

# Earth Science Questions and Answers for Teachers Teaching Grade 6

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## **What is Pangea?**

The *Science Framework* describes the support for the existence of Pangea: When the continental plates of today are returned to their super-continent positions (through computer modeling), the fossil and sedimentary evidence of ancient life distributions and climate becomes coherent, providing strong support for the existence of Pangaea. As plates move in relation to one another, landforms and topographic features, such as volcanoes, mountains, valleys, ocean trenches, and mid-ocean ridges, are generated along plate boundaries. Those regions are also frequently associated with geothermal and seismic activity. There is strong evidence that the divergence and convergence of the lithospheric plates did not begin and end with Pangaea but have been going on continually for most of the history of Earth.

## **What other information should teachers know about this topic?**

The place to start with thinking about the continents and the plates that move on the surface of the Earth is the jig-saw puzzle fit of the continents. Looking at a map of the world shows that the continents look as though they could fit back together, especially South America and Africa. Looking at a map, it is obvious that South America has a bulge on its Atlantic coast that looks like it could snuggle up the indentation on Africa's Atlantic coast. If South America and Africa could be reunited and snuggle together again, the fit would be very close. The key to understanding why the two continents might have been connected in the past is at the bottom of the ocean. Right in the middle of the Atlantic Ocean, exactly half way between South America and Africa, is the mid-ocean ridge. It contains the key to connecting South America and Africa. The mid-ocean ridge is a crack in the surface of the Earth, out of which lava erupts. The spreading of the mid-ocean ridge allows the continents to move apart, or diverge away from each other. Here, new ocean floor is created, so it is called a constructive plate boundary. Lava constructs the new ocean floor. Each half of the mid-ocean ridge is actually a separate plate. So the Atlantic Ocean floor is made of two plates, one to the west of the mid-ocean ridge (toward South America) and another to the east of the mid-ocean ridge (toward Africa).

Elsewhere in the world there is a balancing force to the constructive activity at the mid-ocean ridge. This other activity is destructive. When two continents collide there is a rumpling and crumpling that occurs. This pushes up mountains and cause earthquakes, like in the Himalaya Mountains of Nepal and Tibet. Elsewhere in the world, a continent can crash into ocean floor. In this case, the ocean floor goes under the continent. This creates a dipping down, or subduction zone, as the ocean floor slips under the continent. The subduction zone also causes earthquakes and mountain building and

volcanoes, like along the west coast of South America. In other areas of the world, ocean floor can crash into other ocean floor, and this also causes another version of a subduction zone. Of the two sections of ocean floor, one slides under the other. Forming from the subduction is often a string of volcanic oceanic islands called an island arc. These volcanic islands are rather different than the Hawaiian Islands, which are also volcanic, but Hawaii forms in a hot spot situation in the middle of a plate, rather than in a subduction setting.

**What information for teachers is useful concerning the following science standard? 1.b.** *Students know* Earth is composed of several layers: a cold, brittle lithosphere; a hot, convecting mantle; and a dense, metallic core. *The Science Framework* indicates that students should know the properties of the crust, mantle, core, lithosphere, and plastic mantle region just beneath the lithosphere called the asthenosphere.

**Crust** – is the outermost layer of the earth, like the eggshell on a hardboiled egg. The crust is both the continents and the ocean floor (forget the water in the ocean for now). The continental crust is thicker than the oceanic crust. The continents are made of mostly granite and diorite type rocks, and those rocks are less dense than the oceanic crust, which is made of basalt from the mid-ocean ridges. The lighter continental material “floats” on the heavier oceanic floor material. The crust is also called the lithosphere, because that is where rocks are found, and “litho” refers to rocks. So it is the rock sphere.

**Mantle** – is the layer below the crust, like the white of a hardboiled egg. The mantle is important because it is where so much of the “action” of plate tectonics takes place, especially in the upper part of the mantle called the asthenosphere (see below).

**Core** – is the middle of the Earth, with an inner solid part and an outer liquid part. This is like the yolk of a hardboiled egg. The core provides the heat to drive the convection currents that are important in plate tectonics (convection currents come up right under a mid-ocean ridge). The core also gives the Earth its magnetic field, and when the inner core flip-flops, the magnetic field of the Earth reverses (north and south are reversed).

**Lithosphere** – is another name for the combined ocean floor and continents (see crust, above).

**Asthenosphere** – is the molten, or plastic, region below the crust or lithosphere. It is called “plastic” not because it is made of plastic, but because it can be easily shaped and changed, like plastic material can be molded into different shapes. Important geological events occur in the asthenosphere. One of those events is the melting of a plate that slides down a subduction zone. Another event in the

asthenosphere is the welling up of new, fresh magma that comes out of volcanoes as lava. So the asthenosphere is a place of destruction (of subducted plate material) and of creation (of new lava for volcanoes).

### **What are the three major types of volcanic landforms?**

Volcanoes can take several shapes, based on how they are made. A volcanic **cone** or cinder cone is made when hot, broken material is thrown out of a volcano and up into the air. That hot and broken material is called pyro-clastic, with pyro meaning fire and clastic meaning broken. The material that makes a cinder cone is often cinders and bits of lava called scoria. Both cinders and scoria are pyroclastic materials. They might have the same mineral composition of lava, but lava is not thrown up into the air, lava flows down by gravity. A splatter cone is similar to a cinder cone, except instead of cinders the volcanic vent blows out globs of lava that stick together when they hit the ground and form a cone.

A **shield** volcano is named because from a distance (like out at sea in a boat) it has the curved shape of a warrior's shield in profile, or the lid of a trash can if you prefer. The volcanoes in the Hawaiian Islands are typical shield volcanoes. The shield shape is the result of many years of lava flows of basalt lava that flows easily and is not violently explosive.

A **composite** volcano is essentially the opposite of a shield volcano. While the shield is made of gently-flowing basalt lava, the composite is made of thicker lava flow alternating with layers of cinders. The layers of thick lava and cinders alternate, so a series of layers builds up, like plywood. Those many layers of lava and cinders are called "strata" and thus another name for a composite volcano is a stratovolcano.

### **What are the different types of lava flows?**

The two main types of lava flows are both made of basalt lava, and another type is made of rhyolite lava. Both basalt and rhyolite are igneous rocks that are extrusive, because they were pushed out, or extruded, out of a volcano. Basalt is usually dark colored, often black. Rhyolite is often lighter colored, with colors of tan or white, and even a pinkish color (due to the high level of a pink mineral, potassium feldspar, in rhyolite). The two types of dark basalt lava flows that can easily be seen in places like the Hawaiian Islands, and also in Lake County, are mostly different due to their gas content and not the minerals that make the rock. The type with high gas content flows quickly and is called by its Hawaiian name by geologists: pahoehoe (pronounced pah-hoi-hoi). It can flow very fast, often faster than a man can run, and commonly develops a cooled skin on its surface, like the skin that forms on hot milk or on hot chocolate. This skin on the cooling lava can be pushed up into wrinkles that look like coiled rope on a sailboat, or a coiled garden hose, or even like coiled intestines. The same thing happens when an area rug is pushed on a hardwood floor and it piles up into wrinkles. Thus, pahoehoe is known as "ropy" lava, due to the ropy look of its surface. The other

type of basalt lava flow has lost its gas content, just as a soda or beer can lose its gas content. The less-gassy lava flows more slowly and does not form the ropy surface, but rather ends up with a rough or jagged surface. This gives it its common name of “clinker” lava, because the rough and jagged pieces break off and those look like large cinders, or clinkers. Geologists also use the Hawaiian name for this lava, which is a’ā (pronounced ah-ah, like uh-oh). Basalt lava can start out as pahoehoe and lose its gas and become an a’ā flow, but not the other way around. Both of the types of basalt lava flows come out of volcanoes that erupt lava to make oceanic islands, such as Hawaii or the Galapagos. Rhyolite lava, on the other hand, is from “recycled” lava that comes out of volcanoes that form in a subduction zone setting.

**What information for teachers is useful concerning the following science standard? 1. e.** *Students know* major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.

Most earthquakes and volcanic eruptions occur along plate boundaries where the tectonic plates are moving toward one another. The movement is never smooth; it may produce fractures or faults. The sudden shift of one plate on another plate along faults causes earthquakes, such as along the San Andreas Fault or the Hayward Fault. Volcanic eruptions may occur when one plate slides under another, like a conveyor belt, and sinks deep enough into the asthenosphere to melt part of the descending material. This process of one plate sliding under another is called *subduction*. Great mountain-building episodes occur when two continental plates collide, such as the Andes Mountains along the west coast of South America. The collision (although slow) is enormously powerful because of the mass of the continents or the ocean floor. Over long periods of time, this process may crumple and push up the margins of the colliding continents, again, as with the Andes Mountains or with the Himalaya Mountains.

Students may use a large map of the world or of the Pacific Ocean (including the entire Pacific Ocean Rim) to plot the locations of major earthquakes and volcanic eruptions during the past ten to 100 years. The locations of those volcanoes and earthquakes may be found on the Internet or in various library resources. Different symbols may be used to represent different depths or magnitudes of events. In studying such a map, students should note that tectonic events form a “ring” that outlines the Pacific Plate and that there is also a Hawaiian “hot spot” in the middle of the Pacific. Geographic features associated with the plate boundaries include mountain belts (the Andes), deep ocean trenches (the Mariana Trench), and volcanic island arcs (such as the Mariana Islands, which includes the US Territory of Guam).

**What information for teachers is useful concerning the following science standard? 1. f.** *Students know* how to explain major features of California geology (including mountains, faults, volcanoes) in terms of plate tectonics.

The geology of California is a textbook example of global geology. We are lucky, or cursed, to have so much active geology right in our backyard. When visiting Bodega Head or the Point Reyes Peninsula (or looking at a map of these areas), students can learn that most of California resides on the North American lithospheric (continental) plate. But the rocks at Bodega Head and at Pt. Reyes are actually on the Pacific Plate. This is one of the few places in the world where it is possible to drive from one plate to another. The same situation with two plates making up California is true of land to the east of the San Andreas Fault (the North American Plate) and west of the San Andreas Fault (Pacific Plate). California is made up of two tectonic plates, but most of the other states in the US are just on one plate. The border between those two plates is what makes California prone to earthquakes. The Pacific Plate and the North American Plate are two of the several major plates, and many smaller plates that together form the lithosphere of Earth. Geologic interactions between these two plates over time have also created the complex pattern of mountain belts and intervening large valleys that make up the current California landscape. Large parts of the central and southern parts of California were once covered by a shallow sea. Interactions with the Pacific Plate during the past few million years have compressed, fractured, and uplifted the area. This tectonic deformation has buckled the lithosphere upward to create the high-standing coastal and transverse mountain ranges and downward to form the lower-lying Central Valley, Los Angeles Basin, and Ventura Basin.

### **How did scientists determine that the magnetic north has shifted from south pole to north pole and back?**

The shift of the north and south poles is a crucial piece of information that proves the ocean floor has spread apart and thus that the continents have moved. When lava erupts it is very hot, so hot, in fact, that any minerals made with iron are too hot to accept a magnetic charge. But when the lava cools, the iron-rich minerals can take on a magnetic direction, which is a north or south direction, which is called polarity (pointing to the north or south pole). Once this polarity occurs in cooled lava, it is stuck there forever. The iron-rich minerals act like little compass needles, pointing either north or south. What governs whether they point north or south is whether the Earth's magnetic field is presently pointing the way it does today, or if it has flip-flopped so that today's compass would point to the south. Under those "southerly" conditions, the iron-rich minerals lock into a south direction. When "northerly" conditions prevail, the minerals would take on a north direction. Lava that erupts and cools at the mid-ocean ridges takes on the north or south direction, the lava does not care and takes on the conditions of the day. That mid-ocean lava is split in half as the mid-ocean ridge splits in half, with half the lava going with one half of the ridge, and the other half of the lava going in the opposite direction. So lava ends up on either side of the mid-ocean ridge as magnetic "stripes" of north-pointing or south-pointing lava (it is actually the tiny minerals in the lava that are pointing north or south). The lava at the mid-ocean ridge erupts year after year, and the "stripes" document that the Earth's magnetic field has

flipped from today's "normal" direction to the "reversed" direction. This flip-flop of the polarity is locked in the lava, like tape in a tape recorder.

### **What is the difference between magnetic north and true north?**

When we buy a compass, we expect it to tell us which way is north. This is true of a pocket compass with a needle, or a digital compass as commonly found in automobiles. The needle on a pocket compass is painted either white or red and points toward north. But the "north" the compass points toward is not the actual "candy cane" north pole. That north pole is the axis that the Earth spins on, like a classroom globe with two points that allow the globe to spin. The compass needle is actually pointing to the north magnetic pole, which is slightly different than the geographic north pole (the candy cane). The difference between the geographic north pole and the magnetic north pole changes from year to year. The geographic north pole does not really change (it is the rotating axis of the Earth), but the magnetic north pole does "wander" around from year to year. When using a pocket compass to find our way in the woods, or a compass in a car to find our way on city streets or back roads, the difference between the two north poles does not really matter. Both are "up toward the north" and they differ by a few degrees, but not by enough to keep us from finding our way home again.

### **How were the Earth's poles magnetized in the first place?**

The poles are not magnetized, as a magnet is magnetized. Rather, the Earth's poles (north and south) are the extension of the magnetic field in the core of the Earth. If the core is like a big magnet, then the north and south magnetic poles are the extensions of the invisible lines of force that come out of a magnet, like the iron filings that will line up on a magnet when the filings are sprinkled over a magnet.