



# Mars Image Analysis

## Middle School NGSS, Common Core, and 21<sup>st</sup> Century Skills Alignment Document



### WHAT STUDENTS DO: Establish geologic sequences in a Mars image.

Students step into the shoes of real planetary scientists. Using large-format images of Mars, provided by Mars Education at Arizona State University, students reach conclusions about the geology of Mars. Students are tasked with identifying features on the surface of Mars, determining the surface history of the area, calculating the size of features, and developing research questions.

NGSS CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES
<p><b>WHAT IS THE UNIVERSE, AND WHAT IS EARTH’S PLACE IN IT?</b>  <i>NRC Core Question: ESS1: Earth’s Place in the Universe</i></p> <p><b>How do people reconstruct and date events in Earth’s planetary history?</b>  <i>NRC ESS1.C: The History of the Planet Earth</i></p>	<p style="text-align: center;"><i>Students will be able</i></p> <p><b>IO1: to reconstruct</b>                      geologic events using empirical evidence</p> <p><b>IO2: to use an argument</b>                      to establish a research topic through collaborative debate and decision making</p>



## 1.0 About This Activity

Mars lessons leverage *A Taxonomy for Learning, Teaching, and Assessing* by Anderson and Krathwohl (2001) (see *Section 4* and *Teacher Guide* at the end of this document). This taxonomy provides a framework to help organize and align learning objectives, activities, and assessments. The taxonomy has two dimensions. The first dimension, cognitive process, provides categories for classifying lesson objectives along a continuum, at increasingly higher levels of thinking; these verbs allow educators to align their instructional objectives and assessments of learning outcomes to an appropriate level in the framework in order to build and support student cognitive processes. The second dimension, knowledge, allows educators to place objectives along a scale from concrete to abstract. By employing Anderson and Krathwohl's (2001) taxonomy, educators can better understand the construction of instructional objectives and learning outcomes in terms of the types of student knowledge and cognitive processes they intend to support. All activities provide a mapping to this taxonomy in the *Teacher Guide* (at the end of this lesson), which carries additional educator resources. Combined with the aforementioned taxonomy, the lesson design also draws upon Miller, Linn, and Gronlund's (2009) methods for (a) constructing a general, overarching, instructional objective with specific, supporting, and measurable learning outcomes that help assure the instructional objective is met, and (b) appropriately assessing student performance in the intended learning-outcome areas through rubrics and other measures.

*How Students Learn: Science in the Classroom* (Donovan & Bransford, 2005) advocates the use of a research-based instructional model for improving students' grasp of central science concepts. Based on conceptual-change theory in science education, the 5E Instructional Model (BSCS, 2006) includes five steps for teaching and learning: Engage, Explore, Explain, Elaborate, and Evaluate. The Engage stage is used like a traditional warm-up to pique student curiosity, interest, and other motivation-related behaviors and to assess students' prior knowledge. The Explore step allows students to deepen their understanding and challenges existing preconceptions and misconceptions, offering alternative explanations that help them form new schemata. In Explain, students communicate what they have learned, illustrating initial conceptual change. The Elaborate phase gives students the opportunity to apply their newfound knowledge to novel situations and supports the reinforcement of new schemata or its transfer. Finally, the Evaluate stage serves as a time for students' own formative assessment, as well as for educators' diagnosis of areas of confusion and differentiation of further instruction. The 5E stages can be cyclical and iterative.



## 2.0 Instructional Objectives, Learning Outcomes, & Standards

Instructional objectives and learning outcomes are aligned with

- National Research Council's, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*
- Achieve Inc.'s, *Next Generation Science Standards (NGSS)*
- National Governors Association Center for Best Practices (NGA Center) and Council of Chief State School Officers (CCSSO)'s, *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects*
- Partnership for 21<sup>st</sup> Century Skills, *A Framework for 21<sup>st</sup> Century Learning*

The following chart provides details on alignment among the core and component NGSS questions, instructional objectives, learning outcomes, and educational standards.

- Your **instructional objectives (IO)** for this lesson align with the NGSS Framework and NGSS.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO)**.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics** (see Teacher Guide at the end of this lesson).

### Quick View of Standards Alignment:

The Teacher Guide at the end of this lesson provides full details of standards alignment, rubrics, and the way in which instructional objectives, learning outcomes, 5E activity procedures, and assessments were derived through, and align with, Anderson and Krathwohl's (2001) taxonomy of knowledge and cognitive process types. For convenience, a quick view follows:



## WHAT IS THE UNIVERSE, AND WHAT IS EARTH'S PLACE IN IT?

*NRC Core Question: ESS1: Earth's Place in the Universe*

### How do people reconstruct and date events in Earth's planetary history?

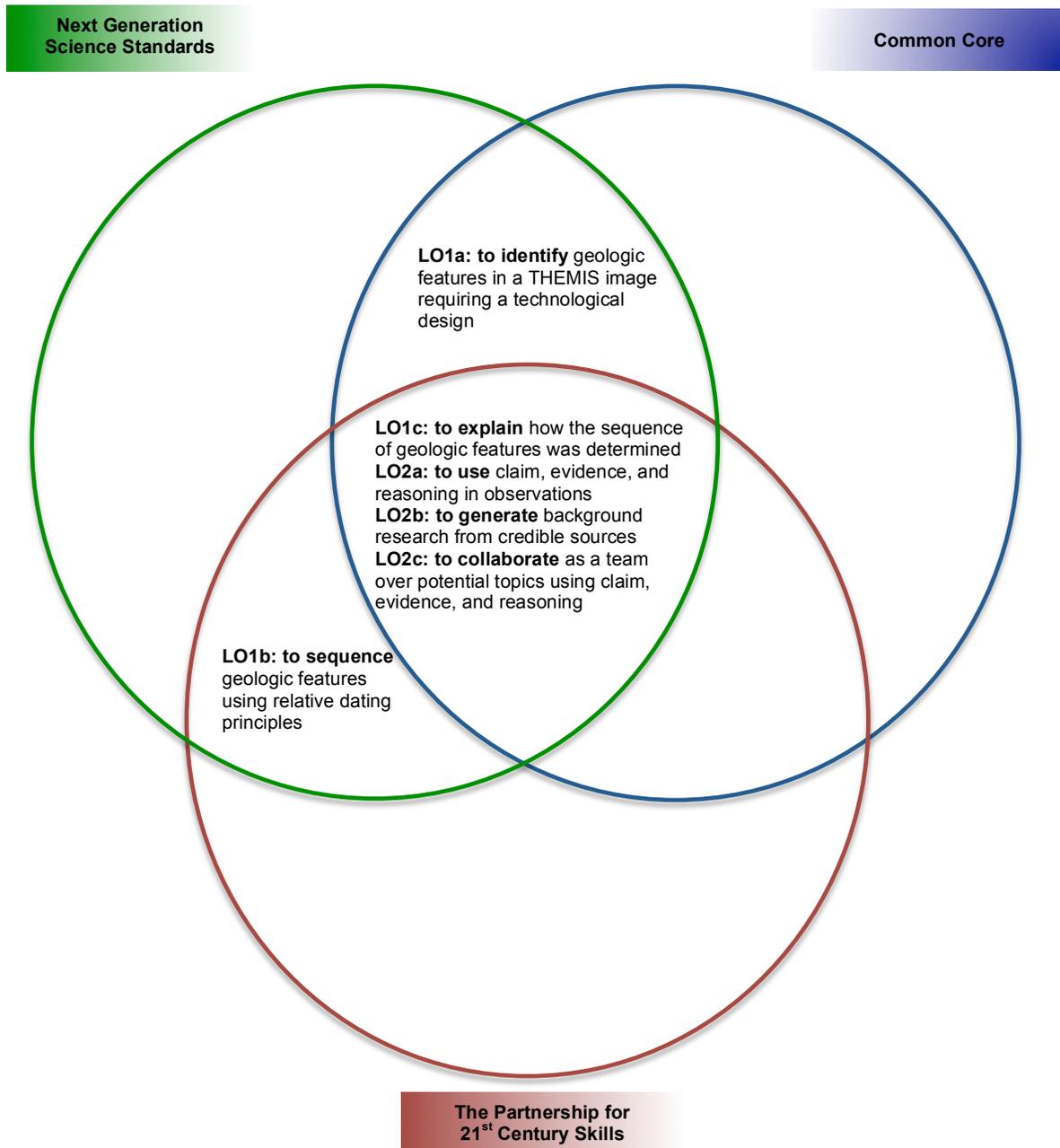
*NRC ESS1.C: The History of the Planet Earth*

Instructional Objective <i>Students will be able</i>	Learning Outcomes <i>Students will demonstrate the measurable abilities</i>	Standards <i>Students will address</i>
<p><b>IO1: to reconstruct geologic events using empirical evidence</b></p>	<p><b>LO1a. to identify geologic features in a THEMIS image</b></p> <p><b>LO1b. to sequence geologic features using relative dating principles</b></p> <p><b>LO1c. to explain how the sequence of geologic features were determined</b></p>	<p><b>NSES: UNIFYING CONCEPTS &amp; PROCESSES: K-12: Evidence, models, and explanations</b></p> <p><b>NSES (D): EARTH AND SPACE SCIENCE: Structure of the Earth System</b>  <b>Grades 5-8: D1c, D1d</b></p> <p><b>Earth's History</b>  <b>Grades 5-8: D2a</b></p> <p><b>NGSS Disciplinary Core Idea:</b>  <b>ESS1.C: The History of Planet Earth (MS-ESS1-4)</b></p> <p><b>NGSS Practices:</b></p> <p><b>Asking Questions and Defining Problems:</b> (Grades 6-8)</p> <p><b>Using Mathematics and Computational Thinking</b> (Grades 6-8)</p> <p><b>Constructing Explanations and Designing Solutions:</b> (Grades 6-8)</p> <p><b>Obtaining, Evaluating, and Communicating Information</b> (Grades 6-8)</p> <p><b>Engaging in Argument from Evidence</b> (Grades 6-8)</p>
<p><b>IO2: to use an argument to establish a research topic through collaborative debate and decision making</b></p>	<p><b>LO2a. to use claim, evidence, and reasoning in observations</b></p> <p><b>LO1b. to generate background research from credible sources</b></p> <p><b>LO1c. to collaborate as a team over potential topics using claim, evidence, and reasoning</b></p>	<p><b>NGSS Cross-Cutting Concept:</b></p> <p><b>Patterns</b> (Grades 6-8)</p> <p><b>Cause and Effect: Mechanism and Prediction</b> (Grades 6-8)</p> <p><b>Scale, Proportion and Quantity</b> (Grades 6-8)</p>



### 3.0 Learning Outcomes, NGSS, Common Core, & 21<sup>st</sup> Century Skills Connections

The connections diagram is used to organize the learning outcomes addressed in the lesson to establish where each will meet the Next Generation Science Standards, ELA and Math Common Core Standards, and the 21<sup>st</sup> Century Skills and visually determine where there are overlaps in these documents.





#### 4.0 Evaluation/Assessment

**Rubric:** A rubric has been provided to assess student understanding of the simulation and to assess metacognition. A copy has been provided in the Student Guide for students to reference prior to the simulation. This rubric will allow them to understand the expectations set before them.

#### 5.0 References

- Achieve, Inc. (2013). *Next generation science standards*. Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS.
- Anderson, L.W., & Krathwohl (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Longman.
- Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J., Westbrook, A., Landes, N. (2006) *The BSCS 5E instructional model: origins, effectiveness, and applications*. Colorado Springs: BSCS.
- Donovan, S. & Bransford, J. D. (2005). *How Students Learn: History, Mathematics, and Science in the Classroom*. Washington, DC: The National Academies Press.
- Miller, Linn, & Gronlund. (2009). *Measurement and assessment in teaching*. Upper Saddle River, NJ: Pearson.
- National Academies Press. (1996, January 1). *National science education standards*. Retrieved February 7, 2011 from [http://www.nap.edu/catalog.php?record\\_id=4962](http://www.nap.edu/catalog.php?record_id=4962)
- National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards*. Washington, DC: Authors.
- National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
- The Partnership for 21<sup>st</sup> Century Skills (2011). *A framework for 21<sup>st</sup> century learning*. Retrieved March 15, 2012 from <http://www.p21.org>

**(L) Teacher Resource. Mars Image Analysis Rubric (1 of 3)**

You will know the level to which your students have achieved the **Learning Outcomes**, and thus the **Instructional Objective(s)**, by using the suggested **Rubrics** below.

**Instructional Objective 1: to reconstruct geologic events using empirical evidence**

**Instructional Objective 2: to use an argument to establish a research topic through collaborative debate and decision making**

**Related Standard(s)****National Science Education Standards (NSES)  
UNIFYING CONCEPTS & PROCESSES****Grades K-12: Evidence, models, and explanations**

Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems. Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations.

Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. Different terms, such as “hypothesis,” “model,” “law,” “principle,” “theory,” and “paradigm” are used to describe various types of scientific explanations.

As students develop and as they understand more science concepts and processes, their explanations should become more sophisticated. That is, their scientific explanations should more frequently include a rich scientific knowledge base, evidence of logic, higher levels of analysis, greater tolerance of criticism and uncertainty, and a clearer demonstration of the relationship between logic, evidence, and current knowledge.

**National Science Education Standards (NSES)****(A) Science as Inquiry: Understandings about Scientific Inquiry**

Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more



information; some involve discovery of new objects and phenomena; and some involve making models (Grades 5-8: A2a).

### **National Science Education Standards (NSES)**

#### **(A) Science as Inquiry: Abilities Necessary to Do Scientific Inquiry**

Think critically and logically to make the relationship between evidence and explanations (Grades 5-8: A1e).

### **National Science Education Standards (NSES)**

#### **(D) Earth and Space Science: Structure of the Earth System**

Landforms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and depositions of sediment, while destructive forces include weathering and erosion (Grades 5-8: D1c).

Some changes in the solid earth can be describes as the “rock cycle.” Old rocks at the Earth’s surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues (Grades 5-8: D1d).

### **National Science Education Standards (NSES)**

#### **(D) Earth and Space Science: Earth’s History**

The earth process we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. Earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet (Grades 5-8: D2a).

\*This lesson supports the preparation of students toward achieving NGSS Performance Expectations using the Practices, Cross-Cutting Concepts and Disciplinary Core Ideas defined below:

(MS-ESS1-4)



### **Next Generation Science Standards (NGSS)**

#### **Practices: Asking Questions and Defining Problems**

(Learning Outcomes Addressed: LO2a, LO2b, LO2c)

- Ask questions
  - that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
  - to identify and/or clarify evidence and/or the premise(s) of an argument.
  - that challenge the premise(s) of an argument or the interpretation of a data set.



**Next Generation Science Standards (NGSS)**  
**Practices: Using Mathematics and Computational Thinking**  
(Learning Outcomes Addressed: LO1a)

- Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.



**Next Generation Science Standards (NGSS)**  
**Practices: Constructing Explanations and Designing Solutions**  
(Learning Outcomes Addressed: LO1a, LO1c, LO2a, LO2b, LO2c)

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.
- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.
- Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.



**Next Generation Science Standards (NGSS)**  
**Practices: Engaging in Argument from Evidence**  
(Learning Outcomes Addressed: LO1a, LO1c, LO2a, LO2b, LO2c)

- Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.
- Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
- Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.



**Next Generation Science Standards (NGSS)**  
**Practices: Obtaining, Evaluating, and Communicating Information**  
(Learning Outcomes Addressed: LO1a, LO1c, LO2a, LO2b, LO2c)

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.



**Next Generation Science Standards (NGSS)**  
**Cross-Cutting Concepts: Patterns**  
(Learning Outcomes Addressed: LO1a, LO1c, LO2a, LO2b, LO2c)

- Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.



**Next Generation Science Standards (NGSS)**  
**Cross-Cutting Concepts: Cause and Effect: Mechanism and Prediction**  
(Learning Outcomes Addressed: LO1a, LO1c, LO2a, LO2b, LO2c)

- Students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.



**Next Generation Science Standards (NGSS)**  
**Cross-Cutting Concepts: Scale, Proportion, and Quantity**  
(Learning Outcomes Addressed: LO1a, LO1c, LO2a, LO2b, LO2c)



- Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.



**Next Generation Science Standards (NGSS)**  
**Disciplinary Core Idea: ESS1.C: The History of Planet Earth**  
(Learning Outcomes Addressed: LO1a, LO1b, LO1c)

- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.



**Common Core State Standards**  
**Reading for Informational Text Standards 5: Key Ideas and Details**  
(Learning Outcomes Addressed: LO2b)

- Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.
- Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.
- Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.



**Common Core State Standards**  
**Reading for Informational Text Standards 5: Craft and Structure**  
(Learning Outcomes Addressed: LO1a, LO2a, LO2b, LO2c)

- Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.



**Common Core State Standards**  
**Reading for Informational Text Standards 5: Integration of Knowledge and Ideas**  
(Learning Outcomes Addressed: LO2a, LO2b, LO2c)



- Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text.
- Compare and contrast the most important points presented by two texts on the same topic.



### **Common Core State Standards**

#### **Reading for Literacy in Science and Technical Subjects Standards 6-8: Key Ideas and Details**

(Learning Outcomes Addressed: LO1c, LO2a, LO2b, LO2c)

- Cite specific textual evidence to support analysis of science and technical texts.
- Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
- Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.



### **Common Core State Standards**

#### **Reading for Literacy in Science and Technical Subjects Standards 6-8: Craft and Structure**

(Learning Outcomes Addressed: LO1a, LO2a, LO2b)

- 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.



### **Common Core State Standards**

#### **Reading for Literacy in Science and Technical Subjects Standards 6-8: Integration of Knowledge and Ideas**

(Learning Outcomes Addressed: LO2a, LO2b, LO2c)

- 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).
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.



### **Common Core State Standards**

#### **Writing Standards 5: Research to Build and Present Knowledge**

(Learning Outcomes Addressed: LO2a, LO2b, LO2c)



- Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- Draw evidence from literary or informational texts to support analysis, reflection, and research.
- Apply grade 5 Reading standards to informational texts (e.g., “Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point[s]”).



**Common Core State Standards**  
**Writing for Literacy in Science and Technical Subjects Standards 6-8:**  
**Research to Build and Present Knowledge**  
(Learning Outcomes Addressed: LO2b)

- Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
- 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.
- Draw evidence from informational texts to support analysis reflection, and research.



**Common Core State Standards**  
**Writing Standards 6-8: Production and Distribution of Writing**  
(Learning Outcomes Addressed: LO1a, LO1d, LO1e)

- Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.



**Common Core State Standards**  
**Writing Standards 6-8: Research to Build and Present Knowledge**  
(Learning Outcomes Addressed: LO1a, LO1d, LO1e)



- Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- Draw evidence from literary or informational texts to support analysis, reflection, and research.



### **Common Core State Standards**

#### **Speaking and Listening 5: Comprehension and Collaboration**

(Learning Outcomes Addressed: LO1c, LO2c)

- Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.
- Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
- Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
- Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.



### **Common Core State Standards**

#### **Math 5: Numbers and Operation in Base Ten (5.NBT.7)**

(Learning Outcomes Addressed: LO1a)

- Add, subtract, multiply, and divide decimals to hundredths, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used.



### **Common Core State Standards**

#### **Math 5: Numbers and Operations - Fractions (5.NF.5b, 5.NF.6, 5.NF.7c)**

(Learning Outcomes Addressed: LO1a)

- Interpret multiplication as scaling (resizing), by:
  - Explaining why multiplying a given number by a fraction greater than 1 results in a product greater than the given number (recognizing multiplication by whole numbers greater than 1 as a familiar case); explaining why multiplying a given number by a fraction less than 1 results



in a product smaller than the given number; and relating the principle of fraction equivalence  $a/b = (n \times a)/(n \times b)$  to the effect of multiplying  $a/b$  by 1.

- Solve real world problems involving multiplication of fractions and mixed numbers, e.g., by using visual fraction models or equations to represent the problem.
- Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions.<sup>1</sup>
- Solve real world problems involving division of unit fractions by non-zero whole numbers and division of whole numbers by unit fractions, e.g., by using visual fraction models and equations to represent the problem. *For example, how much chocolate will each person get if 3 people share  $1/2$  lb of chocolate equally? How many  $1/3$ -cup servings are in 2 cups of raisins?*



### Common Core State Standards

#### Math 5: Measurement and Data (5.MD.1)

(Learning Outcomes Addressed: LO1a)

- Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.



### Common Core State Standards

#### Math 6: Ratios and Proportional Relationships (6.RP.1, 6.RP.3d)

(Learning Outcomes Addressed: LO1a)

- Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, “The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak.” “For every vote candidate A received, candidate C received nearly three votes.”
- Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
- Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.



### Common Core State Standards

#### Math 6: The Number System (6.NS.2, 6.NS.3)

(Learning Outcomes Addressed: LO1a)



- Fluently divide multi-digit numbers using the standard algorithm.
- Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.



### **Common Core State Standards**

#### **Math 6: Expressions and Equations (6.EE.2a)**

(Learning Outcomes Addressed: LO1a)

- Write, read, and evaluate expressions in which letters stand for numbers.
  - Write expressions that record operations with numbers and with letters standing for numbers. *For example, express the calculation “Subtract y from 5” as  $5 - y$ .*



### **Common Core State Standards**

#### **Math 7: Ratios and Proportional Relationships (7.RP.3)**

(Learning Outcomes Addressed: LO1a)

- Use proportional relationships to solve multistep ratio and percent problems. *Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.*



### **Common Core State Standards**

#### **Math 7: The Number System (7.NS.2c, 7.NS.2d)**

(Learning Outcomes Addressed: LO1a)

- Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers.
- Apply properties of operations as strategies to multiply and divide rational numbers.
- Convert a rational number to a decimal using long division; know that the decimal form of a rational number terminates in 0s or eventually repeats.



### **21<sup>st</sup> Century Skills**

#### **Critical Thinking and Problem Solving**

(Learning Outcomes Addressed: LO1c, LO2a, LO2b, LO2c)

- Students plan and conduct scientific investigations and write detailed explanations based on their evidence. Students compare their explanations to those made by scientists and relate them to their own understandings of the natural and designed worlds. (Grade 8 Benchmark)



### **21<sup>st</sup> Century Skills Collaboration**

(Learning Outcomes Addressed: LO1a, LO1c, LO2c)

- Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning. (Grade 8 Benchmark)



### **21<sup>st</sup> Century Skills Information Literacy**

(Learning Outcomes Addressed: LO2b)

- Students are able to locate reliable scientific information in reputable reference books, back issues of journals and magazines, on websites, and in computer databases. (Grade 8 Benchmark)



### **21<sup>st</sup> Century Skills Leadership and Responsibility**

(Learning Outcomes Addressed: LO2b)

- Students understand the importance of proper citations and respect for intellectual property rights. (Grade 8 Benchmark)

**(L) Teacher Resource. Mars Image Analysis Rubric (1 of 3)****Learning Outcomes Assessment:**

	<b>Expert</b>	<b>Proficient</b>	<b>Intermediate</b>	<b>Beginner</b>
<b>LO1a: to identify</b> geologic features in a THEMIS image	Geologic feature identifications are logical and supported by evidence	Geologic features are logical and somewhat supported by evidence	Geologic features are reasonably logical and somewhat supported by evidence	Geologic features are illogical and/or not supported by evidence
<b>LO1b: to sequence</b> geologic features using relative dating principles	Geologic sequences are logical and supported by relative age dating principles	Geologic sequences are logical and somewhat supported by relative age dating principles	Geologic sequences are reasonably logical and somewhat supported relative age dating principles	Geologic sequences are illogical and/or not supported by relative age dating principles
<b>LO1c: to explain</b> how the sequence of geologic features were determined	Geologic sequences are logical and supported by evidence	Geologic sequences are logical and somewhat supported by evidence	Geologic sequences are reasonably logical and somewhat supported by evidence	Geologic sequences are illogical and/or not supported by evidence
<b>LO2a: to use</b> claim, evidence, and reasoning in observations	THEMIS observations include drawings and scientific claims of feature type and formation, supported by evidence provided by the site and lesson, includes a detailed explanation of how this is evidence for the type of formation.	THEMIS observations include drawings and scientific claims of feature type and formation, supported by evidence provided by the site or lesson, includes an explanation of how this is evidence for the type of formation.	THEMIS observations include a drawing and labeling of the feature. Uses evidence from the site or lesson for feature identification.	THEMIS observations include a drawing and labeling of the feature.
<b>LO2b: to generate</b> background research from credible sources	Evaluate all sources for credibility and use informational text to develop a detailed summary describing the feature, how it forms, and the relative similarities and differences between Earth/Mars.	Evaluate most sources for credibility and use informational text to develop a detailed summary describing the feature, how it forms, and the relative similarities and differences between Earth/Mars.	Some sources are credibility and uses informational text to develop a brief summary describing the feature, how it forms, and the relative similarities and differences between Earth/Mars.	May use credible text to develop a brief summary describing the feature, how it forms, and the relative similarities and differences between Earth/Mars.
<b>LO2c: to collaborate</b> as a team over potential topics using claim, evidence, and reasoning	Presents a potential topic of interest to the team including the compelling evidence and reasoning from background research. Effectively shares ideas during collaboration and listens to ideas before providing constructive feedback.	Presents a potential topic of interest to the team including the compelling evidence and reasoning from background research. May shares ideas during collaboration and listen to ideas, but may have difficulty with constructive feedback to ideas.	Shares a number of ideas with the group but may not connect to evidence and reasoning of background research. May or may not fully listen to ideas and/or provide constructive feedback.	Sharing of ideas is limited to a neighbor or written form only. Allows the group to make the decision.

**(L) Teacher Resource. Mars Image Analysis Rubric (2 of 3)****Partnership for 21<sup>st</sup> Century Skills**

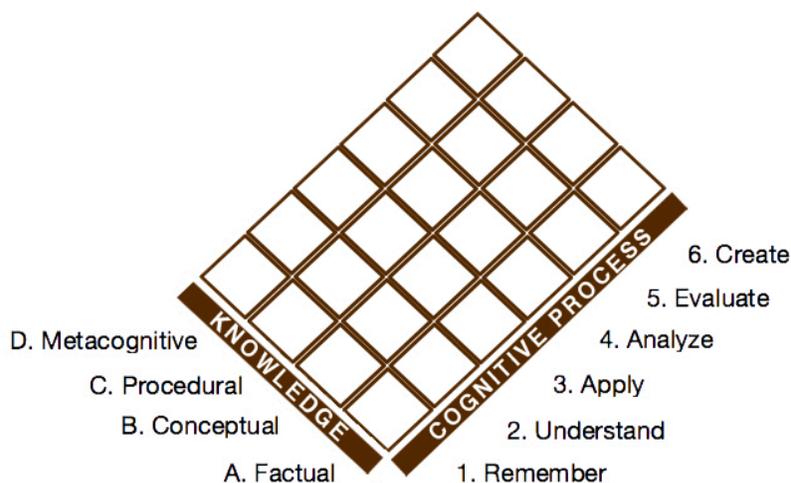
	<b>Expert</b>	<b>Proficient</b>	<b>Intermediate</b>	<b>Beginner</b>
Effectiveness of critical thinking	Develops detailed explanations based on credible evidence. Compares explanations to those made by scientists and relates them to their own understandings of the geology.	Develops detailed explanations based on credible evidence. Relates them to their own understandings of the geology.	Develops explanations. Relates explanation to their own understandings of the geology.	Attempts to explain the geology based on own understanding of geology.
Effectiveness of collaboration with team members and class.	Extremely interested in collaborating in the group. Actively provides solutions to problems, listens to suggestions from others, attempts to refine them, monitors group progress, and attempts to ensure everyone has a contribution.	Extremely Interested in collaborating in the group. Actively provides suggestions and occasionally listens to suggestions from others. Refines suggestions from others.	Interested in collaborating in the group. Listens to suggestions from peers and attempts to use them. Occasionally provides suggestions in group discussion.	Interested in collaborating in the group.
Effectiveness of information literacy in background research	Locates reliable scientific information in reputable reference books, back issues of journals and magazines, on websites, and in computer databases.	Locates reliable scientific information in reputable reference books, back issues of journals <i>or</i> magazines, on websites.	Locates scientific information from a mixed variety of sources, some reputable, others less likely.	Locates information from websites indiscriminately.
Effectiveness of leadership and responsibility for citation and property rights	Demonstrates the importance of proper citations and respect for intellectual property rights through thorough written and verbal citation of sources used in research.	Demonstrates respect for intellectual property rights through thorough written and verbal citation of sources used in research. Citation of work is nearly formatted correctly.	Demonstrates respect for intellectual property rights through thorough written citation of sources used in research. Citation of work may be nearly formatted correctly.	If citation is provided, it is in URL form and lacks formatting. Citation may be missing.

**(L) Teacher Resource. Mars Image Analysis Rubric (3 of 3)****Common Core – ELA**

	<b>Expert</b>	<b>Proficient</b>	<b>Intermediate</b>	<b>Beginner</b>
Production and Distribution of Writing	Produces clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.	Produces clear and coherent writing in which the development and organization are appropriate to task, purpose, or audience.	Produces clear writing in which the development and organization are appropriate to task, purpose, or audience.	Produces writing in which the development is appropriate to task, purpose, or audience.
Research to Build and Present Knowledge	Recalls relevant information from experience; summarizes information in finished work; draws evidence from informational texts to support analysis, reflection, and research.	Recalls relevant information from experience; draws evidence from informational texts to support analysis, reflection, and research.	Recalls information from experience; draws evidence from informational texts to support analysis, reflection, and research.	Recalls information from experience.
Key Ideas and Details	Uses specific evidence from text to support ideas. Develops an accurate and in depth summary, extending prior understanding and opinions.	Uses specific evidence from text to support ideas. Develops an in depth summary, extending prior understanding and opinions.	Uses information from text to support ideas. Develops a summary, extending prior understanding and opinions.	Supports ideas with details, relying on prior understanding and opinions.
Craft and Structure	Develops strong, accurate geologic vocabulary through feature identification and background research on those features.	Develops strong, geologic vocabulary through feature identification and background research on those features.	Develops vocabulary through feature identification.	Vocabulary is rudimentary toward geology and possibly based on prior understanding.
Integration of Knowledge	Successfully combines information from lesson with text found on web-based resources to develop a deep understanding of a geologic topic.	Successfully combines information from lesson with text found on web-based resources to develop an understanding of a geologic topic.	Combines information from lesson with text found on web-based resources to develop a summary of a geologic topic.	References text from web-based resources to develop a summary of a geologic topic.



**(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (1 of 3)**



This lesson adapts Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process, each with types and subtypes (listed below). Verbs for objectives and outcomes in this lesson align with the suggested knowledge and cognitive process area and are mapped on the next page(s). Activity procedures and assessments are designed to support the target knowledge/cognitive process.

Knowledge	Cognitive Process
<b>A. Factual</b> <b>Aa:</b> Knowledge of Terminology <b>Ab:</b> Knowledge of Specific Details & Elements <b>B. Conceptual</b> <b>Ba:</b> Knowledge of classifications and categories <b>Bb:</b> Knowledge of principles and generalizations <b>Bc:</b> Knowledge of theories, models, and structures <b>C. Procedural</b> <b>Ca:</b> Knowledge of subject-specific skills and algorithms <b>Cb:</b> Knowledge of subject-specific techniques and methods <b>Cc:</b> Knowledge of criteria for determining when to use appropriate procedures <b>D. Metacognitive</b> <b>Da:</b> Strategic Knowledge <b>Db:</b> Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge <b>Dc:</b> Self-knowledge	<b>1. Remember</b> <b>1.1</b> Recognizing (Identifying) <b>1.2</b> Recalling (Retrieving) <b>2. Understand</b> <b>2.1</b> Interpreting (Clarifying, Paraphrasing, Representing, Translating) <b>2.2</b> Exemplifying (Illustrating, Instantiating) <b>2.3</b> Classifying (Categorizing, Subsuming) <b>2.4</b> Summarizing (Abstracting, Generalizing) <b>2.5</b> Inferring (Concluding, Extrapolating, Interpolating, Predicting) <b>2.6</b> Comparing (Contrasting, Mapping, Matching) <b>2.7</b> Explaining (Constructing models) <b>3. Apply</b> <b>3.1</b> Executing (Carrying out) <b>3.2</b> Implementing (Using) <b>4. Analyze</b> <b>4.1</b> Differentiating (Discriminating, distinguishing, focusing, selecting) <b>4.2</b> Organizing (Finding coherence, integrating, outlining, parsing, structuring) <b>4.3</b> Attributing (Deconstructing) <b>5. Evaluate</b> <b>5.1</b> Checking (Coordinating, Detecting, Monitoring, Testing) <b>5.2</b> Critiquing (Judging) <b>6. Create</b> <b>6.1</b> Generating (Hypothesizing) <b>6.2</b> Planning (Designing) <b>6.3</b> Producing (Constructing)



### (M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (2 of 3)

**IO 1:** to reconstruct geologic events using empirical evidence (6.3; Bb)

**LO1a.** to identify geologic features in a THEMIS image (1.1; Ab)

**LO1b.** to sequence geologic features using relative dating principles (6.3; Bb)

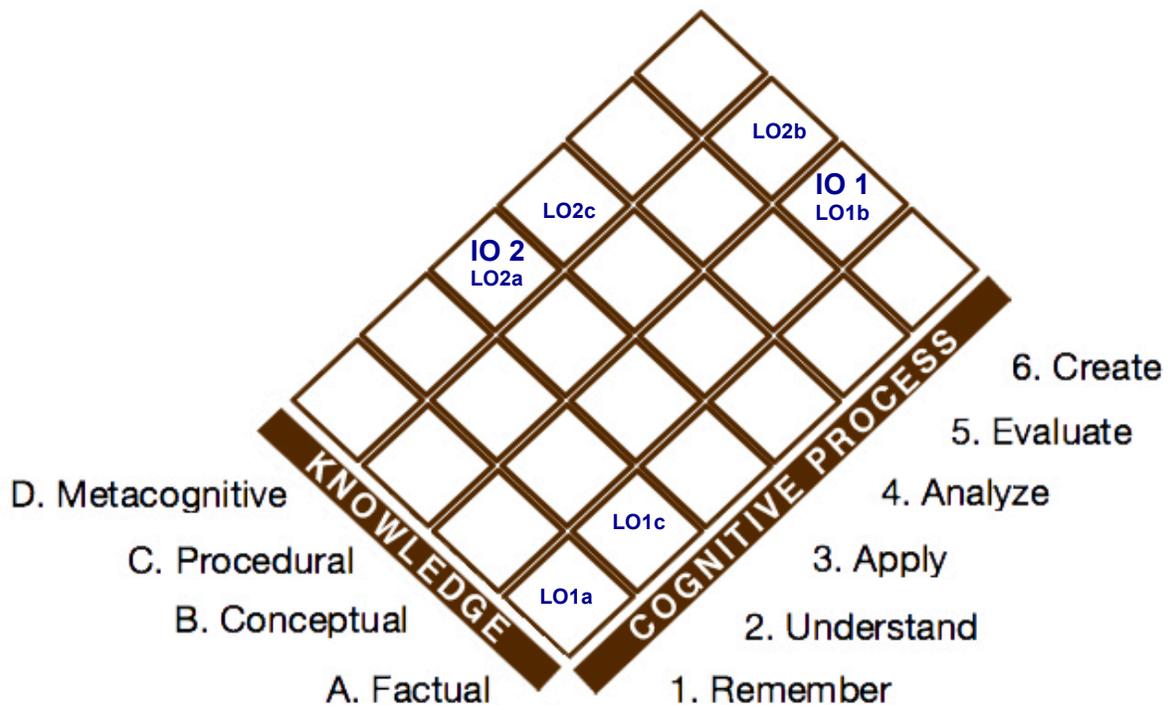
**LO1c.** to explain how the sequence of geologic features were determined (2.7; Ab)

**IO 2:** to use an argument to establish a research topic through collaborative debate and decision-making (3.2; Da)

**LO2a.** to use claim, evidence, and reasoning in observations (3.2; Da)

**LO2b.** to generate background research from credible sources (6.1; Cb)

**LO2c.** to collaborate as a team over potential topics using claim, evidence, and reasoning (4.2; Db)



**(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (3 of 3)**

The design of this activity leverages Anderson & Krathwohl's (2001) taxonomy as a framework. Below are the knowledge and cognitive process types students are intended to acquire per the instructional objective(s) and learning outcomes written for this lesson. The specific, scaffolded 5E steps in this lesson (see 5.0 Procedures) and the formative assessments (worksheets in the Student Guide and rubrics in the Teacher Guide) are written to support those objective(s) and learning outcomes. Refer to (M, 1 of 3) for the full list of categories in the taxonomy from which the following were selected. The prior page (M, 2 of 3) provides a visual description of the placement of learning outcomes that enable the overall instructional objective(s) to be met.

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**At the end of the lesson, students will be able**

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**IO1: to reconstruct geologic events using empirical evidence**

6.3: to construct

Bb: knowledge of principles and generalizations

**IO2: to use an argument to establish a research topic through collaborative debate and decision-making**

3.2: to use

Da: strategic knowledge

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**To meet that instructional objective, students will demonstrate the abilities:**

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**LO1a: to identify geologic features in a THEMIS image**

1.1: to identify

Ab: knowledge of specific details &amp; elements

**LO1b: to sequence geologic features using relative dating principles**

6.3: to construct

Bb: knowledge of principles and generalizations

**LO1c: to explain how the sequence of geologic features were determined**

2.7: to explain

Ab: knowledge of specific details &amp; elements

**LO2a: to use claim, evidence, and reasoning in observations**

3.2: to use

Da: strategic knowledge

**LO2b. to generate background research from credible sources**

6.1: to generate

Cb: knowledge of subject-specific techniques and methods

**LO2c. to collaborate as a team over potential topics using claim, evidence, and reasoning**

4.2: to find coherence

Db: knowledge about cognitive tasks, including appropriate contextual and conditional knowledge