Strand: 7.2.1 and 7.2.6

Emphasis: Rock Cycle and Geologic Time

Anticipated Time Required (assuming 50 minute class periods):
Episode 1 - 30 min
Episode 2-
Dominant CCC: Energy and Matter, Scale, Cause and Effect

Dominant SEP: Develop a model, engaging in argument from evidence, analyzing and interpreting data.

Management Strategies to support equitable access to content: Jigsaw, Rainbow grouping, Card Houses and shuffling the deck

Shopping list:
Episode 1 - rocks and images of landforms and maps (if possible) from wasatch front (if possible)
Episode 2-
  ● Several examples of the rock type labeled and described.
  ● Hand lenses
Episode 3- none
Episode 4-
  ● Graph paper 1 for each student.
  ● Colored pencils
  ● Rulers
  ● Clay kit - air dry clay or salt dough or playdough...colored some ‘fossils’ beads or something
  ● Dental Floss
  ● Transparency sheets
  ● Washable felt tips markers (transparency markers)
  ● Viewing Stands (if available) I’m making mine.
  ● Cardboard (I cut up old science fair boards into squares) or paper plates
Episode 5- none
Episode 6- none
Episode 7- none
Episode 8- none
Episode 9- none
Episode 10
  ● Large paper
  ● Pencils
  ● Paper
  ● Markers
  ● Rulers
## Storyline Planner - 7.2.1 and 7.2.6

### Anchor Phenomenon: Different Rock formations In and Around Utah including the Farmington Canyon Complex portion of the Wasatch Front

### Student Performance Expectation: Develop a model of the Rock cycle including the role of energy in cycling matter by making an argument from evidence using the geologic time scale, superposition and unconformities  7.2.1 and 7.2.6

<table>
<thead>
<tr>
<th>Dominant DCI</th>
<th>Dominant CCC</th>
<th>Dominant SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth and Space Science</td>
<td>Energy and matter Scale</td>
<td>Develop a Model Argue from evidence</td>
</tr>
</tbody>
</table>

### Science Experiences

<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing? (This should match your SEP!)</th>
<th>What specific understandings should students get from this experience? (What pieces of the performance expectation does the experience provide?)</th>
<th>New questions students have to propel us to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Patterns/ Asking Questions</td>
<td>Gallery stroll. Looking at rock samples and pictures of land forms including the Wasatch front and antelope island showing many different types of rock features. Students will complete observation chart, discuss their observations with table partner and write questions on sticky notes for the board.</td>
<td>There are many types of different rocks found in Utah</td>
<td>How do different rocks form? How did the Wasatch front form?</td>
</tr>
<tr>
<td>2</td>
<td>Cause and effect/ Obtaining and communicating information/ carrying out investigation</td>
<td>Given a rock and a resource (text book, google earth, vocabulary list, pictures) and determine the origin of the rock and the role of energy. Jigsaw. Student share knowledge with their work groups as they move from station to station.</td>
<td>Rocks have characteristics related to their origins. Rocks are classified according to their origins. Relationship between minerals and rocks. Process of fossilization</td>
<td>Can rocks change? How old are the rocks? Why do we find certain types of rocks in certain places?</td>
</tr>
<tr>
<td>3</td>
<td><strong>cause and effect, stability and change</strong></td>
<td>Students observe unconformities. Students try to order the events in a geologic cross section. Students construct a personal fossil record Students practice interpreting geologic cross section models.</td>
<td>Law of Uniformitarianism Law of superposition role of deformation and erosion in producing unconformities and the problems of missing time.</td>
<td>what could cause these kinds of events to occur</td>
</tr>
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<td>---</td>
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</tr>
<tr>
<td>4</td>
<td><strong>Patterns/ Asking questions / Developing and Using Models</strong></td>
<td>Students will observe rocks geologic map of Utah Students construct model of layers, modify it and then map it.</td>
<td>Geologic, stratigraphic, and topographic maps show where layers are found. It is inferred that the rocks that can’t be seen are still present under the surface.</td>
<td>How did this happen? What forces could cause this to occur?</td>
</tr>
<tr>
<td>5</td>
<td><strong>Patterns/ scale/ Engaging in argument from evidence/ Obtaining, evaluating and communicating information</strong></td>
<td>Students observe images of the Wasatch front and the Wasatch fault. Students will be given a copy of geologic time scale along with other rocks, images and data from Farmington Complex, including Weber Canyon, Ogden Canyon, Antelope Island. Introduced to vocabulary: rock strata, unconformity, and the names of the different types of rocks found in the Farmington Complex along with their ages. Geologic map of Farmington canyon complex</td>
<td>Recognize that the events that affect Farmington Canyon seemed to have affected a very large area. That the layers have been altered dramatically</td>
<td>How did Wasatch fault forms.</td>
</tr>
<tr>
<td>6</td>
<td><strong>cause and effect, energy and matter and</strong></td>
<td>Students will observe a model of thrust faults observe aerial photographs of areas produced by</td>
<td>Recognize that the Wasatch front was built from a thrust fault acting on many large layers of sedimentary rock</td>
<td>Are these forces still acting on the Wasatch Front? Shouldn’t the</td>
</tr>
<tr>
<td>Step</td>
<td>Subject Area</td>
<td>Activity</td>
<td>Question</td>
<td>Response</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
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<td>----------</td>
</tr>
<tr>
<td>1</td>
<td>Stability and change/developing and using models</td>
<td>Students respond to Explanation A</td>
<td>Wasatch front just be a big set of hills? Why is the range cut open like this?</td>
<td>Students discuss evidence and respond to Explanation B</td>
</tr>
<tr>
<td>2</td>
<td>Cause and effect/Constructing explanations, arguing from evidence</td>
<td>Students view evidence the Sevier Orogeny was caused by a subducting plate off the coast of California by observing models of the Orogeny and thrust faults. Students respond to Explanation B</td>
<td>Recognize that the Wasatch fault came after the folding of rock caused by the interaction of tectonic plates</td>
<td>What is causing the land to compress? what makes plates move? Students discuss evidence and respond to Explanation B</td>
</tr>
<tr>
<td>3</td>
<td>Cause and effect/energy and matter/arguing from evidence</td>
<td>Students construct model of normal fault. Look at maps showing where rivers flow and expose the unconformities. Students look at maps of faults, recent volcanic activity, hot springs and geothermal activity in the Great Basin and Range. Elevation changes? Explanation C</td>
<td>Recognize that the land is still changing because of forces beneath the surface of the earth (heat and pressure from being deep and near the core) which is causing a thinning and stretching of the great basin and range and above the earth due to solar energy and the production of weather and temperature changes.</td>
<td>Can we predict earthquakes? Do scientists all over the world make inferences in the same way? Students discuss evidence and respond to Explanation C</td>
</tr>
<tr>
<td>4</td>
<td>Cause and effect/stability and change/energy and matter/arguing from evidence</td>
<td>Students discuss claims with new group and construct group explanation. Students work with group to complete Worksheet</td>
<td>Recognize that rocks are changing due to forces of erosion, weathering, pressure, heat, folding, and faulting and that these changes occur all the time.</td>
<td>What causes the earth plates to move around? Students discuss claims and complete Argument Tool and Worksheet</td>
</tr>
<tr>
<td>5</td>
<td>Energy and matter/developing and using models</td>
<td>Students will construct a mind map and explanation of the rock cycle describing how energy flows and matter cycles to produce changes to the Earth according to rubric. One Develop a model of the rock cycle to describe the relationship between energy flow and matter cycling that create igneous, metamorphic, and sedimentary rocks</td>
<td>What is going on under the surface..towards 7.2.5 and 7.5.2 What is going on under the surface..towards 7.2.5 and 7.5.2 Each Student construct a model and an explanation (paragraph), according to rubric.(mind map-including words pictures and arrows) of how rocks change and the forces that change them (rock...</td>
<td>Each Student construct a model and an explanation (paragraph), according to rubric.(mind map-including words pictures and arrows) of how rocks change and the forces that change them (rock...</td>
</tr>
<tr>
<td></td>
<td>peer edit is required.</td>
<td>sedimentary, and metamorphic rocks. Emphasize the processes of melting, crystallization, weathering, deposition, sedimentation, and deformation, which act together to form minerals and rocks.</td>
<td>cycle) including three main rock types, heat energy, solar energy, erosion, cycle, weathering, deposition, cementation, compression, heat, pressure and arrows showing where dynamic changes are occurring to rock. One peer edit required before submission.</td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>System and system models/ constructing explanations, arguing from evidence.</td>
<td>Students will participate in a group discussion and direct instruction. journaling Students place Sevier Orogeny Formation of Great Basin and Range on time and spatial scales. (7.2.3)</td>
<td>Recognize that scientists (geologists) infer about the past from rock evidence and justify that with uniformitarianism. Recognize that scientists predict future changes to the earth based on inferences from evidence and that the time and scale of future events is very difficult to predict.</td>
<td>What is going on under the surface? What is causing this movement? Will it stop, does it always move?</td>
</tr>
</tbody>
</table>
### Overarching Performance Expectations (Standard) from State Standards or NGSS:

**7.2.1** Develop a model of the rock cycle to describe the relationship between energy flow and matter cycling that create igneous, sedimentary, and metamorphic rocks. Emphasize the processes of melting, crystallization, weathering, deposition, sedimentation, and deformation, which act together to form minerals and rocks. Make an argument from evidence for how the geologic time scale shows the age and history of Earth. Emphasize scientific evidence from rock strata, the fossil record, and the principles of relative dating, such as superposition, uniformitarianism and recognizing unconformities.

### Lesson Performance Expectations:

Ask questions about the processes that form different types of rocks.

**CCC: Patterns**

**SEP: Asking questions**

#### Students Will . . . To Construct Meaning

**Engage with a Phenomenon:**
The Entire Wasatch Front is composed of sedimentary, metamorphic and igneous rocks that look like they’ve been folded and tilted and moved around.

**Gather:**

1. Students will go on a gallery walk as table partners and observe different rock samples and correlating images and map from landforms along the Wasatch Front. Students will construct an observation/inferences/questions chart in journal and look for patterns they observe and prepare to share with the class in group discussion. Questions should be put on sticky notes and placed on parking lot in categories: possible questions include: how rock was formed? Names of the rock? Location? How rock was acquired? (possibilities)

#### Teacher Will . . . To Support Students

Collect rock samples (or acquire) and images from different rock formations along wasatch front and present throughout the room as a set.

**Teacher Note:** There are examples of every rock type within the ogden-provo area including sedimentary, igneous and metamorphic rocks. The idea is to present students with rocks IN CONTEXT. Igneous rocks make more sense when you see them next to a volcano, and sedimentary rocks make sense when they come from an old delta or glacial moraine. Metamorphic rocks make more sense when you see the twisted and folded rock formations they come from. The goal is a more authentic experience with the things we can LEARN from rock classification about the PROCESSES of land formation and deformation.

If it is not possible for you to collect rocks from your area, then collect rock samples and put up pictures of places where they might **typically** be found. Give them exposure to the idea that a rock is definitely NOT just a rock. Teacher will lead discussion on observations, explanations by randomly generating students to contribute. Select questions relating to rock type and formation for exploration. (20- 30 min)

### Assessment of Student Learning

*Students will bring Observations, Questions, Explanations to the class discussion.*
<table>
<thead>
<tr>
<th>Observations/Facts</th>
<th>Explanations/Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions</td>
<td></td>
</tr>
</tbody>
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### Overarching Performance Expectations (Standard) from State Standards or NGSS:

**7.2.1** Develop a model of the rock cycle to describe the relationship between energy flow and matter cycling that create igneous, sedimentary, and metamorphic rocks. Emphasize the processes of melting, crystallization, weathering, deposition, sedimentation, and deformation, which act together to form minerals and rocks. Make an argument from evidence for how the geologic time scale shows the age and history of Earth. Emphasize scientific evidence from rock strata, the fossil record, and the principles of relative dating, such as superposition, uniformitarianism and recognizing unconformities.

### Lesson Performance Expectations:

Students will specialize in a particular rock classification group and then teach their peers as specialists. They will also rotate and learn from their peers about the other classifications of rocks and minerals. They will complete a guide to rocks and minerals to be used as a reference in constructing their understanding of the rock cycle. They should also begin to recognize the role of energy in causing changes to rocks.

- **CCC:** Patterns, cause and effect
- **SEP:** Obtaining and communicating information

### Students Will... To Construct Meaning

*Which is your favorite Avenger? Choose your favorite card. When told, move to the lab station for your character. Each station should have 4 different colors of cards.*

### Teacher Will... To Support Students

**Management Strategy:** Choose your favorite.
I have stickers with the Avengers on them today. So I have placed 8 different characters on 4 different colored cards.
- I have a blue set with 8 different characters
- A yellow set with the same 8 characters
- A pink set with the same 8 characters and
- A green set with the same 8 characters.
If you have more than 32 kids...you may need to add WONDER WOMAN to the pile...just saying. She rocks.

Students will be asked to choose their favorite avenger. Warn them, there can only be 4 kids in each group. Or if you would rather, just pass out the cards and have them go to their assigned lab station.

For example: if you are ‘Captain America’ you meet at workstation #1. At each lab station you should have a group of 4 matching character cards, one of each color.

**Management Strategy:** Jigsaw
Students will be acting as peer instructors by distributing to learning stations and then returning to teach their peers. 4 Learning Stations should be set up. 1 for each type of rocks and a mineral station. The colors match the card.
At each lab station you should find all of the information and tools necessary to learn and prepare to teach your peers about your particular group of rocks and how they were formed.

Students are required to understand
- Identifying characteristics of each rock group
- How characteristics relate to the origins of the rock
- Important vocabulary related to the content objective
- Role of energy (solar or heat from core) and pressure in forming the rock.
- Relationship between rocks and minerals

Make a plan to help their peers understand this content and connect to it in fun and memorable ways.

Set up stations for sedimentary rocks and fossils, igneous rocks, metamorphic rocks, and minerals.

Provide: Preparing to Teach Template
Give students time to prepare to instruct their group. Provide students with the PREPARING TO TEACH template and have them complete it.

Combine two groups together (Black Widow and Hawkeye or Batman and Captain America) and have them WORK TOGETHER to teach BOTH of their groups at the same time. They will TEAM TEACH.

Each station should include:
- Several examples of the rock type labeled and described.
- Rock and mineral ID key
- Text book
- Map of Utah
- Hand lenses
- Computer with google earth if possible
- Description of 2 energy sources that cause rocks to become or to change.

Provide: something fun or clever to help students with their teaching.
Examples:
- For sedimentary rocks bring them miniature crunch bars or dr goodbars or something that looks ‘sedimentary’ or rice krispy treats or gobstoppers showing layers eroding away.
- For igneous rocks, provide atomic fireballs or something hot. Or melt chocolate and let it cool again.
- Metamorphic could be 3 starbursts wrapped in plastic wrap and then squished to form banded layers.
- Rock Candy for minerals.

Have enough available for the entire class.

You could also provide
Use models and examples of processes that make your rock type.

Come up with a catchy SLOGAN to help students remember the BIG IDEAS (how the rock forms, where they are found, what energy forms them etc.)

With your team teaching partner, teach your groups the content that you specialized in. When you are done, rotate and become the student and learn the content you are required to learn.

Use the notes and information to complete the GUIDE to ROCKS AND MINERALS. Use the rubric to make sure you have included all of the necessary information. After it is graded you will glue the guide into your class journals to use as a reference for this unit.

- 3D models of volcanoes
- water table with sediment (even a jar of dirt and water showing how layers form would work)
- Models of fossils or bones or teeth buried in sediment. examples of fossils in sedimentary rock.
- A tray of salt crystals produced by evaporating water.

Each students are required to come up with a SLOGAN that they can teach their peers to help them remember the origins of each rock type.

When students are prepared (at least one class period), have them return to their lab stations and then have the combined teams meet at 1 learning station so that there are 8 people at each learning station. The specialists at each lab station will instruct their peers and help them complete their “Preparing to Learn” forms. This should take about 10-15 min. Then they should rotate to the next lab station until they have been to all the stations.

Assessment: Students should make a guide that they can glue into their class journals: (papers should be copied double sided and made into booklets).

Assessment of Student Learning
Proficient students will completely create a guide to rocks and minerals that includes includes the required elements listed above for each rock type and an expression of the relationship between rocks and minerals and the role of energy in the rock origins. Graded with a rubric.
Preparing to Teach - Rocks

Name ______________________________

1. What type of rock are you learning about? _______________________________________

2. Draw and label the rocks at your table.

3. Write 5 characteristics that these rocks have in common that could be used to identify the rock type.
   a. What vocabulary words will you need to explain to describe the traits of these rocks?
   b. What tools did you use to observe the rock?
   c. Describe the characteristics of the rocks using correct vocabulary.

4. How are these rocks formed?
   a. What vocabulary words will you need to explain to describe the processes that form these rocks?
   b. Describe the process that made these rocks.
5. Draw a model of how and where these rocks formed. Label the model with important words and use arrows that indicate change.

**Adding to your model:**

6. What type of energy is involved in this process? Is it solar energy (sun energy) producing hot or cold temperatures or weather? Is it heat from inside the earth? Label your model and show where energy is a part of the process.

7. What role does gravity play in this process? Label your model with arrows showing gravity.

8. What role does **pressure** play in this process? Label your model with arrows showing pressure.

9. What questions do you have that you were not able to answer with the resources available?

10. What analogy could you teach someone that would help them remember the origins of this rock type. It's like……

11. Write a slogan you could teach, that would help someone remember the origins of this rock type.
Minerals

1. Draw and Label the different minerals you are observing.

2. Describe the relationship between rocks and minerals.

3. Draw model showing the relationship between rocks and minerals.

4. What is the role of solar energy in making calcite or salt? How do calcite, salt and gypsum form?

5. What is the role of energy from the core in making quartz, muscovite, biotite, feldspar or pyrite?
Preparing to Learn - Sedimentary Rocks

****These are lists of questions you will need to have answers to in order to complete your assignment. Make sure you know the answers to these questions before you leave this station.

1. Draw and label 3-4 examples of sedimentary rocks.

2. What is sediment?

3. What has happened when sediment is deposited?

4. How do sedimentary rocks hold together?

5. What is the role of energy in the process of sedimentary rock formation? What kind of energy is it?

6. Could you find fossils in these rocks? Explain.

7. What is the role of weathering and erosion in sedimentary rock formation?

8. What’s the difference between weathering and erosion?

9. Where do sedimentary rocks usually form?

0. Does heat play a role in formation of these rocks?

11. Does pressure play a role in formation of these rocks?
12. What traits should I look for in these rocks if I want to know if I have a sedimentary rock? Defining characteristics?

13. Draw and label a model of how sedimentary rocks form.

14. Analogy to help you remember the origins of sedimentary rocks. It reminds me of…

15. Slogan to help you remember the origins of sedimentary rocks:
Preparing to Learn- Metamorphic Rocks

*****These are lists of questions you will need to have answers to in order to complete your assignment. Make sure you know the answers to these questions before you leave this station.

1. Draw and label 3-4 examples of metamorphic rocks

2. What does metamorphic mean?

3. What kind of rocks can be changed and become metamorphic rocks?

4. What is the role of energy in the process of metamorphic rock formation? What kind of energy is it?

5. What is the role of weather and erosion in metamorphic rock formation?

6. What is the role of heating and cooling in metamorphic rock formation?

7. What is the role of pressure in metamorphic rock formation?

8. Where do metamorphic rocks usually form?

9. What traits should I look for in these rocks if I want to know if I have a metamorphic rock? Defining Characteristics?

11. What are metamorphic rocks made of?

12. Draw and label a model of how metamorphic rocks form.

13. Analogy to help you remember the origins of metamorphic rocks. It reminds me of…

14. Slogan to help you remember the origins of metamorphic rocks.
Preparing to Learn - Igneous Rocks

****These are lists of questions you will need to have answers to in order to complete your assignment. Make sure you know the answers to these questions before you leave this station.

1. Draw and label 3 igneous rocks

2. Where do igneous rocks come from?

3. What two kinds of igneous rocks are there and what makes them different?

4. What kind of energy is used in the process of making an igneous rock?

5. Is erosion or weathering important part of igneous rock formation?

6. What role does pressure play in igneous rock formation?

7. What role does gravity play in igneous rock formation?

8. What role does heating and cooling play in igneous rock formation?

9. How can I tell if I have an igneous rock? Defining characteristics.

11. What are igneous rocks made of?

12. Draw a model of how different types of igneous rocks form.

13. Analogy to help you remember the origins of igneous rocks. It reminds me of…

14. Slogan to help you remember the origins of igneous rocks.
1. Draw and label 3 different kinds of minerals

2. What is the relationship between rocks and minerals?

3. Are all minerals rocks?

4. Are all rocks minerals?

5. How can you tell if a rock is a pure mineral or a rock made of many minerals?

6. Describe 2 different ways that minerals form including a description of which energy source is involved in the creation of the mineral.: 

   A.

   Examples:

   B.

   Examples:
<table>
<thead>
<tr>
<th>Required Element</th>
<th>Description</th>
<th>Point Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relationship between rocks and minerals described</td>
<td>Rocks are made of minerals</td>
<td></td>
</tr>
<tr>
<td>Role of energy and description (distinction) of energy source in production of minerals</td>
<td>Some minerals form after melted because of heat from core. Some minerals form because of evaporation. crystals</td>
<td></td>
</tr>
<tr>
<td>List of given types of sedimentary rocks Description of sedimentary rock formation and characteristics of sedimentary rocks related to their origins</td>
<td>Including: weathering, erosion, deposition, compression, cementation, crystallization, layers, sandy, rough, earthy luster, parts stuck together, etc. Including rock types: sandstone, shale, limestone, mudstone</td>
<td></td>
</tr>
<tr>
<td>List of given types of metamorphic rocks Description of metamorphic rock formation and characteristics of metamorphic rocks related to their origins</td>
<td>Including, gneiss, schists, slate, marble Heat and pressure, foliated, banded, crystals</td>
<td></td>
</tr>
<tr>
<td>List of given types of igneous rocks Description of igneous rock formation and characteristics of igneous rocks related to their origins</td>
<td>Basalt, granite, pumice, aha Heat, melting, cooling, intrusive, extrusive, magma, lava, ash, core</td>
<td></td>
</tr>
</tbody>
</table>
Igneous Rocks

- Igneous Rocks are formed from MELTED ROCK. The heat that causes the rock to melt comes from earth’s super hot core and mantle.

- Melted Rock is called MAGMA if it’s beneath the surface.

- Melted rock is called LAVA if it comes to the surface (through a crack or volcano).

- If MAGMA cools and hardens beneath the surface it makes INTRUSIVE IGNEOUS ROCKS (REMEMBER: ‘IN’ for INside).

- If LAVA cools it makes EXTRUSIVE IGNEOUS ROCKS. (REMEMBER: Ex for EXit)

- Igneous comes from the Latin Word “IGNIS” which means FIRE!
Intrusive Igneous rocks-

<table>
<thead>
<tr>
<th>Rock Type and origins</th>
<th>Image of Rock</th>
<th>Microscope images</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRANITE-</td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Microscope image 1" /></td>
</tr>
<tr>
<td>All Granite was once</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAGMA. It never made</td>
<td></td>
<td></td>
</tr>
<tr>
<td>it to the surface so</td>
<td></td>
<td></td>
</tr>
<tr>
<td>it cooled VERY slowly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>over millions of years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>until it forms huge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>masses of granite.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt grey is quartz,</td>
<td><img src="image3" alt="Image" /></td>
<td><img src="image4" alt="Microscope image 3" /></td>
</tr>
<tr>
<td>pink is feldspar.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The black is biotite</td>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Microscope image 5" /></td>
</tr>
<tr>
<td>or hornblende.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crystal size is</td>
<td><img src="image7" alt="Image" /></td>
<td><img src="image8" alt="Microscope image 7" /></td>
</tr>
<tr>
<td>evidence of how long</td>
<td></td>
<td></td>
</tr>
<tr>
<td>it took for the rock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to cool. Longer</td>
<td><img src="image9" alt="Image" /></td>
<td><img src="image10" alt="Microscope image 9" /></td>
</tr>
<tr>
<td>cooling times makes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>larger crystals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continents are made</td>
<td><img src="image11" alt="Image" /></td>
<td><img src="image12" alt="Microscope image 11" /></td>
</tr>
<tr>
<td>of this rock. So is</td>
<td></td>
<td></td>
</tr>
<tr>
<td>this…</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| PEGMATITE:            | ![Image](image13) | ![Microscope image 13](image14) |
| Same as granite, but  |               |                   |
| cooled more slowly    |               |                   |
| and made even larger  |               |                   |
| crystals. Most of     |               |                   |
| your granite          |               |                   |
| countertops are made  |               |                   |
| of pegmatite.         |               |                   |
Extrusive Igneous rocks

<table>
<thead>
<tr>
<th>Rock Types and Origins</th>
<th>Images</th>
<th>Microscope images</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PUMICE</strong>: Made from the least dense lava at the top of the volcano. The lava becomes saturated with gases like co2. When this lava explodes out of the volcano and cools it forms ‘ash’ the rock made from this material is pumice.</td>
<td><img src="image1" alt="Image of pumice" /></td>
<td><img src="image2" alt="Microscope image of pumice" /></td>
</tr>
<tr>
<td><strong>OBSIDIAN</strong>: Volcanic glass made when very thick magma cools too quickly to form crystals. It’s the opposite of pegmatite though it is made of similar materials. Mostly silica.</td>
<td><img src="image3" alt="Image of obsidian" /></td>
<td><img src="image4" alt="Microscope image of obsidian" /></td>
</tr>
<tr>
<td><strong>SCORIA</strong>: What we typically identify as “lava rock”. Full of gases before it cools quite quickly. Like pumice, but made from darker, heavier material.</td>
<td><img src="image5" alt="Image of scoria" /></td>
<td><img src="image6" alt="Microscope image of scoria" /></td>
</tr>
<tr>
<td><strong>BASALT</strong>: Made from cooled lava that is less thick than obsidian lava.</td>
<td><img src="image7" alt="Image of basalt" /></td>
<td><img src="image8" alt="Microscope image of basalt" /></td>
</tr>
<tr>
<td>When it cools, it can look a lot like scoria.</td>
<td><img src="image9" alt="Image of basalt cooling" /></td>
<td></td>
</tr>
</tbody>
</table>
Metamorphic rocks-

The word ‘metamorphic’ in Greek means ‘CHANGE IN FORM’. These rocks are CHANGED ROCKS. They change because of EXTREME HEAT AND PRESSURE.

- The heat comes from earth’s interior.
- The pressure is caused by the weight of rock on top of it or squeezing or stretching pressure that can occur as tectonic plates crash into each other or fault lines move.
- Any rock can be changed by heat and pressure into a metamorphic rock.

SEDIMENTARY ROCK ---> Heat and Pressure ---> METAMORPHIC ROCK

IGNEOUS ROCK ---> Heat and Pressure ---> METAMORPHIC ROCK

METAMORPHIC ROCK ---> MORE heat and pressure ---> Rock that is MORE metamorphic.

These rocks MIGHT contain fossils if they were formed from SEDIMENTARY rocks and didn’t get changed so much that the fossil was deformed or destroyed completely.
Vocabulary specific to this rock category.

**FOLIATED** - Foliated means ‘leaves’. It describes the property of some metamorphic rocks to break into sheets.

**BANDED** - Banded means that different minerals in the rock have organized into stripes or bands of minerals.

**NONFOLIATED** - Metamorphic but has neither banding or foliation. Doesn’t break along any particular plane.

---

**FOLIATED AND BANDED METAMORPHIC ROCKS**

<table>
<thead>
<tr>
<th>How much Heat and Pressure</th>
<th>Rock Types and Origins</th>
<th>Images</th>
<th>Microscope Slide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less Heat and Pressure</td>
<td>SLATE: Metamorphic claystone. When mud turns into a rock and that rock gets squeezed until the crystals line up in sheets that cause the rock to FOLIATE.</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="microscope1.png" alt="Microscope Slide" /></td>
</tr>
<tr>
<td>More heat and pressure</td>
<td>PHYLLITE: When Slate experiences even MORE heat and pressure it becomes MORE FOLIATED and very SHINY as the layers of crystals become more clear.</td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="microscope2.png" alt="Microscope Slide" /></td>
</tr>
</tbody>
</table>
MORE heat and pressure

**SCHIST:** When any rock type is exposed to enough heat and pressure, the crystals start becoming very large. Rocks have a lot of texture, very sparkly because of sheets of micah.

MORE heat and pressure

**GNEISS:** When any rock type is exposed to enough heat and pressure the different minerals form BANDED layers of large crystals.

### NONFOLIATED METAMORPHIC ROCKS

<table>
<thead>
<tr>
<th>Amount of heat and pressure</th>
<th>Rock types and origins</th>
<th>images</th>
<th>Microscope slides</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTREME HEAT caused by exposure to magma</td>
<td>HORNFELS: When mudstone, or claystone or siltstone contacts Magma it changes into HORNFELS. Pressure is equal on all side so banding and foliation do NOT occur.</td>
<td><img src="https://example.com/hornfels_image.png" alt="Hornfels Image" /></td>
<td><img src="https://example.com/hornfels_slides.png" alt="Hornfels Microscope Slides" /></td>
</tr>
</tbody>
</table>
### Extremity Pressure

**Caused by Tectonic Plate Movement**

**Quartzite:** When Sandstone gets compressed in such an extreme way and in every direction, Quartz crystals merge with the other crystals to form a very hard and heavy rock with visible crystals.

**Marble:** Created when limestone made from shells and bones of sea creatures is exposed to heat and pressure. Dissolves in acid.

### Metamorphism

- **Shale**
- **Slate**
- **Phyllite**
- **Schist**
- **Gneiss**
Sedimentary rocks- formed by weathered and eroded rock material that was carried by wind or water (usually water) to a place where it was deposited. When this process occurs over a long period of time or during a large event like a mudslide or flash flood, then a lot of material can be laid down very quickly.

Over time, water filters through the particles of sediment. The water has dissolved minerals in it that start to form crystals in between the particles of sediment and cement them together (like calcite and silica).

The pressure of water and the rocks above cause the rocks to fuse into their crystal matrix and become rock. The deeper the rocks go into the earth, the more pressure and heat they will experience. The more heat and pressure they experience the more durable the rocks will be.

Sedimentary rocks are typically dull and appear to be just what they are: a lot of little particles of pebbles, sand, mud, silt or clay that have been stuck together. They can even be made from the little shells and skeletons of sea creatures.

Most of earth’s surface is covered in sedimentary rocks. They are classified by the size of the sediments that make them.
Weathering: caused by changes in temperature caused by changes in solar energy.

https://s-media-cache-ak0.pinimg.com/originals/a8/73/01/a87301afde453b4f4aa2d2234e539c9f.png

Deposition, compaction, cementation of sediment to make rock

Sedimentary Rocks-

<table>
<thead>
<tr>
<th>Size of particles</th>
<th>Type and Origin of Rock</th>
<th>Images</th>
<th>Microscope slide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than .0004 cm</td>
<td>SHALE: Made from clay sized particles falling to the bottom of a lake or pond. Easy to break into weak sheets but not foliated. Dull in appearance, feels gritty. Has layers from the way it was laid down in water</td>
<td><img src="geology.com" alt="Image" /></td>
<td><img src="geology.com" alt="Microscope Images" /></td>
</tr>
<tr>
<td>Size</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.004-.006 cm</td>
<td>SILTSTONE: made from slightly larger particles, feels gritty, looks dull, breaks into weak sheet, not foliated. Good place to look for FOSSILS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.006-.2 cm</td>
<td>SANDSTONE: Made of cemented particles of sand like the kind found on the beach or sand dunes. Very gritty and looks like sand. Good place to look for FOSSILS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pebbles, cobbles or boulders embedded in mud or clay size particles</td>
<td>CONGLOMERATE: made when larger rocks went from a fast moving river to a still lake or ocean. When the water stops moving it doesn’t have enough energy to hold the rocks up anymore. The rocks are buried in mud or silt and overtime get glued together into a very obvious pile of sediment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LIMESTONE: made of the shells and skeletons of dead sea creatures! Dissolves in acid. In Utah, limestone looks like this. Test with acid if you aren’t sure. It should make bubbles. Good place to look for FOSSILS. Sometimes you can still see the shells and skeletons of sea creatures.

Resource:
https://image.slidesharecdn.com/fossilsppt-120502044843-phpapp01/95/fossils-ppt-6-728.jpg?cb=1335934187
Minerals- Minerals are...
- Naturally occurring (not manmade)
- Inorganic (not made by living things...like sugar is not a mineral)
- Solid (water is a mineral when it's frozen but NOT when it's melted)

Minerals have...
- Definite chemical composition (it’s the same substance all the way through, not a mixture)
- Crystal structure. (glass is not a mineral because it doesn’t form crystals)

ALL ROCKS ARE MADE OF DIFFERENT KINDS OF MINERALS. If it's a rock made of one mineral, then it's a mineral, not a rock...ya...it’s a MINERAL ROCK, that’s it.

Minerals are made of elements which are the building blocks of everything...even you.

There are many different minerals, but some are extremely common and are found in most rocks we see.

Minerals form through two process:
1. Evaporation of water that has dissolved minerals in it, like salt, gypsum, calcite
2. Extreme heat and/or pressure causing minerals to combine into large crystals from existing rock or magma.
Crystal structure of Halite

Minerals that form from Evaporation

<table>
<thead>
<tr>
<th>Name of Mineral</th>
<th>Images</th>
<th>Uses in industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcite: Dissolves in water. Mineral forms when water evaporates and leaves the mineral behind. Dissolves in acid. Rhombus crystal structure. Very clear cleavage (looks like foliation)</td>
<td><img src="image1.png" alt="Calcite Image" /></td>
<td>Primary ingredient in marble. Used for buildings, counters, statues, etc.</td>
</tr>
<tr>
<td>Name</td>
<td>Images</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>Quartz</td>
<td><img src="image-url" alt="Quartz Image" /></td>
<td></td>
</tr>
<tr>
<td>Mineral</td>
<td>Image</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Feldspar</td>
<td><img src="image1.jpg" alt="Feldspar" /></td>
<td></td>
</tr>
<tr>
<td>Hornblende</td>
<td><img src="image2.jpg" alt="Hornblende" /></td>
<td></td>
</tr>
<tr>
<td>Biotite, Muscovite</td>
<td><img src="image3.jpg" alt="Biotite, Muscovite" /></td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>Galena</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td><img src="image1.png" alt="Pyrite Image" /></td>
<td><img src="image2.png" alt="Galena Image" /></td>
<td></td>
</tr>
</tbody>
</table>

When Energy Flows, Matter Cycles - Place at every learning station
Heat from inside earth causes rocks to melt and is very important to renewing mineral resources and recycling earth’s crust.

Changes in temperature have a huge impact on weather. Without changes in solar temperature we wouldn’t have the erosion as we see. No erosion, no sediment...no sediment, no sedimentary rocks!

Resource: http://utahscience.oremjr.alpine.k12.ut.us/sciber08/8th/geology/images/cyclwrds.jpg
Use this guide to determine the ways your rock can be changed by energy.

Remember...

**WEATHERING** is caused by SOLAR ENERGY

**MELTING** is caused by HEAT ENERGY from earth’s insides.

Which energy is used to make Sedimentary rocks?
Which energy is used to make Igneous Rocks?
Which energy is used to make Metamorphic Rocks?
Which energy is used to make Minerals?
Which rocks can become sedimentary rocks?
Which rocks can become metamorphic rocks?
Which rocks can become igneous rocks?
<table>
<thead>
<tr>
<th>Minerals</th>
<th>Igneous Rocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics-</td>
<td>Origins-</td>
</tr>
</tbody>
</table>

Minerals are made in 2 ways
1. 

Examples: 

Igneous rocks are made in 2 ways
1. 

Examples: 

2. 

The relationship between rocks and minerals is…

Examples:
Sedimentary Rocks

Weathering and Erosion

When Energy flows, Matter cycles
The energy that causes rock formation comes from 2 sources.
1.

Characteristics

Sediment becomes rock when…

2.

Examples:
Metamorphic rocks come from…

Characteristics

Examples:

Rocks change when….  

Metamorphic Rocks
Guide to

Their Origins and characteristics
‘When Energy Flows, Matter Cycles!!’

By:
### Overarching Performance Expectations (Standard) from State Standards or NGSS:

**7.2.1** Develop a model of the rock cycle to describe the relationship between energy flow and matter cycling that create igneous, sedimentary, and metamorphic rocks. Emphasize the processes of melting, crystallization, weathering, deposition, sedimentation, and deformation, which act together to form minerals and rocks.

Make an argument from evidence for how the geologic time scale shows the age and history of Earth. Emphasize scientific evidence from rock strata, the fossil record, and the principles of relative dating, such as superposition, uniformitarianism and recognizing unconformities.

### Lesson Performance Expectations:

Students will construct a strata column from clay. They will deform and erode it by cutting, folding, faulting and intruding. Students will create an unconformity in their model. They will map 4 maps of their model. Two geologic cross sections (before and after). One geologic map, and one topographic map. Students will reflect on how rocks are used to tell us about the events and forces that shape the earth.

**CCC:** Scale, proportion and quantity and stability and change

**SEP:** Developing and using a model

### Students Will. . . To Construct Meaning

*Glue in a copy of the Geologic Time scale into your journal for reference.*

*Turn and talk: Observe the geologic map of Utah with your neighbor. What does it mean? Ask questions. Be prepared to share.*

### Teacher Will. . . To Support Students

**Pass out** a small version of the geologic time scale students can use to keep track of dates as they are given to them and help them get a grip on time frame for some of the events we will discuss.

*Show students geologic map of Utah. What does this mean? Students may look at the ones in their binders. Generate student names to share. Have students ask questions.*
Listen to introduction to task.

Take binder and turn to episode 3. Remove the loose material. Do not take out the pages that are on the rings.

Your Task is to build a model of rock strata (layers) representing a geologic landform using clay. Once your model is built, then you will produce 3 scaled maps representing the strata (layers) and their relative positions.

Leaders are responsible to read the instructions for each phase OUT LOUD to the team and make sure each phase is completed by each team member.

You have 4 colors of clay. Some of these contain fossils, some do not. The ages and rock types represented by this clay is found in the following chart:

Start with TASK 1- the leader is in charge of
  ● Reading the task
  ● Assigning roles within that task

**Direct Instructions:** To understand what has happened to the rocks of the Wasatch Front, you need to know how Geologists (scientists that study the earth) record the data they collect. Many people use the maps geologists produce: mineral companies, hikers, oil companies, contractors, and engineers are just a few. Geologic, topographic, and geologic cross sections help us to understand the landforms around us and infer the rocks, minerals and other natural resources (minerals, natural gas, oil, water) that lie under our feet!

Pass out Evidence Binders for standard 7.2.1 and 6.

**Episode 4 evidence and materials for binders.**

  ● 3 maps of utah: Satellite, geologic, topographic. Laminated.
  ● Key for marking geologic maps and cross sections.
Making sure task is completed.

https://s-media-cache-ak0.pinimg.com/originals/b1/b4/18/b1b418e1dd0aa546c33a4463a757935a.gif

- 1 inch scale grid paper. Too difficult to put on doc. Print separately.
- Models of different fault types, erosion types, and intrusions.
- Instructions for each episode should be in binder. (see below)

**Materials for each group box:**
- Graph paper 1 for each student.
- Colored pencils
- Rulers
- Clay kit (air dry clay colored with food coloring)
- Dental Floss
- Transparency sheets
- Washable felt tips markers (transparency markers)
- Viewing Stands (if available) I’m making mine.
- Cardboard (I cut up old science fair boards into squares) or paper plates

Give students a closed container of clay with the following clay samples:

<table>
<thead>
<tr>
<th>Color</th>
<th>Rock Type</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>Sandstone</td>
<td>25 million years old</td>
</tr>
<tr>
<td>Blue</td>
<td>Shale (containing fossils)</td>
<td>100 million years old</td>
</tr>
<tr>
<td>White</td>
<td>Limestone (containing fossils)</td>
<td>50 million years old</td>
</tr>
<tr>
<td>Green</td>
<td>Schist (Slate)</td>
<td>200 million years old</td>
</tr>
</tbody>
</table>
Just because mcdonalds sounds amazing right now. :0

Assessment: Students submit maps. Graded on effort and participation.

**Assessment of Student Learning**
*Proficient students will participate with their group to design a geologic cross section using deposition, deformation, erosion and intrusions to create unconformities. Students will produce 4 colored maps with keys showing the different ways geologists communicate about their observations in the field.*
<table>
<thead>
<tr>
<th>Eon</th>
<th>Era</th>
<th>Period</th>
<th>Epoch</th>
<th>Boundary Dates (Ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRECAMBRIAN</td>
<td>Neo-Meso-Paleo-</td>
<td>Ediacaran</td>
<td>~635</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>~4600</td>
</tr>
<tr>
<td>Archean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hadean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>~4000</td>
</tr>
<tr>
<td>PROTEROZOIC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Archean</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hadean</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>~4000</td>
</tr>
<tr>
<td>ARCHEAN</td>
<td></td>
<td></td>
<td></td>
<td>4000</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td>Hadean</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>~4000</td>
</tr>
<tr>
<td>Tertiary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miocene</td>
<td></td>
<td></td>
<td></td>
<td>23.0</td>
</tr>
<tr>
<td>Eocene</td>
<td></td>
<td></td>
<td></td>
<td>55.8</td>
</tr>
<tr>
<td>Paleocene</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cretaceous</td>
<td></td>
<td></td>
<td></td>
<td>146</td>
</tr>
<tr>
<td>Jurassic</td>
<td></td>
<td></td>
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<td>200</td>
</tr>
<tr>
<td>Triassic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permian</td>
<td></td>
<td></td>
<td></td>
<td>251</td>
</tr>
<tr>
<td>Carboniferous</td>
<td></td>
<td></td>
<td></td>
<td>299</td>
</tr>
<tr>
<td>Pennsylvanian</td>
<td></td>
<td></td>
<td></td>
<td>318</td>
</tr>
<tr>
<td>Mississippian</td>
<td></td>
<td></td>
<td></td>
<td>359</td>
</tr>
<tr>
<td>Devonian</td>
<td></td>
<td></td>
<td></td>
<td>416</td>
</tr>
<tr>
<td>Silurian</td>
<td></td>
<td></td>
<td></td>
<td>444</td>
</tr>
<tr>
<td>Ordovician</td>
<td></td>
<td></td>
<td></td>
<td>488</td>
</tr>
<tr>
<td>Cambrian</td>
<td></td>
<td></td>
<td></td>
<td>542</td>
</tr>
<tr>
<td>Paleozoic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cenozoic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quaternary</td>
<td></td>
<td></td>
<td>Holocene</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pleistocene</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pliocene</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Miocene</td>
<td>23.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oligocene</td>
<td>33.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Eocene</td>
<td>55.8</td>
</tr>
</tbody>
</table>

Note #1: Vertical timeline of boundary dates is not drawn with a uniform scale.
Note #2: Boundary dates from the International Commission on Stratigraphy 2010 Geologic Time Scale
Note #3: Carboniferous, Paleogene, and Neogene are more commonly used outside of the U.S.
Note #4: Epochs for the Mesozoic and Paleozoic are too numerous to be shown.
Note #5: The Hadean Eon is not formally recognized.
See our state high points map to learn about Kings Peak at 13,528 feet - the **highest point in Utah**. The lowest point is Beaverdam Wash at 2,000 feet.
Ways that magma can intrude on rock layers. Notice that a laccolith will cause UPLIFT.

Different ways that you can modify your strata: Erosion Folding, Faulting, Tilting


Magma intrusions:
http://intheplaygroundofgiants.com/wp-content/uploads/2013/07/Figure-2.1.11.jpg
Phase 1 – Led by Pink Read out loud.

You have 4 colors of clay, some of these contain fossils, some do not. The ages and rock types represented by this clay is found in the following chart:

1. Take out ONLY the GREEN, WHITE, AND BLUE CLAY. Pretend each one of these layers represents millions of years of sediment deposition in an ocean. Form them into layers and stack them in order. Remember the law of superposition!

2. The layers should form a column and should be centered on the scaled paper provided.

3. Take graph paper and write your name in the bottom right hand corner. Then fold paper in half like a hamburger. You will have 4 maps, one on each half of the graph paper, front and back.

4. Write on each edge of your paper the following labels
   Front Side
   Left hand corner (or along left edge facing towards center of page)- Original Strata- Cross section
   Right Hand corner (or along right edge facing towards center of page)- modified Strata- Cross Section.

   Back Side
   Left hand corner (or along left edge facing towards center of page)- Geologic Map of strata
   Right Hand Corner (or along right edge facing towards center of page)- Topographic map of strata
   Have someone in your group take a picture of the original strata in case someone is gone or assignments get lost.

Key for Clay- Rock types represented and their ages.

<table>
<thead>
<tr>
<th>Color</th>
<th>Rock Type</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>Sandstone</td>
<td>25 million years old</td>
</tr>
<tr>
<td>Blue</td>
<td>Shale (containing fossils)</td>
<td>100 million years old</td>
</tr>
<tr>
<td>White</td>
<td>Limestone (containing fossils)</td>
<td>50 million years old</td>
</tr>
<tr>
<td>Green</td>
<td>Schist (Slate)</td>
<td>200 million years old</td>
</tr>
<tr>
<td>Red</td>
<td>Granite</td>
<td>10 million years old</td>
</tr>
</tbody>
</table>
Phase 2 - Led by Green

1. On Front Right Hand side of graph paper, draw the strata column you created as a GEOLOGIC CROSS SECTION- so you will be drawing it as it appears from the side.

2. Measure how long your model is and draw a line on your graph paper.

3. Draw Scale your model according to this scale: 1 inch is equal to _____ squares on the graph paper.

4. Measure the height of the first layer and measure that far up and draw the top of the layer above the baseline you in the last step.

5. Repeat that for each layer.

6. Color the strata with its appropriate color and pattern according to the Geologic Rock Symbols Provided.

7. Draw a symbol key in a box next to your drawing
Phase 3- Led by Blue- warning read/review ahead!!!

The principle of UNIFORMITARIANISM suggests that the position of the layers allows us to infer the ages of the rocks and the fossils relative to each other.

For example: the bottom layer was laid down first, so it can be assumed that it is the oldest rock while the layer at the top is the youngest. Scientists call this set of rules the LAW of SUPERPOSITION.

Scientists also assume that the fossils in the rock are the same age as the rock itself because the bodies of the organisms would have been laid down at the same time as the sediment that makes the rock.

However, rocks have a lot of forces acting on them all the time. Gravity, Weathering, Erosion, Faulting and Pressure can change rock and the order of the layers. Anytime rock positions do not follow the rule of superposition because they have been folded, faulted, tiled this is called DEFORMATION. If the rock is exposed to the surface, eroded, and new layers deposited on top, it becomes difficult to determine relative time because large amounts of time can be missing from the rock record. Scientists call this an UNCONFORMITY.

Unconformities and deformations can make it very difficult to use the position of rock layers to tell time. Luckily though, they can help us to learn a lot about the forces and events that change earth’s surface.

**Each person in the group will take a turn choosing a way to modify the model.** Blue will decide who goes first and when they’re turn is finished.

1. The first things to do is Deform the Strata. This could be done through folding, compressing, tilting, faulting or uplifting. Notice that magma intrusions like Laccoliths can cause uplift! Add the RED CLAY if you want to add that feature. Look at the ‘Different ways you can modify your model’ document. If you need to cut the model, use the dental floss provided.

2. The lake dried up for several million years The next thing to do is Erode the Strata. Use the ideas on the document to help you decide why the model eroded and make the changes correctly.

3. The ocean rises again, but our strata is on the shore where sand accumulates in large quantities leaving sand behind when the ocean finally recedes (pulls away). Create an Unconformity by placing the sandstone layer on top of the eroded and deformed layers beneath it.

**Phase 4- Led by Yellow**

Take a picture of your modified strata. The clay is going to dry out and that’s ok!

1. On the front, right side of your paper draw your “modified strata - cross section’

2. Draw to scale your new stratigraphic column map (side view) using the same procedure used to make the first model.

3. Color and label according to your key

4. Indicate scale on your map

**Phase 5- Led by pink**

Your next map is a GEOLOGIC MAP. You will draw this on the back left hand side of your graph paper.

We saw a geologic map at the beginning of this episode. This is what you would see if you were flying in an airplane and looking down. Maps like this help geologists to see large patterns in the rock. The geologic map of Utah tells us that the ocean once came clear up to the middle of Utah. Can you infer where that occurred on the geologic map of Utah?

1. Watch the video: (video) [https://www.youtube.com/watch?v=qdz9DN74ukY](https://www.youtube.com/watch?v=qdz9DN74ukY)

2. Pink may choose someone or may do it themselves. Place viewing stand over the top of the column (carefully) so that you are looking down on it through the plastic.

3. Take transparency sheet and place it on plastic. Use the washable felt tip markers (transparency markers) and outline all of the shapes that are visible from the top. JUST the top.

4. Make 2 transparency copies and pass them around for everyone to trace onto their graph paper. If you are having a hard time seeing it under your paper, put it up to a window!

5. Color in each section with the color of the layer that was visible in each location.

6. Write a key.

7. Keep your transparencies in case someone was absent or loses the assignment.
Phase 6- Led by Green-Green may make the transparencies or ask someone to help.

Your next map is a TOPOGRAPHIC MAP. This map is very important to hikers and climbers because it is 2-D view of the 3-D world a hike actually has to climb on. This is shown by changes in ALTITUDE. Altitude is how far you are above sea level.

We will not be making this map to scale.

Watch the video: [https://www.youtube.com/watch?v=L1AWNR-Y0pQ](https://www.youtube.com/watch?v=L1AWNR-Y0pQ)

1. Carefully remove model to a piece of cardboard.
2. Place clean transparency sheet over the grid where the model was sitting.
3. Replace the model onto the transparency sheet that is now sitting on the grid.
4. Trace around the base of your model with a washable marker onto the transparency sheet.
5. Use a ruler to measure from the base of your model, up ½ inch. Use dental floss to cut all the way across the model ½ so that you remove the top of the model.
6. Carefully remove the base and put onto the cardboard. (layers will be put back together when you are done)
7. Place the top of the model on top of the drawing of the base exactly where it would be on the grid if the model was whole.
8. Draw an outline around the bottom of this remaining strata section. Measure up ½ again and cut with the dental floss
9. Repeat until you get to the top of your strata column.
10. When you are done, label each layer with its altitude (in inches above table level)

Notice that the closer contour lines match steep slopes on your model. Keep the transparency in case someone was absent or loses their assignment.
**Phase 7 – Led by blue - Ask questions out loud and take turns responding.**

As a group discuss the following questions:

A. What did you learn from this process?
B. Which map was the hardest to make?
C. Which map would a paleontologist need to use to find fossils?

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**Phase 8 – Led by yellow - In charge of completion and cleanup. Everyone helps.**

1. Gently reassemble your model.
2. Transfer your model to a piece of cardboard and let it dry if you have not already done so.
3. Make sure everyone has completed their maps.
4. Thank your team for helping you.
### Overarching Performance Expectations (Standard) from State Standards or NGSS:

**7.2.1** Develop a model of the rock cycle to describe the relationship between energy flow and matter cycling that create igneous, sedimentary, and metamorphic rocks. Emphasize the processes of melting, crystallization, weathering, deposition, sedimentation, and deformation, which act together to form minerals and rocks.

Make an argument from evidence for how the geologic time scale shows the age and history of Earth. Emphasize scientific evidence from rock strata, the fossil record, and the principles of relative dating, such as superposition, uniformitarianism and recognizing unconformities.

### Lesson Performance Expectations:

Students will construct the Law of Uniformitarianism and the Law of superposition from geologic cross section analysis and construction of a personal fossil record. Students will recognize the problems presented by deformation and unconformities in determining the past using rock strata.

- **CCC:** Cause and effect, stability and change
- **SEP:** Analyzing and interpreting data, using models, engaging in argument from evidence

<table>
<thead>
<tr>
<th>Students Will . . . To Construct Meaning</th>
<th>Teacher Will . . . To Support Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write an OEQ template and prepare to observe phenomenon.</td>
<td><strong>Prepare:</strong> Students should make questions and construct explanations OEQ template.</td>
</tr>
<tr>
<td>Observe folded and tilted rocks and unconformities from mountainside. How did this happen? Which rock is the oldest?</td>
<td><strong>Phenomenon:</strong> Show this unconformity.</td>
</tr>
</tbody>
</table>

![Image 1](https://scontent.cdninstagram.com/t51.2885-15/s480x480/e15/11263614_1676708522552180_674153171_n.jpg?ig_cache_key=OTgyODM5NiJgxMTQzNDU4MTg1.2)

![Image 2](https://scontent.cdninstagram.com/t51.2885-15/s480x480/e15/11263614_1676708522552180_674153171_n.jpg?ig_cache_key=OTgyODM5NiJgxMTQzNDU4MTg1.2)
Receive a copy of Geologic Cross Section assignments (packet).
With lab group look at the image, make observations and discuss with your group.
Put the events modeled in the image in order from oldest event to youngest event.

Or

http://geotripperimages.com/images/Dsc00042%20Best%20Angular%20Unconformity%20at%20Box%20Cyn%20b.jpg

After students have had a chance to think...
Ask students to tell you which of these rocks was made first. Generate names for discussion.

**Pass Out** Image of Geologic Cross section with labels and questions. Let students study the image for 2-3 minutes and discuss it. Go over the image with students and help them to see all of the different events that are occurring here. Have students struggle to place the events in order. (wksh below)

http://gotbooks.miracosta.edu/geology/images/cross_section_quiz.jpg

How did you know which was oldest and which was youngest? You have just made a claim. You have based that claim on some unspoken rules relating to the NATURE of the UNIVERSE. In other words you know that certain events occur in order, because they always occur that way.
As a team, have students infer some rules and have them write 1 rule per sticky note and bring to parking lot.
As a lab group construct a set of rules that justify your claims regarding the order of the events in the model. Write one rule per sticky note and bring to the parking lot. Match with the other sticky notes so that similar rules are grouped together.

Class Discussion and Assignment: Personal Fossil Record

Students should participate in discussion while completing the PERSONAL FOSSIL RECORD assignment. Draw a cave at the top of a hill.

Pretend you live in a cave at the top of a large hill. You were born in this cave. As your family walks around in the cave they cause WEATHERING to occur and the cave gets pretty dirty and full of SEDIMENT. So, your mom decides to wash out the cave with water.

You are a year old when the cave is cleaned. During the last year you have left some FOSSILS of the last year of your life laying around. Things like a pacifier, diapers, baby rattle, teddy bears, etc. As mom washes away the sediment from the cave, she also washes away the fossils of your life and they all wash down the hill. The sediment, water and fossils are deposited in a layer at the bottom of the hill.

Draw this layer.

You continue to grow and change over the next 3 years, you are now 4 years old and it's time to wash the sediment and the fossils of your life out of the dusty cave. These form a new layer at the bottom of the hill, on TOP of the layer made 3 years ago. What fossils would be in your layer if you are 4 years old?

This washing and depositing process occurs every 3 years at 7, 10 and 13 years old. Draw a layer for every year and include the fossils that are found in those layers.
In your journal take notes on the **LAWS of UNIFORMITARIANISM**, and **SUPERPOSITION** and recognize the role of erosion, deformation and unconformities in messing with the geologic time scale.

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**Assessment:** Allow students a few minutes to complete the personal fossil record assignment.

**Class discussion:** What can we assume about those layers? What can we assume about those fossils? Generate student names to respond.

Go through the rules students wrote on sticky notes. See if there are any other rules besides the ones they have just discussion

**Direction Instruction:** In their journals have students write as much of this information as you think is necessary. **Law of Superposition, Unconformities and Uniformitarianism are required by the core. You may want to post these rules on a poster in the room or on a word wall.**

**Law of Uniformitarianism** states that we can assume that natural forces (gravity, electricity, magnetism) function in the past in the same way we observe today.

**Rules that support our assumptions when we use relative dating and geologic cross-sections to determine past events.**

- **Rule #1** Sedimentary rocks form as sediments are deposited on the bottom of a body of water.
- **Rule #2** Weathering and Erosion of rock occurs at the surface (not under water)
- **Rule #3** Layers at the bottom are the oldest. (Law of Superposition)
- **Rule #4** Sedimentary layers are deposited horizontally. Deformation has occurred if layers are NOT horizontal. This is caused by folding, faulting, and tilting.
- **Rule #5** Intrusions are younger than the rocks they change (metamorphosis)
- **Rule #6** Faults are younger than the rocks they cut through.
Rule #7: uplift, weathering, erosion followed by more deposition create unconformities. Unconformities represent missing time, a geologic mystery.

Rule #8: Rocks or pebbles in conglomerates will be older than the layer they are in because they were eroded and deposited from somewhere else first.

Rule #9: Fossils embedded in sedimentary rock layers are the same age as the sedimentary rock. All fossils found in that layer existed together.

These rules derived from an awesome video on this topic: https://www.youtube.com/watch?v=fYSeM63Fv0s

**Assignment:** Have students practice identifying the order of events on worksheet.

**Direct Instruction:**
There are 2 ways scientists age rocks.
1. Absolute dating- they chemically analyze the rocks and determine exactly how old they are.
   Example:
   This rock is 3.2 billion years old
   This rock is 1 million years old.
2. Relative dating. The layers on the bottom are older than the rocks on the top.
   7th grade we will focus on the 2nd way.

**Assessment:** Exit Ticket: What does this quote mean?

Amid all the revolutions of the globe, the economy of nature has long been uniform and her laws are the only things which have resisted the general movement. The rivers and the rocks, the seas and the continents have been changed in all their parts, but the laws which direct those changes, and the rules to which they are subject, have remained invariably the same.

John Playfair - 1802
Complete exit ticket using required vocabulary.

Assessment of Student Learning

Proficient students should be able to infer the order of events given a geologic cross section. Students should be able to use their own personal fossil record to construct the law of superposition and uniformitarianism. Proficient students will be able to use required vocabulary to explain the quote on uniformitarianism on an exit ticket.

Using Strata in a GEOLOGIC CROSS SECTION to tell TIME. STRATA means LAYER
There are many EVENTS represented in this image.

- Sediments were DEPOSITED: P,E,F,D,O,M,J,K,G
- ROCK SHIFTED as cracks in the earth (FAULTS) shifted: H and one unlabeled fault.
- UPLIFT, TILTING, or FOLDING created layers of strata that are no longer horizontal. All the strata beneath layer O
- EROSION wore away previously deposited materials: L and A
- Magma INTRUDED (pushed its way in) through already existing STRATA: C,N,I
- UNCONFORMITIES occur where there was a change in the strata that indicates we are missing time in the GEOLOGIC RECORD: L and A

Put the events in order from FIRST (OLDEST) to LATEST (YOUNGEST).

1st  2nd  3rd  4th  5th  6th  7th
8th  9th 10th 11th 12th 13th 14th
15th  LAST

Personal Fossil Record: Name ______________________
Pretend you live in a cave at the top of a large hill. You were born in this cave. As your family walks around in the cave they cause WEATHERING to occur and the cave gets pretty dirty and full of SEDIMENT. So, your mom decides to wash out the cave with water.

You are a year old when the cave is cleaned. During the last year you have left some FOSSILS of the last year of your life laying around. Things like a pacifier, diapers, baby rattle, teddy bears, etc. As mom washes away the sediment from the cave, she also washes away the fossils of your life and they all wash down the hill.

The sediment, water and fossils are deposited in a layer at the bottom of the hill. Draw this layer.

You continue to grow and change over the next 3 years, you are now 4 years old and it's time to wash the sediment and the fossils of your life out of the dusty cave. These form a new layer at the bottom of the hill, on TOP of the layer made 3 years ago. What fossils would be in your layer if you are 4 years old?

This washing and depositing process occurs every 3 years at 7, 10 and 13 years old. Draw a layer for every year the cave is cleaned and include the fossils that are found in those layers.

Which layers are oldest?

What do the fossils tell us about you and your life over time?

Which layers are youngest?

Practice:
Label the events and Place these events in order:

Image #1

Image #2

Label the events and Place these events in order:
Label the events and Place these events in order:
LAW of UNIFORMITARIANISM states that we can ASSUME that natural forces (gravity, electricity, magnetism) function in the past in the same way we observe today.

The follow are RULES that support our ASSUMPTIONS when we use RELATIVE dating and Geologic Cross-sections to determine past events.

Rule #1 Sedimentary rocks form as sediments are deposited on the bottom of a body of water.

Rule #2 Weathering and Erosion of rock occurs at the SURFACE (not under water)

Rule #3 Layers at the bottom are the oldest. (Law of Superposition)

Rule #4 Sedimentary layers are deposited HORIZONTALLY. DEFORMATION has occurred if layers are NOT horizontal. This is caused by folding, faulting, and tilting.

Rule #5 Intrusions are younger than the rocks they change (metamorphosis)

Rule #6 Faults are younger than the rocks they cut through.

Rule #7: uplift, weathering, erosion followed by more deposition create unconformities. Unconformities represent missing time, a geologic mystery.

Rule #8 Rocks or pebbles in conglomerates will be older than the layer they are in because they were eroded and deposited from somewhere else first.

Rule #9. Fossils embedded in sedimentary rock layers are the same age as the sedimentary rock. All fossils found in that layer existed together.

These rules derived from an awesome video on this topic: https://www.youtube.com/watch?v=fYSYeM63Fv0s
Amid all the revolutions of the globe, the economy of nature has long been uniform and her laws are the only things which have resisted the general movement. The rivers and the rocks, the seas and the continents have been changed in all their parts, but the laws which direct those changes, and the rules to which they are subject, have remained invariably the same.

John Playfair - 1802
Response Key:

This statement is explaining the Law of Uniformitarianism which says that we can assume the laws of nature and natural forces like gravity, electricity and magnetism functioned or acted in the past the way they do in the present. This means we can use the Law of superposition which says that oldest rocks are on the bottom and youngest rocks are at the time. When erosion or deformation changes rocks it can create unconformities which are missing segments of time.