**LAB Module 12: Internal Structure of the Earth**

**Note:** Please refer to the GETTING STARTEDmodule to learn how to maneuver through and answer the lab questions using Google Earth (GE.gif).

**KEY TERMS**

You should know and understand the following terms:

|  |  |  |
| --- | --- | --- |
| Asthenosphere | Extrusive igneous | Metamorphic rocks |
| Chemically precipitated sedimentary rocks | Geologic time scale | Organic sedimentary |
| Cinder cone volcanoes | Igneous rocks | Rock cycle |
| Clastic sedimentary | Intrusive igneous | Sedimentary rocks |
| Composite Volcanoes | Lithification | Seismic waves |
| Core | Lithosphere | Shield Volcanoes |
| Crust | Mantle |  |

**LAB MODULE LEARNING OBJECTIVES**

After successfully completing this module, you should be able to do the following tasks:

* Describe the spatial patterns of the location of volcanoes
* Identify and describe the different rock types
* Define the process of *lithification*
* Identify and describe the various internal layers of the Earth
* Identify and describe the different types of volcanoes
* Describe the *rock cycle*
* Interpret the topographic profile of a landscape

**INTRODUCTION**

This module examines the internal structure of the Earth. Topics include rock types, the rock cycle, geologic time and volcanoes. While these topics may appear to be disparate, you will learn how they are inherently related. The modules start with four opening topics, or vignettes, which are found in the accompanying Google Earth file. These vignettes introduce basic concepts of the internal structure of the Earth. Some of the vignettes have animations, videos, or short articles that will provide another perspective or visual explanation for the topic at hand. After reading the vignette and associated links, answer the following questions. Please note that some links might take a while to download based on your Internet speed.

GE.gif Expandthe **INTRODUCTION** folder and then select **Topic 1: The Earth’s Internal Composition**.

GE.gif Read **Topic 1**: **The Earth’s Internal Composition**

**Question 1**:Calculate the depth of the Kola borehole as a percentage of the Earth’s radius? (Hint: borehole depth in km / Earth’s radius in km x 100%)

Description: Description: GE.gif Read **Topic 2: Rock Types**

**Question 2:** What are other terms used in place of extrusive and intrusive igneous rocks?

Description: Description: GE.gif Read **Topic 3: Geologic Time**

**Question 3:** Where is North America located relative to the equator during the Devonian period? (Hint: click on the Devonian period in the time scale image of under the Phanerozoic Eon heading)

Description: Description: GE.gif Read **Topic 4: Volcanoes**

**Question 4:** Of the three types of volcanoes, which is the largest?

For the rest of this module, you will identify and explain the geographic distribution, patterns, and processes associated with Earth’s internal structure. In doing so, you will recognize and appreciate the impact the interior of the Earth has on the surface.

Description: Description: GE.gifCollapse and uncheck the **INTRODUCTION** folder.

**Global Perspective**

Volcanoes are not randomly distributed across the globe; their locations are found in distinct patterns. Despite the potential dangers associated with living near volcanoes, many cities are located near volcanoes. In this exercise you will describe the spatial patterns of the location of volcanoes, and identify volcanoes located near major world cities.

Description: GE.gif Expand the **GLOBAL PERSPECTIVE** folder. Double‑click and select the **Mediterranean and W Asia** folder.

**Question 5:** Where will you find the majority of volcanoes in Europe?

Description: Description: GE.gif Zoom in to the Island of Sicily and then zoom into Mt. Etna.

Description: Description: GE.gif Click the Mt. Etna symbol.

**Question 6:** What type of volcano is Mt. Etna?

Description: Description: GE.gif Close the Smithsonian Institute window. Double‑click and select the **Africa and Red Sea** folder.

**Question 7:** Describe the general spatial pattern of volcanoes found on the continent of Africa (you might have to zoom in and zoom out to see the location of volcanoes).

Description: Description: Description: GE.gif Zoom in to Nairobi, Kenya.

**Question 8:** What type of volcano is the volcano found just to the west of Nairobi??

Description: Description: Description: GE.gif Double‑click and select the **Philippines and SE Asia** folder.

**Question 9:** Describe the general spatial pattern of volcanoes found in this region (you might have to zoom in and zoom out to see the location of volcanoes).

Description: Description: Description: GE.gif Zoom in to Jakarta, Indonesia.

**Question 10:** What is the name of the volcano found to the south of Jakarta?

**Question 11:** What type of volcano is this?

Description: Description: Description: GE.gif Double‑click and select the **Hawaii and Pacific Ocean** folder.

**Question 12:** What type of volcano are these?

Description: Description: Description: GE.gif Collapse and uncheck the **GLOBAL PERSPECTIVES** folder.

**ROCK TYPES**

As noted in the introduction, there are three major rock types: *igneous*, *sedimentary*, and *metamorphic*.

**Igneous rocks**

Igneous rocks are further divided into *intrusive* and *extrusive*. Intrusive igneous rocks are formed (cooled) in the Earth and unless there has been significant erosion of surface material, they are not easily detectable on the surface. Figure 1 shows the formation of intrusive formations (in red). Vertical intrusive rocks formed by magma cooling in fissures in the bedrock are called *dikes*. *Sills* are intrusive rocks formed in horizontal fissures. A *batholith* is the largest pluton that can be several hundred miles long.

Description: Description: Description: Description: Description: GE.gif Expand the **ROCK TYPES** and **Igneous Rocks** folders.

Click and expand the **Shiprock, NM** folder.



This feature is the remnant of a throat of a volcano, with radiating dikes. This volcano erupted over 27 million years ago.

Description: Description: Description: Description: Description: GE.gif Double click on the **Ship Rock Tour** link to view an animation of the feature.

Description: Description: Description: Description: GE.gif Click **Photo 1** for a different view.

Description: Description: Description: Description: Description: GE.gif Uncheck the **Shiprock, NM** folder.

Description: Description: Description: Description: GE.gif Double‑click the **Stone Mountain, GA** folder.

This is a large pluton near Atlanta, GA that was formed during the Devonian period in the Paleozoic Era.

Description: Description: Description: Description: Description: GE.gif Double click on the **Stone Mountain Tour** link to view an animation of the feature.

Description: Description: Description: Description: GE.gif Click **Photo 2** for a different view.

Description: Description: Description: Description: Description: GE.gif Uncheck the **Stone Mountain, GA** folder.

Description: Description: Description: Description: Description: GE.gif Click the **Krafla, Iceland** folder.

The dark areas are a lava flow from the Krafla volcano in Northern Iceland. The lava cooled formed basalt and rhyolite, which are extrusive igneous rocks.

Description: Description: Description: Description: Description: GE.gif Double click on the **Krafla Tour** link to view an animation of the feature.

Description: Description: Description: Description: GE.gif Click **Photo 3** for a different view.

Description: Description: Description: Description: Description: GE.gif Uncheck the **Krafla, Iceland** folder.

**Question 13:** What is the difference between the two types of igneous rocks?

**Sedimentary rocks**

Sedimentary rocks are formed by the deposition of sediments (usually in a marine environment) that under pressure slowly turn into rock. *Lithification* (cementing of sediment into rock) is an important process in the formation of this type of rock. There are three board types of sedimentary rock: *organic*, *clastic*, and *chemical precipitation*.

*Organic sedimentary rocks* are formed from the deposition of carbon based material. Subjected to pressure, this material, over time, can form coal.

Description: Description: Description: Description: GE.gif Expand the **Sedimentary Rocks** folder and then double‑click the **West Virginia** folder.

This is a coal mine in West Virginia, where mountain top removal is a common way of mining this sedimentary rock. Coal is an economically important sedimentary rock worldwide as nearly 40 percent of the electricity generated comes from coal power plants (Worldcoal, 2006).

Description: Description: Description: Description: GE.gif Click **Photo 4** for a different view (**Note:** The image might take a few minutes to display). Notice the layering in the black band of coal.

Description: Description: Description: Description: Description: GE.gif Uncheck the **West Virginia** folder.

|  |  |
| --- | --- |
| *Clastic sedimentary rocks* are sedimentary rocks composed of *clasts* or pieces of weathered and eroded rocks. They are classified by grain size and range from fine grained claystone (Figure 1) to coarse grained conglomerate (Figure 2).  Description: Description: Description: Description: Description: Description: GE.gif Double‑click the **Grand Canyon, AZ** folder.  The Grand Canyon is a showcase of clastic sedimentary rock. Erosion by the Colorado River has exposed layers of different types of largely sedimentary rock dating back nearly 2 billion years to the Proterozoic period in the late Precambrian Era.  Description: Description: Description: Description: Description: Description: GE.gif Click the **GC Rock Layers** folder to see an illustration of a cross section of the Grand Canyon.  **Question 14:** Why are there no rock layers younger than the Kaibab formation?  Description: Description: Description: Description: Description: GE.gif Click **Photo 5** to see various rock layers in the Grand Canyon.  Description: Description: Description: Description: Description: Description: GE.gif Uncheck the **Grand Canyon, AZ** folder. | [File:GLMsed.jpg](http://upload.wikimedia.org/wikipedia/commons/5/5)  Figure 1. Claystone ([Wikipedia](http://en.wikipedia.org/wiki/File:GLMsed.jpg)). |
| http://upload.wikimedia.org/wikipedia/commons/e/e1/Conglom%C3%A9rat.jpg  Figure 2. Conglomerate ([Wikimedia](http://upload.wikimedia.org/wikipedia/commons/e/e1/Conglom%C3%A9rat.jpg)). |

*Chemically precipitated sedimentary rocks* are formed through the precipitation of calcium carbonate which is then deposited on the ocean floor. Over time, enough pressure can built such that lithification occurs creating this type of sedimentary rock. Limestone is a common example of a chemical precipitated sedimentary rock.

Description: Description: Description: Description: Description: Description: Description: GE.gif Double‑click the **Rocky Mountains** folder.

The Rocky Mountains in Canada are comprised primarily of limestone and shale, suggesting at one time this area was once covered by an ocean. Scientists estimate this limestone was created during the Paleozoic Era (350 million years ago), and that uplift to create the mountains began during the last half of the Mesozoic Era (180 million years ago) (Gadd, 2008).

Description: Description: Description: Description: Description: GE.gif Click **Photo 6** to see various rock layers in the Rocky Mountains (**Note:** This image might take a few minutes to display).

Description: Description: Description: Description: Description: Description: GE.gif Uncheck the **Rocky Mountains** folder.

Description: Description: Description: Description: Description: Description: GE.gif Double click on the photo link and answer the following questions.

**Question 15:** Based on the sedimentary rock images, which type of sedimentary rock (organic, clastic or chemical precipitated) is present in this photo?

**Question 16:** Describe why the process of lithification is important in the formation of sedimentary rocks.

**Metamorphic Rocks**

|  |
| --- |
| Figure 3. Gneiss, foliated ([Wikimedia](http://upload.wikimedia.org/wikipedia/commons/6/60/Gneiss.jpg)). |
| Figure 4. Marble, non-foliated ([Wikimedia](http://upload.wikimedia.org/wikipedia/commons/8/8a/MississippianMarbleUT.JPG)). |

*Metamorphic rocks* are formed form igneous or sedimentary rock that have been subjected to heat and pressure. The heat and pressure results in the rearrangement or recrystallization of minerals to form different minerals. Metamorphic rocks formed from igneous rocks are sometimes called meta-igneous. Likewise meta-sedimentary rocks are metamorphic rocks formed from sedimentary rocks. Common metamorphic rocks include marble (from limestone) and gneiss (usually from granite).

Metamorphic rocks are divided into two broad categories, *foliated* and *non-foliated*. Foliated metamorphic rocks (Figure 3) exhibit banding as the minerals present align to form bands. Conversely, non-foliated rocks (Figure 4) lack this banding.

Metamorphoses can occur in two ways, namely *contact metamorphism* and *regional metamorphism*. The former happens over a small area and entails magma coming in direct contact with rock. The heat from the magma alters the crystal structure of the rock. The latter occurs over a much larger area and entails high heat and great pressure altering rock.

Description: Description: Description: Description: Description: Description: Description: GE.gif Expand the **Metamorphic Rocks** folder.

Description: Description: Description: Description: Description: Description: Description: GE.gif Double‑click and select the **Jeff Davis Peak** folder.

This is Jeff Davis peak which is comprised primarily of quartzite, a metamorphic rock formed from sandstone.

Description: Description: Description: Description: Description: GE.gif Double click on the **Jeff Davis Peak Tour** link to view an animation of the feature.

Description: Description: Description: Description: Description: GE.gif Click **Photo 7** to see various rock layers of quartzite (**Note:** This image might take a few minutes to display).

Description: Description: Description: Description: Description: Description: GE.gif Uncheck the **Jeff Davis Peak** folder.

Description: Description: Description: Description: Description: Description: Description: Description: GE.gif Double‑click and select the **Carrara Italy** folder.

The white areas are marble quarries near Carrara, Italy, not far from Pisa. The area is well known for Carrara marble which is found in the surrounding mountains. This marble is used for statues and buildings such as the Pantheon in Rome.

Description: Description: Description: Description: Description: Description: GE.gif Click **Photo 8** to see a Carrara marble quarry.

**Question 17:** Why is contact metamorphism restricted to a small area?

Description: Description: Description: Description: Description: Description: Description: GE.gif Collapse and Uncheck the **ROCK TYPES** folder.

**EARTH’S INTERIOR**

By interpreting seismic waves from earthquakes, scientists have divided the Earth’s interior into three major sections: *core*, *mantle*, and *crust*.

Description: Description: Description: Description: Description: GE.gif Click **Earth’s Interior** and use the illustration to identify the layers in the table below.

**Question 22**: Explain how the structure of rock changes as you go from the lithosphere through the asthenosphere and upper mantle.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Layer** | **Composition** | **Structure** | **Depth** |
| **Q18** |  | Iron | Liquid | 2250 km |
| **Q19** |  | Iron & Nickel | Solid | 1220 km |
| **Q20** |  | Iron, Magnesium & Silicon | Solid | 2230 km |
| **Q21** |  | Nickel | Viscous | 250-425 km |

Description: Description: Description: Description: Description: GE.gif Collapse and Uncheck **EARTH’S INTERIOR**.

**VOLCANOES**

Volcanoes are divided into three types: *cinder cone*, *composite*, (or stratovolcano) and *shield*. These classifications are based largely on whether the eruption is fluid or explosive in nature.

Description: GE.gif Expand the **VOLCANOES** folder. Double click on the **Capulin Mountain Tour** link to view an animation of the feature.

This is Capulin Mountain in New Mexico. It is a cinder cone volcano. Cinder cone volcanoes are the smallest of the three types of volcanoes and are characterized by steep sides.

Double click and check the **Folsom, NM** box



Double‑click and select **Folsom, NM**.



**Question 23:** What is the contour interval of this map? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 24:** What is the highest elevation on this volcano? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 25:** What is the elevation in the center of the crater? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Description: GE.gif Uncheck **Folsom, NM** and then select **Profile** **#1**. Right‑click the title **Profile** **#1** and then select **Show Elevation Profile**.

**Question 26:** What is the diameter of the volcano? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 27:** What is the average slope of the profile line? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Description: Description: GE.gifClose the **Elevation profile** window and uncheck **Profile #1**.

Description: Description: Description: GE.gif Double click on the **Mount Baker Tour** link to view an animation of the feature.

Double‑click and select **Mt. Baker, WA** link.



This is Mt. Baker in Washington State. It is a composite volcano, which grows over the course of several eruptions. They can remain inactive for hundreds of years, but when they do erupt, they tend to be quite explosive.

**Question 28:** What is the contour interval, in feet, of this map? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 29:** What is the highest elevation, in feet, on this volcano? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Description: Description: GE.gif Uncheck **Mt. Baker, WA** and then select **Profile #2**. Right‑click the title **Profile #2** and then select **Show Elevation Profile**.

**Question 30:** What is the approximate diameter of the volcano? \_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 31:** What is the average slope of the profile line? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Close the **Elevation profile** window and uncheck **Profile #2**.



Description: Description: Description: GE.gif Double click on the **Kilauea Tour** link to view an animation of the feature.

Description: Description: Description: GE.gifDouble‑click and select **Kilauea Crater** link.

Description: Description: Description: GE.gif Double‑click and select **Kilauea Crater**.

This is the Kilauea volcano on the island of Hawai’i. It is a shield volcano, whose eruptions are characterized as being fluid and non-explosive – notice the parking lot near the crater.

**Question 32:** What is the highest elevation on this volcano in feet? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 33:** What is the elevation of the benchmark in Halema’uma’u Crater? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Description: Description: GE.gif Uncheck **Kilauea Crater** and then select **Profile #3**. Right‑click the title **Profile #3** and then select **Show Elevation Profile**.

**Question 34:** What is the approximate diameter of the volcano in feet? \_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 35:** What is the average slope of the profile line? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Description: Description: Description: GE.gif Collapse and Uncheck the **VOLCANOES** folder.

**ROCK CYCLE**

Thus far, we know how each type of rock is formed. This section addresses the rock cycle that examines the processes and conditions in which one rock type is changed into another.

Description: Description: Description: Description: Description: GE.gif Click **ROCK CYCLE** and answer the following questions:

**Question 36:** Which process changes igneous rock to sedimentary rock?

**Question 37:** Which process changes sedimentary rock to metamorphic rock?

**Question 38:** Which process changes igneous rock to metamorphic rock?

**Question 39:** Which process changes metamorphic rock to sedimentary rock?

**Question 40:** Which process changes igneous rock to magma?

**Question 41:** Which process changes magma to igneous rock?

Description: Description: Description: Description: GE.gifUncheck the **ROCK CYCLE** folder.

**REFERENCES**

Gadd, Ben (2008). Geology of the Rocky Mountains and Columbias. <http://www.bengadd.com/Downloads/Geology%20of%20the%20Rockies%20and%20Columbias%202008.pdf>. [Date Accessed January 11, 2012]

World Coal Association. 2006. <http://www.worldcoal.org/coal/uses-of-coal/coal-electricity/>. [Date Accessed January 11, 2012]