model to describe how the landscapes were formed. Be sure to include:
   - How the landscapes changed at different scales, from the atomic to the very large, and over time
   - How energy drove their formation
   - How matter was cycled.

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Hills and Mountains, or Volcanoes? Student Rubric

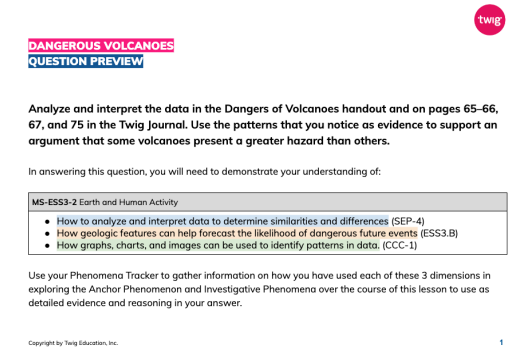
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about volcanic landscapes. This task assesses their mastery of **MS-ESS2-1** Earth's Systems.

In L2 S6, as part of the Some Volcanoes Are Dangerous Summative Assessment, students are introduced to the **Dangerous Volcanoes Student Rubric**. This helps them successfully apply the three dimensions as they write a scientific argument in response to the claim: *Some volcanoes are more dangerous than others*, using evidence from the module to support their argument. This task assesses their mastery of **MS-ESS3-2** Earth and Human Activity.

In L3 S4, as part of the Categorizing Volcanic Activity Formative Assessment, students are introduced to the **Warning Levels Student Rubric**. Students first review the volcanic activity data from the previous session and assign warning levels to each data period. They then write a scientific argument, justifying why they put the volcano on alert at particular points and why they didn't at other points. They use evidence from their datasets. This task assesses their growing mastery of **MS-ESS3-2** Earth and Human Activity.

At the end of Lesson 3, students complete a Summative Assessment in two parts across the final two sessions. In L3 S5, students complete part 1 of the Summative Assessment, Identifying Undermonitored Volcanoes. In teams, students look at a dataset of undermonitored volcanoes and, considering a number of variables, identify one they think should be monitored more. They



DANGEROUS VOLCANOES
QUESTION PREVIEW

Analyze and interpret the data in the Dangers of Volcanoes handout and on pages 65–66, 67, and 75 in the Twig Journal. Use the patterns that you notice as evidence to support an argument that some volcanoes present a greater hazard than others.

In answering this question, you will need to demonstrate your understanding of:

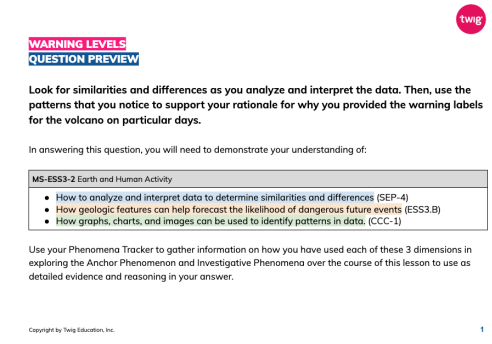
MS-ESS3-2 Earth and Human Activity

- How to analyze and interpret data to determine similarities and differences (SEP-4)
- How geologic features can help forecast the likelihood of dangerous future events (ESS3.B)
- How graphs, charts, and images can be used to identify patterns in data. (CCC-1)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

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Dangerous Volcanoes Student Rubric



WARNING LEVELS
QUESTION PREVIEW

Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days.

In answering this question, you will need to demonstrate your understanding of:

MS-ESS3-2 Earth and Human Activity

- How to analyze and interpret data to determine similarities and differences (SEP-4)
- How geologic features can help forecast the likelihood of dangerous future events (ESS3.B)
- How graphs, charts, and images can be used to identify patterns in data. (CCC-1)

Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer.

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Warning Levels Student Rubric

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create a monitoring plan for their chosen volcano, identifying hazards, monitoring techniques, and the expected data output. In L3 S6, students complete part 2 of the Summative Assessment, Presenting Our Plans. Students review and present their monitoring plans to another team, use the peer feedback to revise their own monitoring plans, and are assessed with a rubric. Across both these sessions, students use the **Monitoring Volcanoes Student Rubric** to plan and check their approach to the assessment. This task assesses their mastery of **MS-ESS3-2** Earth and Human Activity.

Connect

At appropriate points, the teacher instruction provides connections to the CCCs, SEPs, and DCIs.

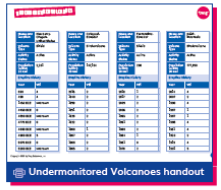
In L1 S6, students' learning is connected to CCC-7 (Stability and Change). As part of their learning around how rocks form and change over time, students consider time spans and how these connect to stability and change in the investigation of phenomena. They answer questions and complete the graphic organizers in their Twig Journals. This helps teachers connect students' learning closely to CCC-7 as they are directed to consider their learning in the context of stability and change over time.

In L2 S3, the teacher supports students to connect the Anchor Phenomenon to the DCIs. They display a visual of two of the key areas from the Anchor Phenomenon, pass around 'lava samples'

Summative Assessment:
Identifying Undermonitored Volcanoes 30 min

Analyze Hazard Risks

Have students meet in small teams. Distribute the **Undermonitored Volcanoes handout**.


Undermonitored Volcanoes handout

Ask teams to identify one volcano from the dataset they think should be prioritized for monitoring. They should consider:

- The activity status of the volcano
- The type of volcano
- The local population
- The eruptive history.

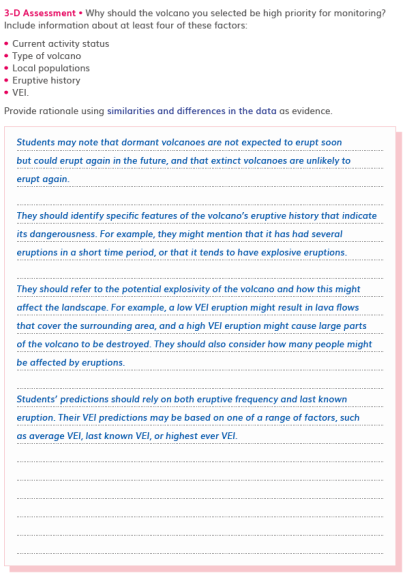
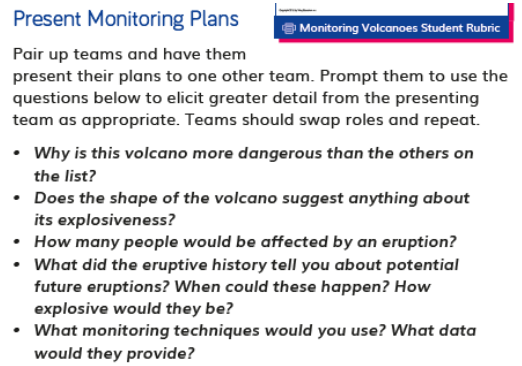
Have teams complete the graphic organizer and support their choice on pages 112–113 in their Twig Journals.


Volcano Blog Posts handout

Provide support with reading the eruptive histories and help teams calculate the average VEI of each volcano's eruptions. If teams discount dormant volcanoes, point out that a dormant volcano can become active again. Optional: Provide copies of the **Volcano Blog Posts handout** if needed.

L3 S5, Summative Assessment: Identifying Undermonitored Volcanoes, TE p. 103

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	for student observation, and invite students to consider how physical differences between lava at the two sites affect the dangerousness of the volcanoes. This supports students to situate their science learning in the context of the **Anchor Phenomenon**. Finally, in **L3 S6**, in the Connect to the Nature of Science section, teachers are recommended to highlight the point that the scientist in the **Volcano Team: Life of a Volcanologist video** made about his research trip generating more questions. The teacher then asks students to share any new **Wonder Questions** they have about volcanoes now that they have completed the module. This allows students to connect their learning to the wider nature of science.	 3-D Assessment • Why should the volcano you selected be high priority for monitoring? Include information about at least four of these factors: • Current activity status • Type of volcano • Local populations • Eruptive history • VEI. Provide rationale using similarities and differences in the data as evidence. *Students may note that dormant volcanoes are not expected to erupt soon but could erupt again in the future, and that extinct volcanoes are unlikely to erupt again.* *They should identify specific features of the volcano's eruptive history that indicate its dangerousness. For example, they might mention that it has had several eruptions in a short time period, or that it tends to have explosive eruptions.* *They should refer to the potential explosivity of the volcano and how this might affect the landscape. For example, a low VEI eruption might result in lava flows that cover the surrounding area, and a high VEI eruption might cause large parts of the volcano to be destroyed. They should also consider how many people might be affected by eruptions.* *Students' predictions should rely on both eruptive frequency and last known eruption. Their VEI predictions may be based on one of a range of factors, such as average VEI, last known VEI, or highest ever VEI.* **L3 S5 3-D Assessment, TJ p. 113**  Present Monitoring Plans Monitoring Volcanoes Student Rubric Pair up teams and have them present their plans to one other team. Prompt them to use the questions below to elicit greater detail from the presenting team as appropriate. Teams should swap roles and repeat. • ***Why is this volcano more dangerous than the others on the list?*** • ***Does the shape of the volcano suggest anything about its explosiveness?*** • ***How many people would be affected by an eruption?*** • ***What did the eruptive history tell you about potential future eruptions? When could these happen? How explosive would they be?*** • ***What monitoring techniques would you use? What data would they provide?*** **L3 S6 Present Monitoring Plans, TE p. 105**

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MONITORING VOLCANOES
QUESTION PREVIEW

1. **Why should the volcano you selected be high priority for monitoring?**
   Include information about at least four of these factors:
   - **Current activity status**
   - **Type of volcano**
   - **Local populations**
   - **Eruptive history**
   - **VEI**

   Provide rationale using similarities and differences in the data as evidence.

2. **Use patterns in the data you analyzed to design a volcano monitoring plan, providing reasoning for your choices.**
   a. What devices or techniques would you use to monitor the volcano?
   b. What data will be given by the devices you chose to use?
   c. How will this data be useful for predicting eruptions?
   d. Sketch your volcano and mark where you would place the monitors.

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Monitoring Volcanoes Student Rubric

Communicate Information • Think about the rock cycle and identify:

- The time span in which the different steps occur
- The size of the physical changes.

Fill out the first row of each table, providing examples of rock cycle processes and events relevant to each category. An example has been provided for you.

Then, complete the sentence starters in the second row with one of the following words:

- Changing
- Stable
- Both changing and stable

Provide reasoning to support your answer.

Scale of Changes	Large Time Span	Short Time Span
Processes	• The weathering of a volcano happens very slowly. • A magma chamber builds up over time. • Sediment cements together in layers to become sedimentary rocks over millions of years.	• A volcano can erupt very suddenly and change quickly. • Magma quickly cools and forms extrusive igneous rock.
Is the Landscape Changing or Stable?	At this scale, landscapes can appear to be stable.	At this scale, landscapes can appear to be changing.
Reasoning	Everything happens over such a long period of time that, in a human lifetime, they would seem to be unchanging.	These events happen fast enough that people can observe them during their lifetimes.

L1 S6 Communicate Information, TJ p. 46

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Blowing Bubbles

15 min

Observe the Investigative Phenomenon (Session 3)

Arrange students into teams and give each team three straws. Explain that three members from each team will use the straws to test three different liquids. **Note:** Remind students not to share straws.

Invite teams to observe the different liquids in the plastic containers and use straws to create bubbles. Ask team members who are not blowing bubbles to carefully observe the three liquids.

Challenge students to:

- Blow the same amount of air into each liquid, observing the differences
- Blow air into the oil, then try to recreate the same frequency of bubbles in the syrup and ketchup.

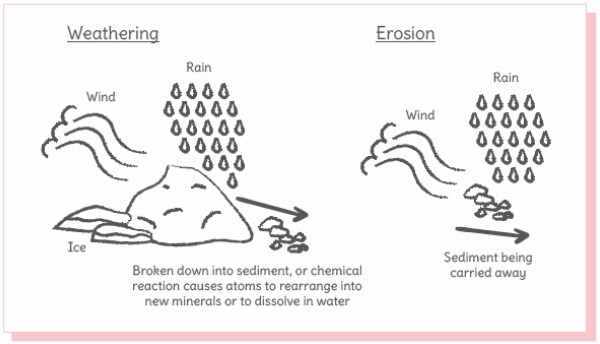
Note: Remind students not to suck the different liquids up the straws.

Have students share their observations.

- ***How easy is it to create bubbles in the <oil/syrup/ketchup>? How much air did you have to add?***
  It was really easy to create bubbles in the oil, and we didn't have to add much air. We needed a lot more air with the syrup and ketchup.
- ***What differences were there between the bubbles?***
  The bubbles in the oil were pretty regular in frequency and size, and if they popped it wasn't that explosive. There were fewer bubbles in the syrup and ketchup, and they were more unpredictable. They popped more explosively than the bubbles in the oil.
- ***What differences are there between these liquids?***
  The oil is a lot runnier/less thick than the syrup and ketchup.
- ***Why might you need more air to create bubbles in the syrup/ketchup than in the oil?***
  The liquids are thicker and they need more air/pressure to get moving.

L2 S3 Observe the Investigative Phenomena (Session 3), TE p. 64

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		Connect to the Nature of Science Connect back to the point the scientist in the **Volcano Team: Life of a Volcanologist video** made about his research trip generating more questions. Invite students to share any new wonder questions they have about volcanoes following their completion of the module. **L3 S6 Connect to the Nature of Science, TE p. 107**
G. **Scaffolded differentiation over time:** Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.	**Evidence of G. Scaffolded differentiation over time:** Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems. Students are provided with decreasing levels of support as they engage with Science and Engineering practices (SEPs). For example, in Volcano Hunters, L1 focuses on how and why an area might change as a result of geoscience processes associated with volcanic activity, and students are developing mastery of the SEP aligned with **MS-ESS2-1**: • **SEP-2**: Develop and use a model to describe phenomena. They are building on the practice mastered in Grades 3–5: • **SEP-2**: Develop and/or use models to describe and/or predict phenomena. Students begin engaging with the practice in L1 S3, where they develop 2-D and 3-D models of geologic processes including weathering, erosion, and deposition. At this early stage, they work in teams.	**Evidence of G. Scaffolded differentiation over time:** Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems. Draw 2-D models to distinguish the processes of weathering and erosion.  **L1 S3 Station 5 and 6: Weathering and Erosion, TJ p. 29**

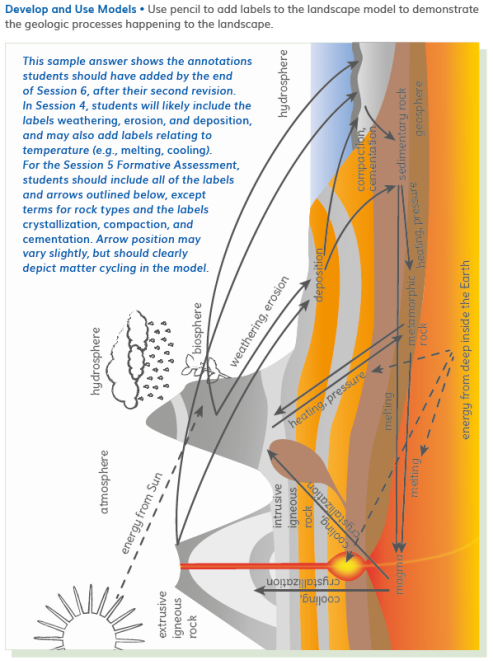
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In L1 S4, students begin to develop a 2-D model focusing on processes that change the landscape and how these form the rock cycle. The landscape background is provided for them, so that they have a more scaffolded starting point.

In L1 S5 students use a think-pair-share to discuss the processes that make up their models, and work with partners to further develop their 2-D models. Their work is assessed (Different Types of Rocks Formative Assessment) at this midway stage so that the teacher can provide feedback and future support as needed. In L1 S5, teachers are also prompted to use the **Developing and Using Models handout** to support students who are struggling to create their models.

In L1 S6, students read a scientific text about different rock types and how they form. They are provided with a graphic organizer to summarize their understanding, ensuring they record all the relevant information. They use a Productive Discussion language routine to discuss the rock types in the context of their landscape models, allowing them to share and develop their ideas with their peers. They then use their learning to add grade-appropriate terminology to their 2-D landscape models.

At this stage, students are still only developing or using a model, not both. They are therefore still working toward grade level. The Honors and Advanced Extension task in L1 S6 provides an

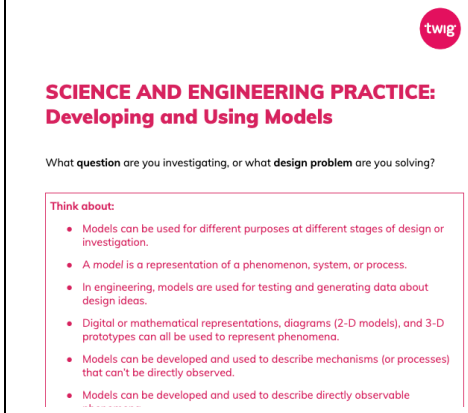


L1 S4 Develop and Use Models, TJ p. 33

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	opportunity for GATE students to begin to work at grade level, as they develop a 2-D model, use their models to compare and contrast types of models, and apply their understanding from the models to research the rock type of 10 rock samples. In **L1 S7**, students independently develop a 2-D model showing changes to Mount Mazama over time. None of the model elements are pre-printed for them, showing progression from the models they developed earlier in the lesson. In **L1 S8**, students independently develop models that describe processes and physical and chemical changes that result in different rock types. They include labels and arrows to show the source(s) and flow of energy and the movement of matter. They then use their model to describe how the landscapes of four different locations formed. In this task, students are engaging with the practice at grade level, as they are both developing and using models to describe phenomena. These examples show students applying SEP-2 with an increasing degree of sophistication as they move through the lesson, and their mastery of the SEP helps them explain the **Investigative Phenomena**, which in turn helps them ultimately make sense of the **Anchor Phenomenon**.	Explain the Rock Cycle Journey  Have students add their rock journey to the landscape model on page 33 in their Twig Journals. Ask them to add arrows and labels to their rock cycle journey, using the information they recorded during the activity. Have students use a think-pair-share to discuss their rock cycle journeys. • ***What happens to magma when it erupts?*** It cools on the surface. Over a long period of time, the cooled magma can create a large volcanic feature. • ***How could a rock move from a mountain to the ocean floor?*** The mountain is weathered by wind and rain, which can then erode the pieces of rock and move them to the ocean. It is weathered by water and other rocks. • ***Explain the processes it would undergo as it moves along a river or across the ocean floor.*** It is transported by water, breaking down or collecting other small pieces. • ***What effect would being inside the mantle have on a rock?*** It's likely to experience lots of high temperatures and pressure. The transfer of energy may result in the rock being crushed and melted or heated. • ***How could a rock in the soil or ocean eventually melt into magma?*** It moves much farther down into the Earth, and experiences intense high temperatures and pressure. • ***Once a rock is in the Earth's interior, does it stay there?*** It could be pushed up and form part of a mountain. It could melt and move to a magma chamber. **L1 S5 Explain the Rock Cycle Journey, TE p. 35**

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SCIENCE AND ENGINEERING PRACTICE: Developing and Using Models

What **question** are you investigating, or what **design problem** are you solving?

Think about:

- Models can be used for different purposes at different stages of design or investigation.
- A *model* is a representation of a phenomenon, system, or process.
- In engineering, models are used for testing and generating data about design ideas.
- Digital or mathematical representations, diagrams (2-D models), and 3-D prototypes can all be used to represent phenomena.
- Models can be developed and used to describe mechanisms (or processes) that can't be directly observed.
- Models can be developed and used to describe directly observable

Developing and Using Models handout

Think Talk—Productive Discussion

Use the Productive Discussion language routine with pairs or small groups of students.

- **Discussion Goal:** Students discuss rock types in the context of the landscape models they developed in the last session.
- ***What do igneous and metamorphic rocks have in common, and where do they form on the landscape model?***
  They have crystallization and temperature in common. Igneous rocks form near magma and at volcanoes. Metamorphic rocks form in the Earth's interior, where there is a lot of energy. Metamorphic rocks are formed by high temperatures and pressure.
- ***Could an extrusive igneous rock eventually become metamorphic? Would this process occur quickly or gradually?***
  It could be weathered and then eroded into the ocean.

L1 S6 Think Talk—Productive Discussion, TE p. 39

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Honors and Advanced Extension:
Applying Rock Cycle Knowledge

Evaluate Models

Have students look at the classic rock cycle model on page 48 in their Twig Journals. Prompt them to fill out the Venn diagram on page 49.

Think Talk—Productive Discussion

Use the Productive Discussion language routine with pairs or small groups of students.

- **Discussion Goal:** Students compare and contrast the models.
- ***What are the limitations of the two models? Draw on evidence from your Venn diagram.***
  You cannot see where in the landscape each step occurs. The landscape model shows you the areas of the Earth where the processes would occur. The landscape model is more complicated and harder to interpret at a glance. The rock cycle model is clearer in showing the cycle.
- ***Which model is more accurate, and why?***
  The landscape model is more accurate because it shows where each step occurs and connects how the steps happen visually. The rock cycle model summarizes the steps but does not tell you where everything happens.

Research Different Rock Samples

Have students use the internet to research the rock type of the 10 rock samples on the **Rock Samples from Around the World handout**.

- ***Are the rocks sedimentary, metamorphic, or igneous?***
- ***Could they be from a volcano?***

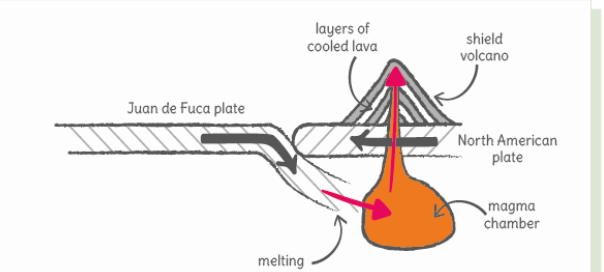


L1 S6 Honors and Advanced Extension: Applying Rock Cycle Knowledge, TE p. 41

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Develop Models • Mount Mazama was once on the boundary between the Juan de Fuca plate and the North American plate. The Juan de Fuca plate moved beneath the North American plate in a process called subduction.

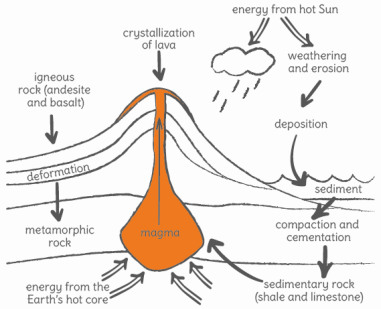
Draw the steps that occurred at the plate boundary during Phase 1 of Mount Mazama's formation. Use arrows to show how the materials are cycling.



L1 S7 Develop Models, TJ p. 53

3-D Assessment • Develop a **landscape model** to **describe** the **processes** and **physical and chemical changes** that result in different rock types. Your model should include labels and arrows to show the **source(s) and flow of energy and the movement of matter.** You should indicate where the rocks from the four locations would have formed.

Students' models should show how different rocks are formed. They should show how energy flows and matter cycles (e.g., from the Earth's hot interior to form magma, which is then erupted and cools to form a volcano). They should also include labels that focus on how energy drives the formation processes, how matter is cycled through it, and how fast or slow the processes are.



L1 S8 3-D Assessment, TJ p. 58

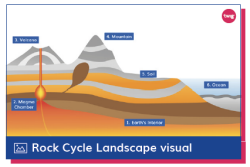
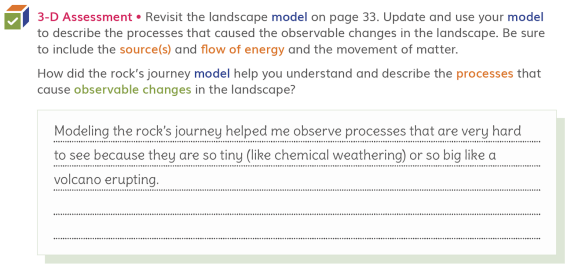
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Rating for Category II: NGSS Instructional Supports—units After carefully weighing the evidence, reasoning, and suggestions for improvement, rate the degree to which the criteria are met across the unit.	**Unit rating scale for Category II (Criteria A–G):** 3: At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria 2: Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A 1: Adequate evidence for at least three criteria in the category 0: Adequate evidence for no more than two criteria in the category	**Unit rating scale for Category II (Criteria A–G): 3**

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Category III: Monitoring NGSS Student Progress (lessons and units)

The lesson/unit supports monitoring student progress in all three dimensions of the NGSS as students make sense of phenomena and/or design solutions to problems.

Lesson and Unit Criteria Lessons and units designed for the NGSS include clear and compelling evidence of the following:	**Specific evidence from materials and reviewers' reasoning**	**Evidence of Quality**
A. **Monitoring 3D student performances:** Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.	**Evidence of A. Monitoring 3D student performances:** Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions. Twig Science Next Gen sessions provide opportunities for teachers to monitor student performance as they master the three dimensions of the NGSS standards. The activities and assessment pieces elicit direct, observable evidence of three-dimensional learning. Students use SEPs, CCCs, and DCIs to make sense of phenomena and design solutions. In **Volcano Hunters**, students' 3-D performances are assessed through six **Formative**, **Summative**, and **Benchmark Assessments**. • Riding the Rock Cycle Formative Assessment (**L1 S5**) • Volcanic and Nonvolcanic Rocks Summative Assessment (**L1 S8**) • Some Volcanoes Are Dangerous Summative Assessment (**L2 S6**) • Categorizing Volcanic Activity Formative	**Evidence of A. Monitoring 3D student performances:** Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions. **Formative Assessment:** 35 min **Riding the Rock Cycle** Investigate Geologic Processes Display the **Rock Cycle Landscape visual**. Explain that this is the same landscape model students saw in the previous session. However, point out the six labels on the visual and point out the corresponding stations set up around the classroom.  Rock Cycle Landscape visual **L1 S5 Formative Assessment, TE p.34**  3-D Assessment • Revisit the landscape model on page 33. Update and use your model to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter. How did the rock's journey model help you understand and describe the processes that cause observable changes in the landscape? Modeling the rock's journey helped me observe processes that are very hard to see because they are so tiny (like chemical weathering) or so big like a volcano erupting. **L1 S5 Formative Assessment, TJ p.37**

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Assessment (L3 S4)
- Identifying Undermonitored Volcanoes and Presenting Our Plans Summative Assessments (L3 S5, L3 S6)
- Volcano Hunters Benchmark Assessment

For example, students complete the Riding the Rock Cycle Formative Assessment in L1 S5 as they make sense of the Investigative Phenomenon:

- The features of a landscape change over time.

Students revisit and revise a 2-D model of the Earth's landscape, adding information about processes that cause observable change, the source and flow of energy, and the movement of matter. They write how the kinesthetic model they used earlier in the session helped them understand and describe these processes.

The task allows students to demonstrate their growing mastery of these elements of **MS-ESS2-1**:

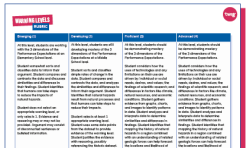
- **SEP-2**: Develop and use a model to describe phenomena.
- **ESS2.A**: All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- **CCC-7**: Explanations of stability and

Formative Assessment: 30 min

Categorizing Volcanic Activity

Introduce the Rubric

Share the **Warning Levels Student Rubric** and explain that you will use this to assess the analyses and scientific arguments students will develop today.



L3 S4 Formative Assessment, TE p.98

3-D Assessment • Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days.

Warning Level	Days	Argument
Warning	Day 1 to 7	I didn't assign this level to the volcano as the data didn't start to rapidly increase at any point from day 7 onward.
Watch	Day 9 to Day 19	A Watch level should be assigned for days 9–19. There are a few overlapping peaks in data, like the three data types on Day 11, which might mean a lot of volcanic activity. Values are high in all four data types. For example, COSPEC readings are over 300 metric tons, even over 400 at the beginning, and the temperature is in the upper 30s and lower 40s. Readings are high, but they are not high enough to need a Warning label anymore. The readings are also dropping. The historic data for the Warning period showed that COSPEC readings were close to or above 1,000 metric tons. The current data matches the historic Watch data, with temperatures from 36°C to 43°C and COSPEC from 159 to 487 metric tons/day.

L3 S4 Formative Assessment, TJ p.110

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change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.

The student-facing version of the **Different Types of Rocks Rubric** uses prompts and color-coding to clearly indicate the role of the three dimensions in making sense of the phenomenon. The teacher-facing version uses formatting to clearly indicate which parts of the dimensions are assessed during the task, and which parts are addressed at a different point in the module.

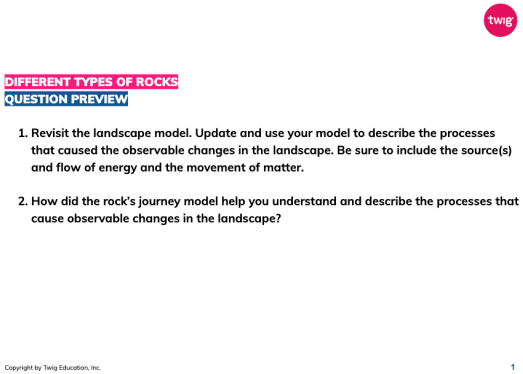
Students complete the Categorizing Volcanic Activity Formative Assessment in L3 S4 as they make sense of the Investigative Phenomenon:

- Volcanoes change in measurable ways before an eruption.

Students analyze a dataset of potential activity from a fictional volcano. They compare the data to their earlier analyses of data from the volcano, considering potential eruptive risk. They apply warning levels, based on the **Warning Levels visual**, to different date ranges in the dataset, and write scientific arguments to justify their choices.

The task allows students to demonstrate their growing mastery of these elements of **MS-ESS3-2**:

- **SEP-4**: Analyze and interpret data to determine similarities and differences in findings.


DIFFERENT TYPES OF ROCKS
QUESTION PREVIEW

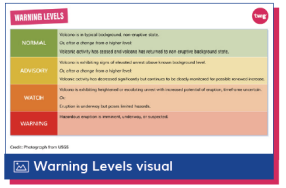
1. Revisit the landscape model. Update and use your model to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter.

2. How did the rock's journey model help you understand and describe the processes that cause observable changes in the landscape?

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L1 S5 Different Types of Rocks Rubric

Display the **Warning Levels visual**. Explain that volcano observatories categorize their alerts in a similar way.

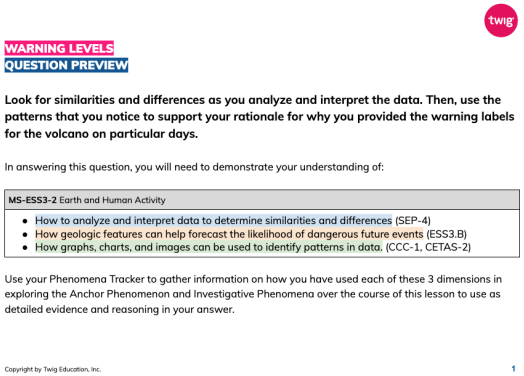


Warning Levels visual

Have students meet in small groups and review the **Historic Dataset handout** from the previous session. Remind students that the data covers four data periods: ten days, two months, six months, and several years before an eruption.

L3 S4 Warning Levels visual

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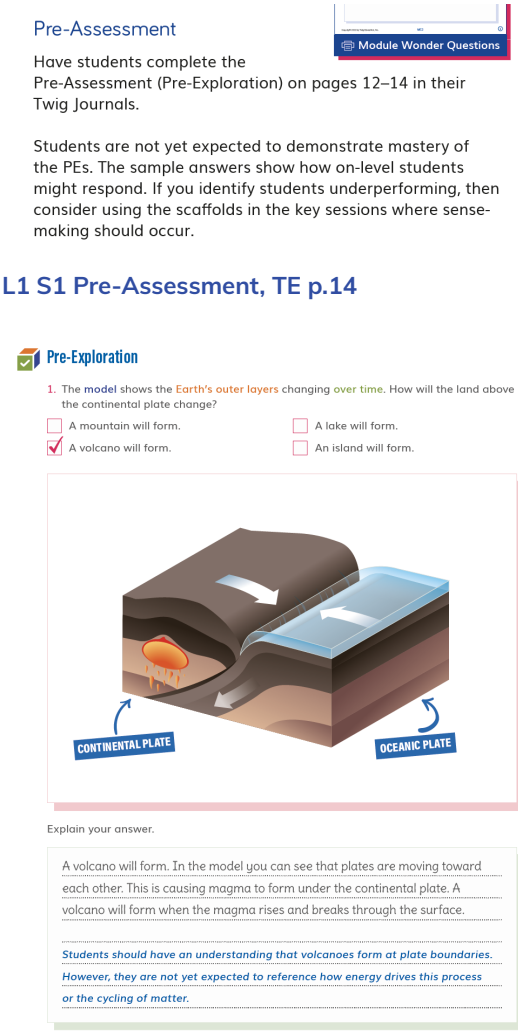
	• **ESS3.B**: Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. • **CCC-1**: Graphs, charts, and images can be used to identify patterns in data. • **CETAS-2**: The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. The student-facing version of the **Warning Levels Rubric** uses prompts and color-coding to clearly indicate the role of the three dimensions in making sense of the phenomenon. The teacher-facing version uses formatting to clearly indicate which parts of the dimensions are assessed during the task, and which parts are addressed at a different point in the module.	 WARNING LEVELS QUESTION PREVIEW **Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days.** In answering this question, you will need to demonstrate your understanding of: **MS-ESS3-2** Earth and Human Activity • How to analyze and interpret data to determine similarities and differences (SEP-4) • How geologic features can help forecast the likelihood of dangerous future events (ESS3.B) • How graphs, charts, and images can be used to identify patterns in data. (CCC-1, CETAS-2) Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer. Copyright by Twig Education, Inc. 1 L3 S4 Warning Levels Rubric
B. **Formative:** Embeds formative assessment processes throughout that evaluate student learning to inform instruction.	**Evidence of B. Formative:** Embeds formative assessment processes throughout that evaluate student learning to inform instruction. Ongoing formative assessments are woven into each lesson. These are a quick way to gauge student understanding, allowing teachers to tailor their instruction accordingly. They include class	**Evidence of B. Formative:** Embeds formative assessment processes throughout that evaluate student learning to inform instruction.

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discussions, constructed responses (written and drawn), self and peer assessment, and teacher observations.

[Volcano Hunters contains a **Pre-Assessment**, two formal **Formative Assessments**, 17 informal formative assessments (**3-D Reflects** and **exit tickets**). Examples include:

- **L1 S1**, in which students complete the module **Pre-Assessment**. They answer three prompts in their Twig Journals about landscape change at plate boundaries, whether all volcanoes are dangerous, and how we can protect communities at risk from volcanoes. The teacher is supported with learning scaffolds to help students who may not be performing on level. At this point, students are not expected to display mastery of the PEs.
- **L2 S3**, in which students complete an **exit ticket**: *What makes volcanic eruptions explosive?* This provides an opportunity for them to demonstrate their understanding of the key points of the session, and signals their readiness to move onto the next session where they will begin to explore the societal impacts of explosive eruptions.
- **L3 S2**, in which students complete a **3-D Reflect** that targets elements of **MS-ESS3-2** Earth and Human Activity. At the end of a session focusing on tools and techniques that monitor volcanic activity



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and predict eruptions, the **3-D Reflect** allows students to demonstrate understanding by applying their ideas to tools and techniques that monitor rainfall and predict floods.

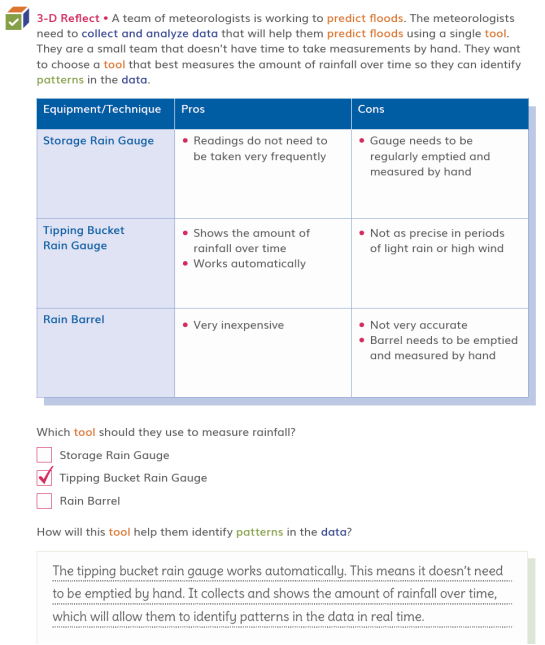
- **L1 S5**, in which students complete the **Riding the Rock Cycle Formative Assessment**. They use their learning to create a 2-D model of a rock journey which they add to the landscape model in their Twig Journal. This task assesses their growing mastery of **MS-ESS2-1** Earth's Systems.
- **L3 S4**, in which students complete the **Categorizing Volcanic Activity Formative Assessment**. Students first review the volcanic activity data from the previous session and assign warning levels to each data period. They then write a scientific argument, justifying why they put the volcano on alert at particular points and why they didn't at other points. They use evidence from their datasets. This task assesses their growing mastery of **MS-ESS3-2** Earth and Human Activity.

Exit Ticket

Have students complete the exit ticket:

- ***What makes volcanic eruptions explosive?***
  Volcanic eruptions are explosive when they involve a lot of pressure. The most explosive eruptions are caused by a combination of viscous magma and a high gas content. The gas pushes through the viscous liquid, creating pressure. This pressure builds up and creates an explosive eruption.

L2 S3 Exit Ticket, TE p.66



3-D Reflect • A team of meteorologists is working to predict floods. The meteorologists need to collect and analyze data that will help them predict floods using a single tool. They are a small team that doesn't have time to take measurements by hand. They want to choose a tool that best measures the amount of rainfall over time so they can identify patterns in the data.

Equipment/Technique	Pros	Cons
Storage Rain Gauge	• Readings do not need to be taken very frequently	• Gauge needs to be regularly emptied and measured by hand
Tipping Bucket Rain Gauge	• Shows the amount of rainfall over time • Works automatically	• Not as precise in periods of light rain or high wind
Rain Barrel	• Very inexpensive	• Not very accurate • Barrel needs to be emptied and measured by hand

Which tool should they use to measure rainfall?

- [ ] Storage Rain Gauge
- [x] Tipping Bucket Rain Gauge
- [ ] Rain Barrel

How will this tool help them identify patterns in the data?

The tipping bucket rain gauge works automatically. This means it doesn't need to be emptied by hand. It collects and shows the amount of rainfall over time, which will allow them to identify patterns in the data in real time.

L3 S2 3-D Reflect, TJ p.100

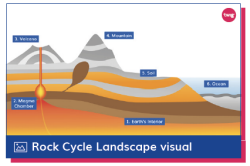
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Formative Assessment: 35 min

Riding the Rock Cycle

Investigate Geologic Processes

Display the **Rock Cycle Landscape visual**. Explain that this is the same landscape model students saw in the previous session. However, point out the six labels on the visual and point out the corresponding stations set up around the classroom.



L1 S5 Formative Assessment, TE p.34

3-D Assessment • Revisit the landscape **model** on page 33. Update and use your **model** to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter.

How did the rock's journey **model** help you understand and describe the processes that cause observable changes in the landscape?

Modeling the rock's journey helped me observe processes that are very hard to see because they are so tiny (like chemical weathering) or so big like a volcano erupting.

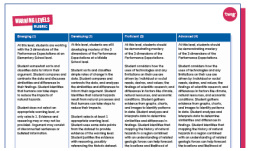
L1 S5 Formative Assessment, TJ p.37

Formative Assessment: 30 min

Categorizing Volcanic Activity

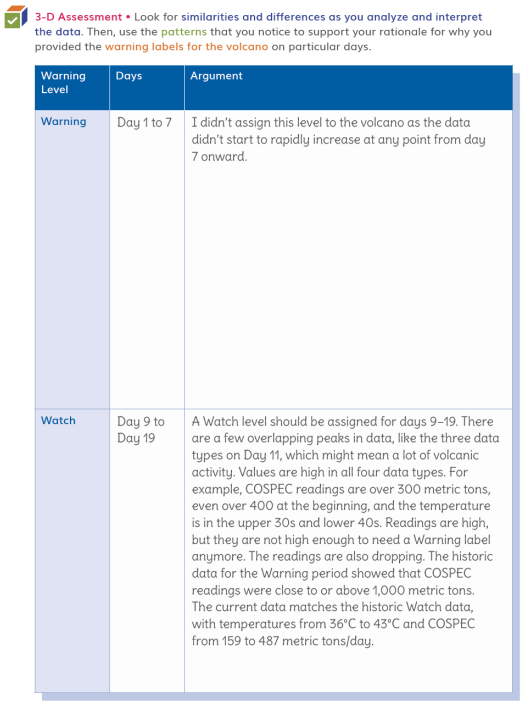
Introduce the Rubric

Share the **Warning Levels Student Rubric** and explain that you will use this to assess the analyses and scientific arguments students will develop today.



L3 S4 Formative Assessment, TE p.98

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		 3-D Assessment • Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days. **L3 S4 Formative Assessment, TJ p.110**
C. **Scoring guidance:** Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.	**Evidence of C. Scoring guidance:** Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students. Student and teacher rubrics are provided for all formal performance tasks, which provide teachers with guidance on how to interpret student	**Evidence of C. Scoring guidance:** Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.

Warning Level	Days	Argument
Warning	Day 1 to 7	I didn't assign this level to the volcano as the data didn't start to rapidly increase at any point from day 7 onward.
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performance along the three dimensions.

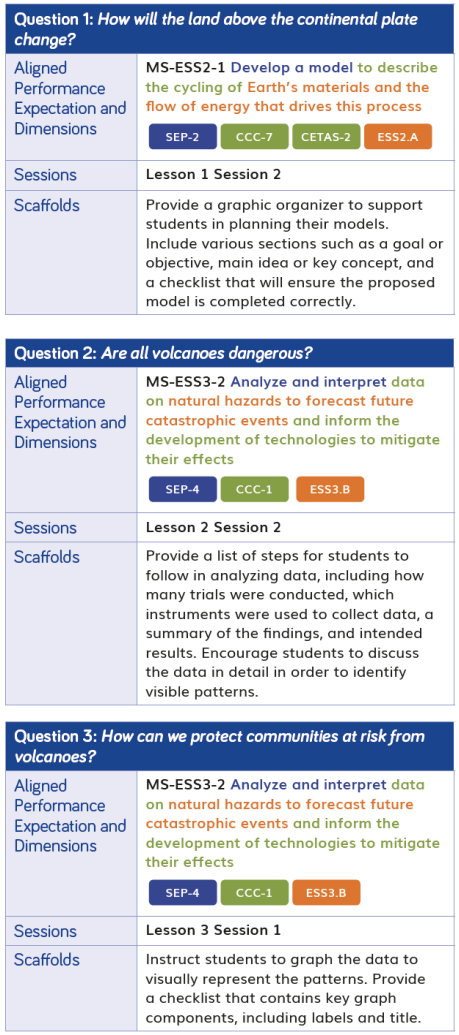
In Volcano Hunters there are 6 formal assessment tasks with accompanying rubrics.

- Pre-Assessment rubric (L1 S1)
- **Different Types of Rocks Rubric** (L1 S5)
- **Hills and Mountains, or Volcanoes? Rubric** (L1 S8)
- **Dangerous Volcanoes Rubric** (L2 S6)
- **Warning Levels Rubric** (L3 S4)
- **Monitoring Volcanoes Rubric** (L3 S5, L3 S6)

Pre-Assessment Rubric
The module Pre-Assessment in L1 S1 is designed to check student prior knowledge, ensuring students have an appropriate level of understanding before they work toward the targeted dimensions. The example answers provided in the student answer Twig Journal clarify what students are expected to know from earlier grades. For example, in Volcano Hunters, the answer to Q1 states that:

- Students should have an understanding that volcanoes form at plate boundaries. However, they are not yet expected to reference how energy drives this process or the cycling of matter.

The Pre-Assessment rubric in the Teacher Edition provides strategies that the teacher can use later in the module to help students who require



Question 1: *How will the land above the continental plate change?*	
Aligned Performance Expectation and Dimensions	MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process SEP-2 CCC-7 CETAS-2 ESS2.A
Sessions	Lesson 1 Session 2
Scaffolds	Provide a graphic organizer to support students in planning their models. Include various sections such as a goal or objective, main idea or key concept, and a checklist that will ensure the proposed model is completed correctly.

Question 2: *Are all volcanoes dangerous?*	
Aligned Performance Expectation and Dimensions	MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects SEP-4 CCC-1 ESS3.B
Sessions	Lesson 2 Session 2
Scaffolds	Provide a list of steps for students to follow in analyzing data, including how many trials were conducted, which instruments were used to collect data, a summary of the findings, and intended results. Encourage students to discuss the data in detail in order to identify visible patterns.

Question 3: *How can we protect communities at risk from volcanoes?*	
Aligned Performance Expectation and Dimensions	MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects SEP-4 CCC-1 ESS3.B
Sessions	Lesson 3 Session 1
Scaffolds	Instruct students to graph the data to visually represent the patterns. Provide a checklist that contains key graph components, including labels and title.

L1 S1 Pre-Assessment rubric, TE p.15

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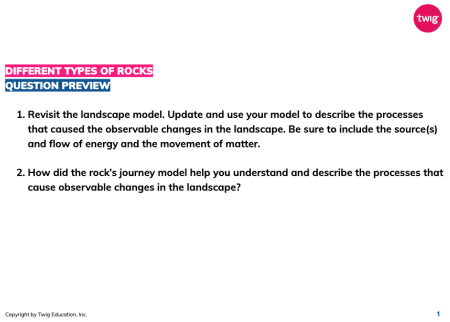
additional support in specific areas. For example, the Volcano Hunters **Pre-Assessment rubric** suggests the teacher could scaffold the **L1 S2** activity for students who struggled with interpreting the model in Q1:

- Provide a graphic organizer to support students in planning their models. Include various sections such as a goal or objective, main idea or key concept, and a checklist that will ensure the proposed model is completed correctly.

Formative/Summative Rubrics

Formative and **Summative Assessments** are designed to establish students' level of mastery of the targeted dimensions. In **L1 S8**, students complete the Hills and Mountains, or Volcanoes? Summative Assessment—they develop models that describe the processes and physical and chemical changes that result in different rock types, including annotations to show the source(s) and flow of energy and the movement of matter. They use their models to describe how the landscapes at four locations formed, making a claim as to which locations are volcanic.

Before beginning the task, students view the **Hills and Mountains, or Volcanoes? Student Rubric**. This rubric includes student-friendly statements about what to include in the response, color-coded to show the three dimensions, and a checklist of key features to include.

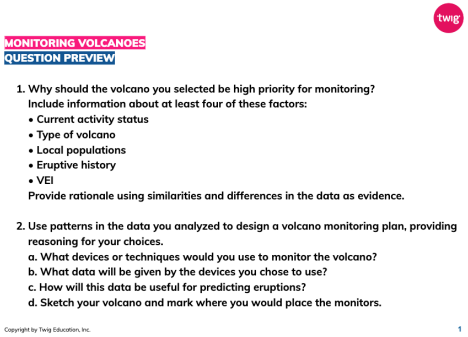


DIFFERENT TYPES OF ROCKS
QUESTION PREVIEW

1. Revisit the landscape model. Update and use your model to describe the processes that caused the observable changes in the landscape. Be sure to include the source(s) and flow of energy and the movement of matter.
2. How did the rock's journey model help you understand and describe the processes that cause observable changes in the landscape?

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L1 S5 Different Types of Rocks Rubric



MONITORING VOLCANOES
QUESTION PREVIEW

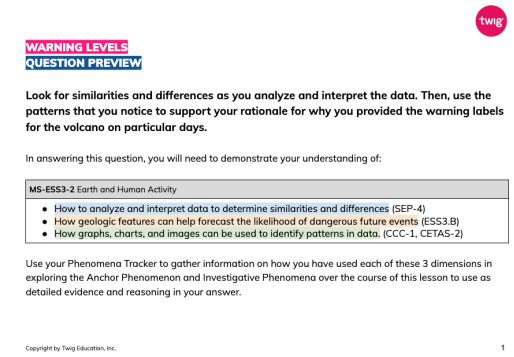
1. Why should the volcano you selected be high priority for monitoring?
   Include information about at least four of these factors:
   - Current activity status
   - Type of volcano
   - Local populations
   - Eruptive history
   - VEI

   Provide rationale using similarities and differences in the data as evidence.
2. Use patterns in the data you analyzed to design a volcano monitoring plan, providing reasoning for your choices.
   a. What devices or techniques would you use to monitor the volcano?
   b. What data will be given by the devices you chose to use?
   c. How will this data be useful for predicting eruptions?
   d. Sketch your volcano and mark where you would place the monitors.

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L2 S6 Dangerous Volcanoes Rubric

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	The teacher uses the **Hills and Mountains, or Volcanoes? Teacher Rubric** to assess student performance. The rubric provides guidance for interpreting responses according to four proficiency levels (Emerging, Developing, Proficient, Advanced) with a combination of descriptive paragraphs and bulleted 'Look Fors'. The rubric clearly indicates the three dimensions being assessed and identifies any parts of the dimensions that are deliberately not covered in the task. In the L1 S8 rubric, it is clearly marked that the 'living organisms' section of ESS2.A is not addressed (it is instead addressed in the Future Food module). The student-facing and teacher-facing rubrics work in conjunction, allowing the teacher to easily interpret student responses and use the student rubric checklist as a tool to support future student development.	 WARNING LEVELS QUESTION PREVIEW **Look for similarities and differences as you analyze and interpret the data. Then, use the patterns that you notice to support your rationale for why you provided the warning labels for the volcano on particular days.** In answering this question, you will need to demonstrate your understanding of: **MS-ESS3-2** Earth and Human Activity • How to analyze and interpret data to determine similarities and differences (SEP-4) • How geologic features can help forecast the likelihood of dangerous future events (ESS3.B) • How graphs, charts, and images can be used to identify patterns in data. (CCC-1, CETAS-2) Use your Phenomena Tracker to gather information on how you have used each of these 3 dimensions in exploring the Anchor Phenomenon and Investigative Phenomena over the course of this lesson to use as detailed evidence and reasoning in your answer. Copyright by Twig Education, Inc. 1 L3 S5 Monitoring Volcanoes Rubric
D. **Unbiased tasks/items:** Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.	**Evidence of D. Unbiased tasks/items:** Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students. Twig Science Next Gen student tasks are unbiased, offer equity of voice and experience to all learners, and allow students to create evidence of progression in a variety of ways. Student proficiency across the three dimensions is assessed using methods that are accessible and	**Evidence of D. Unbiased tasks/items:** Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.

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	unbiased for all students. All assessments can be completed either in print or digitally. The Middle School digital platform strives to meet WCAG 2.1 AA accessibility standards. All videos are captioned and include transcripts, student pages have a text-to-speech function (coming for Aug 2022), and the platform is keyboard navigable and screen reader friendly. Differentiation strategies are provided at point of use for how teachers can accommodate students with special educational needs and English language learners. Spanish cognates are also often provided as a way to make content accessible for ELA students. For example, in L3 S6, the Special Needs sidebar provides strategies relating to Social–Emotional Functioning to support students in observing and asking questions about their peers' assessed presentations. As far as the dimensions allow, teacher rubrics allow for interpretation according to student needs, meaning proficiency is assessed in an unbiased and accessible way. For example, in L1 S8 the teacher uses the **Hills and Mountains, or Volcanoes Teacher Rubric** to assess: Develop and use a model to describe phenomena. Drawing space is provided in the Twig Journal, but the language of the rubric does not specify that the model must be drawn, meaning that teachers may choose to have students develop a 3-D model instead if it is more appropriate to their	**Special Needs** **Social–Emotional Functioning** Provide expectations for observing the presentations: • Be respectful. Listen without interrupting. Wait until the end of the presentation to ask questions. • Be responsible. Take notes in your Twig Journal. Listen carefully to understand the presentation. • Be engaged. Raise your hand to ask questions at the end of the presentation. • Be fair. Use the rubric to grade presentations. Consider the information and how it was presented. Remember all other groups will be scoring you. **L3 S6 Special Needs sidebar, TE p. 106** **Discuss 3-D Models** Prompt students to discuss their 3-D models. • ***Describe how energy was transferred during your modeling process.*** Energy transferred from the hot plate to the crayon. Energy transferred from my hands to the crayon. Energy transferred from the melted crayon to the surrounding air as the wax cooled. • ***How do the processes we used compare to processes that happen in the environment?*** Rocks might be heated by the Sun or in the middle of volcanoes. They can be broken down by weathering, and squashed under other rocks or ice or buildings. **Note:** At this point, students are not expected to have correct answers. **L1 S4 class discussion, TE p. 31**

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	needs. Other assessments in Volcano Hunters include: • L1 S5: Students develop a 2-D rock cycle model that shows how energy flows and matter cycles through the landscape. The landscape background is provided for them so they have a more scaffolded starting point. Their models are developed over several sessions and the teacher is provided with strategies throughout to support students with varying needs (e.g., class discussion in L1 S4, English Learners sidebar and Below-Level Learners sidebar in L1 S5). • L2 S6: Students provide evidence and reasoning to support the claim: Some volcanoes are more dangerous than others. They are provided with a graphic organizer to help them collect their ideas before writing the assessed argument. Supports for English language learners and students working below grade level are provided in the Teacher Edition (Below-Level Learners sidebar, English Learners sidebar).	**English Learners** To include ELs in the discussion, invite them to recreate a rock cycle journey model on the board to support their explanations, and provide appropriate scaffolds. **Emerging Proficiency** Allow ELs to refer to their Twig Journals or provide key words and/or sentence frames on the board for students to complete. • When magma _____, it _____ on the surface. **Expanding Proficiency** Allow ELs to refer to their Twig Journals but encourage them to answer discussion questions in their own words. Have them recast their answers with key words they have gathered while working at their stations, e.g., *weathered*. **Bridging Proficiency** Have ELs present alongside proficient English speakers who can support them in answering the questions in their own words. Encourage them to recast some answers using relevant vocabulary. L1 S5 English Learners sidebar, TE p. 35 **Below-Level Learners** For students who struggle to model journeys using the 2-D landscape, use the **Developing and Using Models handout** to help them understand all possible connections. L1 S5 Below-Level Learners sidebar, TE p. 35 **Below-Level Learners** Provide support for students in writing scientific arguments with the **Engaging in Argument from Evidence handout** and direct students to pages in their Twig Journals where they can find evidence. L2 S6 Below-Level Learners sidebar, TE p. 77

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		English Learners Some ELs may need prompts to help synthesize what they know about dangerous volcanoes and to revisit the claim: Some volcanoes are more dangerous than others. Offer proficiency-leveled sentence frames and prompt questions to assist students in their writing of a scientific argument to support the claim. **Emerging Proficiency** Provide sentence frames: • Dangerous volcanoes have _____. Less dangerous volcanoes have _____. • Thick, sticky magma _____, but runny magma _____. • <Mount St. Helens> was a _____ volcano, because _____. • Hawaiian eruptions are _____, because _____. **Expanding Proficiency** Provide prompt questions. • *What do you know about <dangerous/less dangerous> volcanoes?* • *Does thick or runny magma usually cause more explosive eruptions?* • *What do you know about <Mount St. Helens>? Was it a dangerous volcano?* • *What do you know about <Hawaiian eruptions>? How dangerous are they?* **L2 S6 English Learners sidebar, TE p. 77**

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Category III: Monitoring NGSS Student Progress (additional criteria for units only)

Unit Criteria A unit or longer lesson designed for the NGSS will also include clear and compelling evidence of the following:	Specific evidence from materials and reviewers' reasoning	Evidence of Quality
E. **Coherent Assessment system:** Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.	**Evidence of E. Coherent Assessment system:** Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning. The **Twig Science Assessment System** has been developed in partnership with Stanford University's SCALE team. It is designed to provide a three-dimensional assessment system that allows teachers to evaluate student attainment of the three dimensions and **Performance Expectations** (PEs) of the NGSS standards. The assessment strategies measure students' knowledge and ability. They favor **Performance Tasks** over rote memorization and include a rich variety of measures, such as written assignments, collaborative engineering design challenges, and oral presentations. There are also lots of informal ways to quickly evaluate student progress. Full details of the assessment opportunities in each module are provided in the **Twig Science Assessment Center.** **Pre-Explorations (Diagnostic Pre-Assessment)** Near the start of each module, students complete a **Pre-Exploration** (Diagnostic **Pre-Assessment**). **Pre-Explorations** enable teachers to identify	**Evidence of E. Coherent Assessment system:** Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

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student prior knowledge and misconceptions. Pre-Assessment rubrics support teachers to help students address their misconceptions as they progress through the module.

Formative Assessments
Ongoing formative assessments are woven into each lesson. These are a quick way to gauge student understanding, allowing teachers to tailor their instruction accordingly. They include class discussions, constructed responses (written and drawn), self and peer assessment, and teacher observations.

Volcano Hunters contains two formal Formative Assessments and 17 informal formative assessments (3-D Reflects and exit tickets).

Summative Assessments
Summative Assessments are rich and highly engaging activities designed to motivate students to show off their attainment level of the module PEs. Rubrics support easy grading. Leveled rubrics are provided to give students a clear understanding of what success looks like.

Modules include Benchmark Assessments, created in conjunction with SCALE (Stanford Center for Assessment, Learning and Equity). These two-part assessments assess students' abilities to apply the three dimensions of the NGSS to new contexts. In Part A, students answer a series of multiple-choice questions and in Part B, students complete a short performance task.

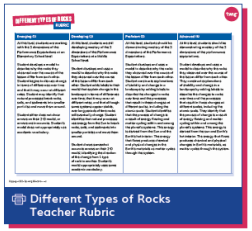
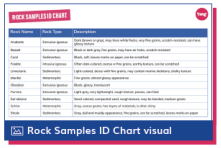
Question 1: ***How will the land above the continental plate change?***	
Aligned Performance Expectation and Dimensions	MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process SEP-2 CCC-7 CETAS-2 ESS2.A
Sessions	Lesson 1 Session 2
Scaffolds	Provide a graphic organizer to support students in planning their models. Include various sections such as a goal or objective, main idea or key concept, and a checklist that will ensure the proposed model is completed correctly.

Question 2: ***Are all volcanoes dangerous?***	
Aligned Performance Expectation and Dimensions	MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects SEP-4 CCC-1 ESS3.B
Sessions	Lesson 2 Session 2
Scaffolds	Provide a list of steps for students to follow in analyzing data, including how many trials were conducted, which instruments were used to collect data, a summary of the findings, and intended results. Encourage students to discuss the data in detail in order to identify visible patterns.

Question 3: ***How can we protect communities at risk from volcanoes?***	
Aligned Performance Expectation and Dimensions	MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects SEP-4 CCC-1 ESS3.B
Sessions	Lesson 3 Session 1
Scaffolds	Instruct students to graph the data to visually represent the patterns. Provide a checklist that contains key graph components, including labels and title.

L1 S1 Pre-Assessment rubric, TE p.15

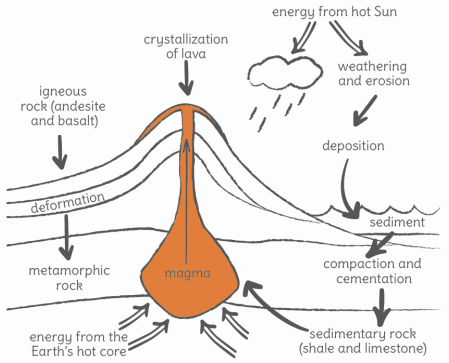
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	This gives students exposure to the types of assessment items they will face in the state test. Leveled rubrics support easy grading with sample student answers provided in the form of "Look Fors." Student versions of these rubrics are available without the "Look Fors." Grades 6–8 also include **3-D Multiple Choice Assessments,** which quickly assess student understanding of a range of dimensions covered in the module.	Formative Assessment: Growing Mastery of MS-ESS2-1 Use the **Different Types of Rocks Teacher Rubric** to assess students' models.  Different Types of Rocks Teacher Rubric **L1 S5 Formative Assessment, TE p.36** **Summative Assessment:** 35 min **Explaining the Anchor Phenomenon** Observe and Identify Rock Samples Divide students into teams. Distribute the rock sample bags and hand lenses from Session 1. Display the **Rock Samples ID Chart visual**.  Rock Samples ID Chart visual Have students record their observations of the rock samples on page 57 in their Twig Journals. Help students correctly identify their rock samples and use a think-pair-share to discuss their findings. **L1 S8 Summative Assessment, TE p.47**

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3-D Assessment • Develop a landscape model to describe the processes and physical and chemical changes that result in different rock types. Your model should include labels and arrows to show the source(s) and flow of energy and the movement of matter. You should indicate where the rocks from the four locations would have formed.

Students' models should show how different rocks are formed. They should show how energy flows and matter cycles (e.g., from the Earth's hot interior to form magma, which is then erupted and cools to form a volcano). They should also include labels that focus on how energy drives the formation processes, how matter is cycled through it, and how fast or slow the processes are.



L1 S8 Summative Assessment, TJ p.58

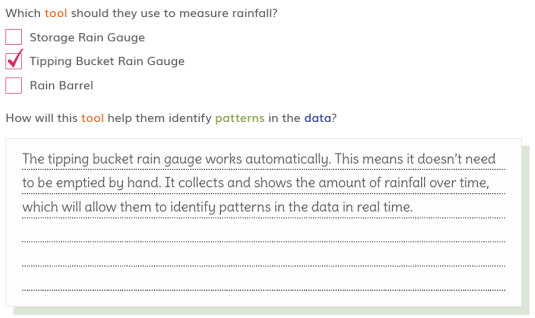
Exit Ticket

Have students complete the exit ticket:

- ***Consider the data you collected today as well as the Merapi and Auckland visual and accompanying lava samples. Why is it helpful to be able to identify the differences in how lava behaves?***
  Understanding the differences in how lava behaves can help us understand how dangerous an eruption could be, and how widespread its impact might be.

L2 S2 Exit Ticket, TE p.62

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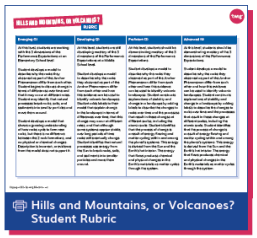
		 **L3 S2 3-D Reflect, TJ p.100**
F. **Opportunity to learn:** Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.	**Evidence of F. Opportunity to learn:** Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback. Twig Science Next Gen provides students with the opportunity to demonstrate performance of the SEPs and receive feedback through formal assessments. They also have ongoing opportunities to demonstrate the practices and receive feedback outside of the formal assessments. Teacher support is provided so that they can provide critical, but friendly feedback, and encourage students to review and revise their understanding. For example, in **L1 S4–6**, students demonstrate the SEP-2 element 'Develop and use a model to describe phenomena' as they develop a rock cycle model over several sessions and use it to explain concepts associated with ESS2.A and CCC-7. In	**Evidence of F. Opportunity to learn:** Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback. **Below-Level Learners** For students who struggle to model journeys using the 2-D landscape, use the **Developing and Using Models handout** to help them understand all possible connections. **L1 S5 Below-Level Learners sidebar, TE p.35** Develop Model Ask students to turn to page 53 in their Twig Journals to draw a diagram that illustrates the steps that occurred at the plate boundary during Phase 1 of Mount Mazama's creation. Encourage students to add labels and use arrows to demonstrate how the materials cycle through the landscape. **L1 S7 Develop Model, TE p.43**

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the L1 S5 Below-Level Learners sidebar the teacher is prompted to use the **Developing and Using Models handout** to support students who struggle to develop their models. Students' models are formatively assessed in L1 S5, ensuring the teacher has opportunities to review their understanding of the dimension before they complete the Summative Assessment in L1 S8. They additionally develop models during the lesson that are not assessed, ensuring they have further opportunities to demonstrate usage of the dimensions. For example, in L1 S6, students further update their rock cycle models, engaging in peer discussion to consolidate concepts, and in L1 S7 they develop models of the formation of Mount Mazama.

Introduce the Rubric

Share the **Hills and Mountains, or Volcanoes? Student Rubric** and explain that you will use this to assess the models and CER charts students will develop today.


Hills and Mountains, or Volcanoes? Student Rubric

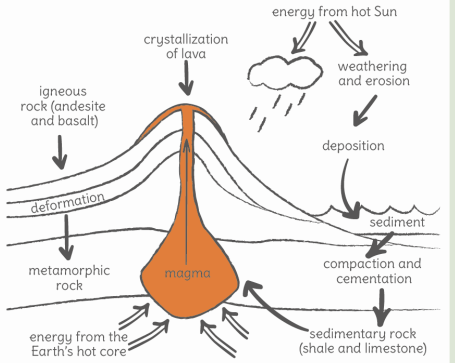
Develop Models

Have students turn to page 58 in their Twig Journals. Ask them to develop and use a model to describe how the different rocks found at the four different sites could have formed.

L1 S8 Summative Assessment, TE p.48

3-D Assessment • Develop a landscape model to describe the processes and physical and chemical changes that result in different rock types. Your model should include labels and arrows to show the source(s) and flow of energy and the movement of matter. You should indicate where the rocks from the four locations would have formed.

Students' models should show how different rocks are formed. They should show how energy flows and matter cycles (e.g., from the Earth's hot interior to form magma, which is then erupted and cools to form a volcano). They should also include labels that focus on how energy drives the formation processes, how matter is cycled through it, and how fast or slow the processes are.



L1 S8 Summative Assessment, TJ p.58

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Rating for Category III: Monitoring NGSS Student Progress—units After carefully weighing the evidence, reasoning, and suggestions for improvement, rate the degree to which the criteria are met across the unit.	**Unit Rating scale for Category III (Criteria A–F):** 3: At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion 2: Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A 1: Adequate evidence for at least three criteria in the category 0: Adequate evidence for no more than two criteria in the category	**Unit Rating scale for Category III (Criteria A–F): 3**

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Category Ratings:

Category I: NGSS 3D Design	Category II: NGSS Instructional Supports	Category III: Monitoring NGSS Student Progress
3	3	3

Overall ratings: The score total is an approximate guide for the rating. Reviewers should use the evidence of quality across categories to guide the final rating. In other words, the rating could differ from the total score recommendations if the reviewer has evidence to support this variation.	E: Example of high quality NGSS design—High quality design for the NGSS across all three categories of the rubric; a lesson or unit with this rating will still need adjustments for a specific classroom, but the support is there to make this possible; exemplifies most criteria across Categories I, II, & III of the rubric. (total score ~8–9) E/I: Example of high quality NGSS design if Improved—Adequate design for the NGSS, but would benefit from some improvement in one or more categories; most criteria have at least adequate evidence (total score ~6–7) R: Revision needed—Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5) N: Not ready to review—Not designed for the NGSS; does not meet criteria (total 0–2)	E

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