### OVERVIEW:
This unit focuses on the effects produced by plate tectonic processes on geologic features on land and in the oceans. Previous grades students became familiar with physical features of the earth. Although the theory of plate tectonics will be formally introduced in high school science the unit will provide an understanding of characteristic geologic structures at three crustal boundaries as well as localized hot spots as a result of energy transfer within the mantle. The concept of earth cycles—long-term (plate movement) and short-term (volcanic eruptions, hydrothermal vents). Students will understand how geysers and hydrothermal vents can become the input for renewable energy resources (geothermal energy) and the formation of ocean floor mineral deposits. Students will experience how scientific knowledge is generated, specifically fossils as evidence for plate tectonic theory. Using an inquiry based approach, students will use empirical evidence resulting from field and laboratory investigations to support scientific ideas of the processes of organic matter preservation during soil formation, sediment deposition, and burial over time.

### Culminating Activity: Where in the World Are Mineral Resources & Geothermal Energy?
The scientific team will present information to advise the Departments of Energy and Natural Resources of the potential for alternative energy and mineral resources at hydrothermal vent sites and geysers.

### STANDARDS ADDRESSED IN THIS UNIT

#### Focus Standard(s):

**S6E3. Students will recognize the significant role of water in earth processes.**
- c. Describe the composition, location, and subsurface topography of the world’s oceans.

**S6E5. Students will investigate the scientific view of how the earth’s surface is formed.**
- a. Compare and contrast the Earth’s crust, mantle, and core including temperature, density, and composition.
- d. Describe processes that change rocks and the surface of the earth.
- e. Recognize that lithospheric plates constantly move and cause major geological events on the earth’s surface.
- f. Explain the effects of physical processes (plate tectonics, erosion, deposition, volcanic eruption, gravity) on geological features including oceans (composition, currents, and tides).
Supporting Standard(s):
S6E5. Students will investigate the scientific view of how the earth’s surface is formed.
   c. Classify rocks by their process of formation.
   g. Describe how fossils show evidence of the changing surface and climate of the Earth.
   h. Describe soil as consisting of weathered rocks and decomposed organic material.

STANDARDS Addressed IN THIS UNIT (continuation)

Characteristic of Science:
S6CS1. Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
   a. Understand the importance of—and keep—honest, clear, and accurate records in science.
   b. Understand that hypotheses are valuable if they lead to fruitful investigations, even if the hypotheses turn out not to be completely accurate descriptions.
S6CS4. Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.
   a. Use appropriate technology to store and retrieve scientific information in topical, alphabetical, numerical, and keyword files, and create simple files.
S6CS5. Students will use the ideas of system, model, change, and scale in exploring scientific and technological matters.
   a. Observe and explain how parts are related to other parts in systems such as weather systems, solar systems, and ocean systems, including how the output from one part of a system (in the form of material, energy, or information) can become the input to other parts. (For example: El Nino’s effect on weather.
   b. Identify several different models (such as physical replicas, pictures, and analogies) that can be used to represent the same thing, and evaluate their usefulness, taking into account such things as the model’s purpose and complexity.
S6CS6. Students will communicate scientific ideas and activities clearly.
   b. Understand and describe how writing for scientific purposes is different than writing for literary purposes.
   c. Organize scientific information using appropriate tables, charts, and graphs, and identify relationships they reveal.
S6CS7. **Students will question scientific claims and arguments effectively.**
   d. Recognize that there may be more than one way to interpret a given set of findings.

S6CS8. **Students will investigate the characteristics of scientific knowledge and how it is achieved.**

Students will apply the following scientific concepts:
   a. When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, which often requires further study even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as meaningful.
   b. When new experimental results are inconsistent with an existing, well-established theory, scientists may require further experimentation to decide whether the results are flawed or the theory requires modification.
   c. As prevailing theories are challenged by new information, scientific knowledge may change and grow.

**Nature of Science:**

S6CS9. **Students will investigate the features of the scientific process of scientific inquiry.** Students will apply the following to inquiry learning practices:
   a. Scientific investigations are conducted for different reasons. They usually involve collecting evidence, reasoning, devising hypotheses, and formulating explanations.
   c. Accurate record keeping, data sharing, and replication of results are essential for maintaining an investigator's credibility with other scientists and society.
   d. Scientists use technology and mathematics to enhance the process of scientific inquiry.

S6CS10. **Students will enhance reading in all curriculum levels by:**
   a. Reading in All Curriculum areas
   c. Building vocabulary knowledge
   d. Establishing context
ENDURING UNDERSTANDINGS

Students will understand that:

- Lithospheric plates on the scales of continents and oceans constantly move.
- At the boundaries of the plates, the earth’s crust is in motion.
- The Theory of Plate Tectonics connects the evidence for the formation, movement, and destruction of the plates.
- Major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions.
- Some changes in the earth’s surface are abrupt (such as earthquakes and volcanic eruptions) while other changes happen very slowly (such as large-scale plate movement and wearing down of mountains).
- Heat sources near the earth’s surface can produce geologic features not located at major plate boundaries.
- The remains and evidence of plants and animals that once lived on Earth are called fossils.
- Fossils may be used to interpret earth history of plate movement, past environmental conditions, and history of life on earth.

ESSENTIAL QUESTIONS:

- How does the movement of lithospheric plates cause major events on earth’s surface?
- What evidence do scientists have that lithospheric plates move?
- Where are plate tectonic features located other than at plate boundaries?
- How are hydrothermal vents and geysers produced?
- Where are sources of geothermal energy on the sea-floor? On continents?
- What conditions are favorable to the preservation of organic matter?
- What is the significance of fossils?
- What can fossil evidence tell us about the history of earth? Life on earth?
- What are renewable resources produced by tectonic processes?
## Georgia Performance Standards Framework for Where in the World? – 6th Grade

### CONCEPTS:
Plate tectonics, energy transfer, earth’s layers, geologic features, earth cycles, geologic time, Earth systems, earth history, environments, soil composition, renewable energy, sea water, groundwater

### LANGUAGE:

<table>
<thead>
<tr>
<th>Plate Tectonics</th>
<th>Geyser</th>
<th>Preservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mantle</td>
<td>Black Smoker</td>
<td>Deposition</td>
</tr>
<tr>
<td>Crust</td>
<td>Divergent Boundary</td>
<td>Burial</td>
</tr>
<tr>
<td>Plate boundaries</td>
<td>Hot Spot</td>
<td>Renewable Resource</td>
</tr>
<tr>
<td>Subduction</td>
<td>Organic Matter</td>
<td>Geothermal Energy</td>
</tr>
<tr>
<td>Rifting</td>
<td>Decomposition</td>
<td>Organic Matter</td>
</tr>
<tr>
<td>Convergent Boundary</td>
<td>Imprint</td>
<td></td>
</tr>
<tr>
<td>Hydrothermal Vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISCONCEPTIONS</td>
<td>PROPER CONCEPTIONS</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>The world map is unchanging; or a major change – such as California separating from North America – could happen within my lifetime.</td>
<td>Moving plates cause major changes in a world map over tens of millions of years.</td>
<td></td>
</tr>
<tr>
<td>The mantle is molten everywhere; volcanoes happen whenever the crust is thin enough for magma to break through.</td>
<td>The mantle is solid but capable of flow. Only under special conditions (at hot spots and along plate boundaries) does the mantle or crust melt to make magma, which then rise to the surface to make a volcanic eruption.</td>
<td></td>
</tr>
<tr>
<td>Earthquakes are random spasms in the earth which suddenly create major crustal features.</td>
<td>Earthquakes represent sudden breaks in crust continuously stressed by plate movement. Gradually over time, the same movements result in major crustal features.</td>
<td></td>
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<tr>
<td>Very old objects are fossils.</td>
<td>Fossils are very old, but fossils are defined as the remains, imprint, or trace of a once living organism.</td>
<td></td>
</tr>
<tr>
<td>All energy sources come from the Sun.</td>
<td>Energy also originates from the Earth’s internal heat, geothermal energy. Most geothermal energy sources are most common in areas of high volcanic activity. Geothermal energy may be harnessed for use as an alternative energy source.</td>
<td></td>
</tr>
</tbody>
</table>
EVIDENCE OF LEARNING:

Culminating Activity:

Goal: Apply your knowledge of geologic processes and features at hydrothermal vents and geysers.

Role: You are a member of a scientific team composed of a marine geologist, hydrologist, mineralogist, micro-paleontologist, and a biologist.

Audience: U.S. Department of Energy, Department of Natural Resources

Situation: Your team has been charged with the task of designing a schematic plan and rationale for utilizing hydrothermal vents and geysers as an alternative energy source.

Product: The scientific team will present information to advise the Departments of Energy and Natural Resources of the potential for alternative energy and mineral resources from hydrothermal vents and geysers. Geologist: Presentation that shows a model of the structure of earth’s interior with an overview of properties of each layer; a map representation of earth’s tectonic plate boundaries and associated geologic features, overview of evidence for plate tectonic theory that includes fit of continental outlines and fossil correlations between widely separated continents. Marine geologist – image of ocean subsurface topography to predict the location of hydrothermal vents most suitable for mining iron ore. Hydrologist – diagram of plumbing of a geyser to illustrate groundwater storage and heating by near surface hot spots in a table or graphic representation of sea water composition at a hydrothermal vent; video clip of black or white smoker and iron mineral formation. Micro-paleontologist/Biologist provides an argument opposing mining hydrothermal vents supported by his/her overview of current scientific knowledge of the unique biology at hydrothermal vents and the implications for obtaining knowledge of Life in Extreme Environments (solar energy no longer requirement for life on earth—challenges long held scientific views of solar energy as a necessary requirement for life on earth).

Standard:

S6E5. Students will investigate the scientific view of how the earth’s surface is formed.

S6CS6. Students will communicate scientific ideas and activities clearly.
# Energy and Minerals Presentation Rubric

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geologic Features at Plate Boundaries</strong></td>
<td>Thoroughly and accurately describes the geologic features at divergent, convergent, and transform boundaries. Identifies heat convection in the mantle as diving mechanism for plate motions. May demonstrate the beginnings of understanding plate motions are cycling of earth matter.</td>
<td>Accurately describes the locations of earthquakes and volcanoes at plate boundaries but does not include the properties of earth’s layers or the driving mechanism for plate motions.</td>
<td>Includes accurate but incomplete information of geologic features and plate boundaries.</td>
<td>Includes inaccurate or no information of relationship between geologic features and plate boundaries.</td>
</tr>
<tr>
<td><strong>Hydrothermal Vents and Geysers</strong></td>
<td>Thoroughly and accurately describes process of formation and location of vents and geysers. Describes significance of vents and geysers to seawater composition and groundwater.</td>
<td>Accurately describes location and processes of formation. Little or no explanation of impact to sea water or groundwater.</td>
<td>Includes accurate but incomplete information of processes of formation and location of vents and geysers.</td>
<td>Includes inaccurate or no information on location of hydrothermal vents or geysers.</td>
</tr>
<tr>
<td><strong>Fossil Preservation</strong></td>
<td>Thorough and accurate description of conditions for preservation of organic matter. Describes rock types where fossils are present. Explains significance of fossils to the evidence of earth changes and history of life on earth.</td>
<td>Accurate description of the conditions for preservation of organic matter. Limited information of rock types and deposition and burial. Little or no information of significance of fossils to our knowledge of earth history.</td>
<td>Includes accurate but incomplete description of process of preservation of organic matter. Little or no information of fossils as evidence for changes on earth.</td>
<td>Includes inaccurate or no information on organic matter preservation.</td>
</tr>
</tbody>
</table>
### Renewable Energy

| Thorough and accurate description of geothermal energy produced at hydrothermal vents and geysers. Explains internal processes related to hot spots; justifies why the energy is “renewable”, therefore an alternative energy resource. Distinguishes energy at vents to energy produced at geysers. Limited suggestion of cycles and transfer between systems. | Accurate description of renewable energy and geothermal sources. Inaccurate or limited description of heat source. No explanation of why geothermal energy is “renewable”. | Includes accurate description of geothermal energy. Inaccurate or limited explanation of the processes. | Includes inaccurate or no information of renewable energy. |

### Mineral Resources

| Thoroughly and accurately describes the formation of mineral resources at hydrothermal vents. Predicts location of hydrothermal vents using ocean subsurface topography. Limited information of impacts of mining to sea water and ocean floor. | Accurately describes formation and type of mineral resources at hydrothermal vents. Inaccurate or no prediction of favorable locations to mine resources. | Incomplete but accurate information of mineral resources at hydrothermal vents. Limited or no information of process of formation. | Little or no information of mineral resources at hydrothermal vents and their potential for mining. |
UNIT RESOURCES

About Geysers
American Museum of Natural History Expeditions: Black Smokers
Deep Sea Hydrothermal Vents
National Geographic News
Voyage to the Deep: Creature Features
Voyage to the Deep: Plate Tectonics
American Museum of Natural History: Expeditions—Black Smokers
Extreme 2000: Voyage to the Deep
National Geographic Magazine: Deep Sea Vents—Science at the Extreme
National Geographic News
National Geographic: Dawn in the Deep
National Geographic: Fantastic Journeys—Yellowstone
http://www.geology.siu.edu/outreach/volcano.htm
http://www.uwgb.edu/dutchs/EarthSC202Slides/EVOLSLID.HTM