Phoenixville Area School District Understanding by Design (UbD) Science Template

Grade Level &/or HS Subject: Environmental Science — Unit Name: Earth's Geosphere

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td rowspan="4">Overarching NGSS & PA Standards:

<u>HS-ESS1-5</u>
Evaluate evidence of the past and current movements of continental crust and the theory of plate tectonics to explain the ages of crustal rocks

<u>HS-ESS1-6</u>
Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…

Ask questions and/or define problems
Develop and/or use models
Plan and/or carry out investigations
Analyze and interpret data using computational thinking
Obtain, evaluate, and communicate information (supported by evidence)
Construct explanations and design solutions</td></tr>
<tr><td colspan="2">Meaning-Making</td></tr>
<tr><td>Students will understand that…

Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of sea floor spreading) and the ages of North American continental crust decreasing with distance away from central ancient core of the continental plate (a result of past plate interactions).

Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact of cratering record of planetary surfaces.

Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).

Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on</td><td>ESSENTIAL QUESTIONS
Students will keep considering...

In what ways has Earth changed throughout its 4.6-billion-year history?

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

How and why is the surface of Earth constantly changing?

Why do the continents move, and what causes earthquakes and volcanoes?</td></tr>
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<td rowspan="3">formation and Early History.

<u>HS-ESS2-1</u>
Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

<u>HS-ESS2-3</u>
Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

Which branch(es) of science apply:

LS PS
E&SS</td>
<td>convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.</td>
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<td colspan="2">Knowledge and Skills Acquisition</td>
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<td>UNDERSTANDINGS
Students will know…

ESS1.C: The History of Planet Earth
-Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.
-Although geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed very little over billions of years. Studying these objects can provide information about Earth's formation and early history.

PS3.D: Nuclear Processes
-Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.

ESS2.B: Plate Tectonics and Large-Scale System Interactions
-Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history.
ESS2.A: Earth Materials and Systems
-Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.
-Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle, and crust. Motions of the mantle and its plats occur primarily through thermal convection, which involves the cycling of matter due to outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.

ESS2.B: Plate Tectonics and Large-Scale System Interactions
-The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.
-Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate</td>
<td>Students will be skilled at…

• Identifying explanations
• Identifying evidence
• Evaluating and critiquing evidence
• Reasoning patterns from evidence
• Articulating the explanation of phenomena
• Describing evidence
• Using reason to construct an explanation
• Developing a model
• Describing relationships
• Making connections</td>
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	movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and mineral within Earth's crust. PS4.A: Wave Properties Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. ESS2.A: Earth Materials and Systems -Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. -Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.	
	KEY VOCABULARY catastrophism, uniformitarianism, numerical dates, relative dating, index fossils, geologic time scale, supercontinent cycle, rock cycle, continental drift, oceanic ridge, ocean trenches, rift valley, subduction zones, continental volcanic arc, volcanic island arc, convection, slap pull, ridge push	

Stage 2 – Evidence		
Evaluative Criteria	***Assessment Evidence***	
Project Rubrics Labs Quizzes Tests	PERFORMANCE TASK(S): HS-ESS1-5 • Students identify the given explanation, which includes the following idea: that crustal materials of different ages are arranged on Earth's surface in a pattern that can be attributed to plate tectonic activity and formation of new rocks from magma rising where plates are moving apart. • Students identify the given evidence to be evaluated. • Students identify and describe* additional relevant evidence (in the form of data, information, models, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given evidence, including: o Measurement of the ratio of parent to daughter atoms produced during radioactive decay as a means for determining the ages of rocks	Differentiation Considerations:

- Ages and locations of continental rocks
    - Ages and locations of rocks found on opposite sides of mid-ocean ridges
    - The type and location of plate boundaries relative to the type, age, and location of crustal rocks.
- Students use their additional evidence to assess and evaluate the validity of the given evidence.
- Students evaluate the reliability, strengths, and weaknesses of the given evidence along with its ability to support logical and reasonable arguments about the motion of crustal plates.
- Students describe* how the following patterns observed from the evidence support the explanation about the ages of crustal rocks:
    - The pattern of the continental crust being older than the oceanic crust
    - The pattern that the oldest continental rocks are located at the center of continents, with the ages decreasing from their centers to their margin
    - The pattern that the ages of oceanic crust are greatest nearest the continents and decrease in age with proximity to the mid-ocean ridges.
- Students synthesize the relevant evidence to describe the relationship between the motion of continental plates and the patterns in the ages of crustal rocks, including that:
    - At boundaries where plates are moving apart, such as mid-ocean ridges, material from the interior of the Earth must be emerging and forming new rocks with the youngest ages.
    - The regions furthest from the plate boundaries (continental centers) will have the oldest rocks because new crust is added to the edge of continents at places where plates are coming together, such as subduction zones.
    - The oldest crustal rocks are found on the continents because oceanic crust is constantly being destroyed at places where plates are coming together, such as subduction zones.

HS-ESS1-6

- Students construct an account of Earth's formation and early history that includes that:
    - Earth formed along with the rest of the solar system 4.6 billion years ago.
    - The early Earth was bombarded by impacts just as other objects in the solar system were bombarded.
    - Erosion and plate tectonics on Earth have destroyed much of the evidence of this bombardment, explaining the relative scarcity of impact craters on Earth.

- Students include and describe* the following evidence in their explanatory account:
    - The age and composition of Earth’s oldest rocks, lunar rocks, and meteorites as determined by radiometric dating
    - The composition of solar system objects
    - Observations of the size and distribution of impact craters on the surface of Earth and on the surfaces of solar system objects (e.g., the moon, Mercury, and Mars); and
    - The activity of plate tectonic processes, such as volcanism, and surface processes, such as erosion, operating on Earth.
- Students use reasoning to connect the evidence to construct the explanation of Earth’s formation and early history, including that:
    - Radiometric ages of lunar rocks, meteorites and the oldest Earth rocks point to an origin of the solar system 4.6 billion years ago, with the creation of a solid Earth crust about 4.4 billion years ago.
    - Other planetary surfaces and their patterns of impact cratering can be used to infer that Earth had many impact craters early in its history.
    - The relative lack of impact craters and the age of most rocks on Earth compared to other bodies in the solar system can be attributed to processes such as volcanism, plate tectonics, and erosion that have reshaped Earth’s surface, and that therefore most of Earth’s rocks are much younger than Earth itself.

HS-ESS2-1

- Students use evidence to develop a model in which they identify and describe* the following components:
    - Descriptions and locations of specific continental features and specific ocean-floor features
    - A geographic scale, showing the relative sizes/extents of continental and/or ocean-floor features
    - Internal processes (such as volcanism and tectonic uplift) and surface processes (such as weathering and erosion); and
    - A temporal scale showing the relative times over which processes act to produce continental and/or ocean-floor features.
- In the model, students describe* the relationships between components, including:
    - Specific internal processes, mainly volcanism, mountain building or tectonic uplift, are identified as causal agents in building up Earth’s surface over time.

  - Specific surface processes, mainly weathering and erosion, are identified as causal agents in wearing down Earth's surface over time.
  - Interactions and feedbacks between processes are identified (e.g., mountain-building changes weather patterns that then change the rate of erosion of mountains).
  - iv. The rate at which the features change is related to the time scale on which the processes operate. Features that form or change slowly due to processes that act on long time scales (e.g., continental positions due to plate drift) and features that form or change rapidly due to processes that act on short time scales (e.g., volcanic eruptions) are identified.
- Students use the model to illustrate the relationship between 1) the formation of continental and ocean floor features and 2) Earth's internal and surface processes operating on different temporal or spatial scales.

HS-ESS2-3

- Students develop a model (i.e., graphical, verbal, or mathematical) in which they identify, and describe* the components based on both seismic and magnetic evidence (e.g., the pattern of the geothermal gradient or heat flow measurements) from Earth's interior, including:
  - Earth's interior in cross-section and radial layers (crust, mantle, liquid outer core, solid inner core) determined by density
  - The plate activity in the outer part of the geosphere
  - Radioactive decay and residual thermal energy from the formation of the Earth as a source of energy
  - The loss of heat at the surface of the earth as an output of energy; and
  - The process of convection that causes hot matter to rise (move away from the center) and cool matter to fall (move toward the center).
- Students describe* the relationships between components in the model, including:
  - Energy released by radioactive decay in the Earth's crust and mantle and residual thermal energy from the formation of the Earth provide energy that drives the flow of matter in the mantle.
  - Thermal energy is released at the surface of the Earth as new crust is formed and cooled.
  - The flow of matter by convection in the solid mantle and the sinking of cold, dense crust back into the mantle exert forces on crustal plates that then move, producing tectonic activity.
  - The flow of matter by convection in the liquid outer core generates the Earth's magnetic field.

	o Matter is cycled between the crust and the mantle at plate boundaries. Where plates are pushed together, cold crustal material sinks back into the mantle, and where plates are pulled apart, mantle material can be integrated into the crust, forming new rock. • Students use the model to describe* the cycling of matter by thermal convection in Earth's interior, including: o The flow of matter in the mantle that causes crustal plates to move o The flow of matter in the liquid outer core that generates the Earth's magnetic field, including evidence of polar reversals (e.g., seafloor exploration of changes in the direction of Earth's magnetic field); o The radial layers determined by density in the interior of Earth; and o The addition of a significant amount of thermal energy released by radioactive decay in Earth's crust and mantle.	
Question Accuracy Project Rubric	OTHER EVIDENCE: Optional • Project o Geologic Timeline Project • Labs o Earth's Interior Lab o Relative Age Dating Lab o Radiometric Dating Lab o Plate Tectonic Lab o Sea Floor Spreading Lab • Unit Test o Historical Geology o Physical Geology	Differentiation Considerations: