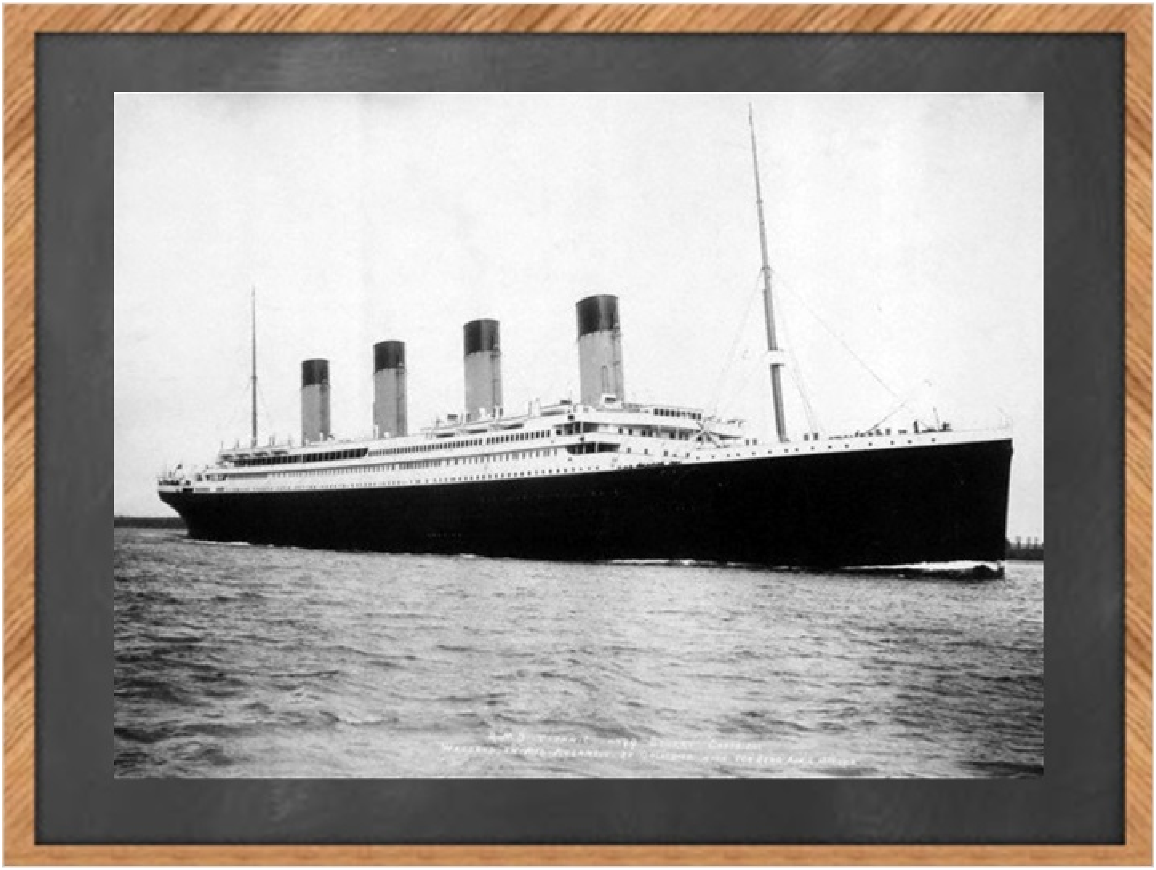
Module 3: Geology
Topic 3 Content: Seafloor Spreading Notes



On April 14, 1912, the *RMS Titanic* struck an iceberg on its maiden voyage from England to the United States. By the next morning, the *Titanic* was at its final resting place somewhere on the bottom of the North Atlantic Ocean. At the time, nobody knew exactly where the *Titanic* sank or if human eyes would ever again see this great ship.

Image credit: F.G.O. Stuart: Public Domain

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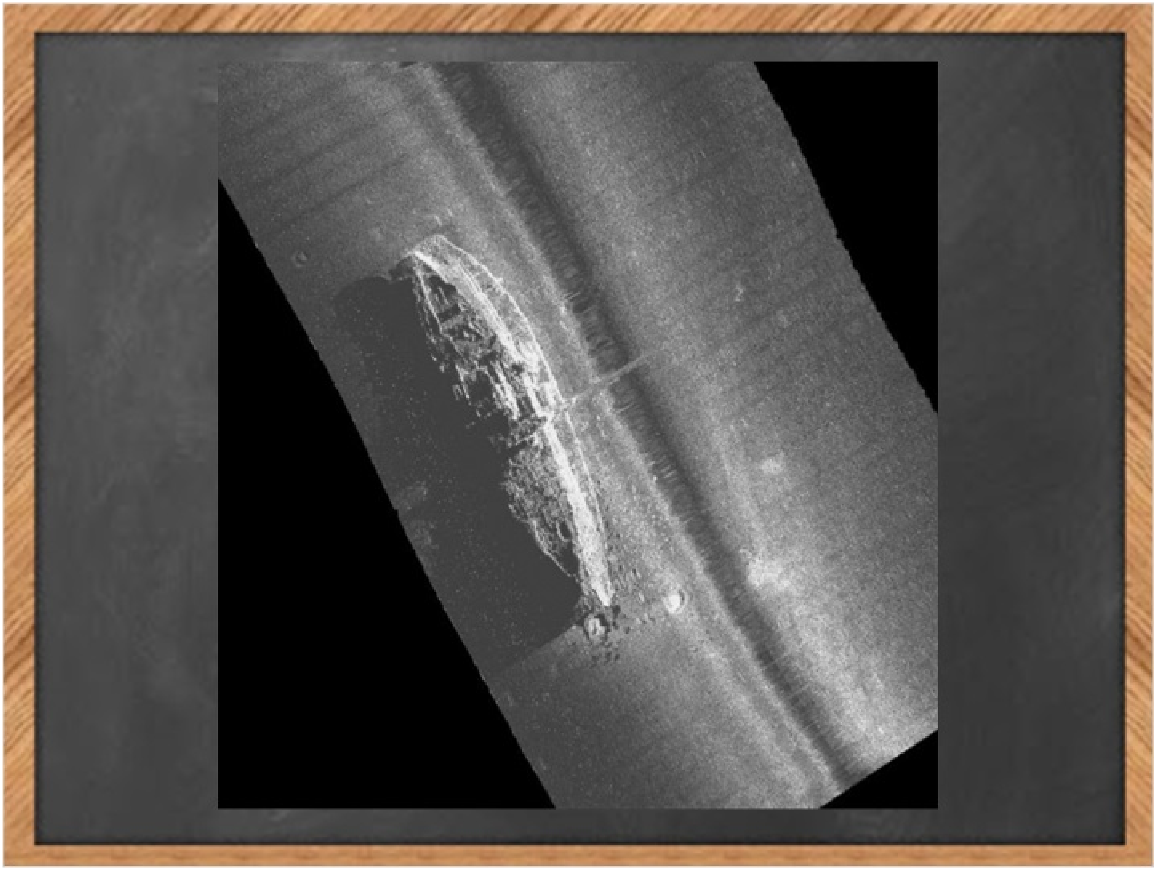

To find the exact location of the *Titanic* wreckage required a new technology called Sonar**.** Developed in the 1930s, Sonar is an acronym that stands for Sound Navigation And Ranging. Shown here is an actual sonar image of the *Titanic* from the National Oceanic and Atmospheric Administration, or NOAA.

Image credit: NOAA Ocean Explorer: Public Domain

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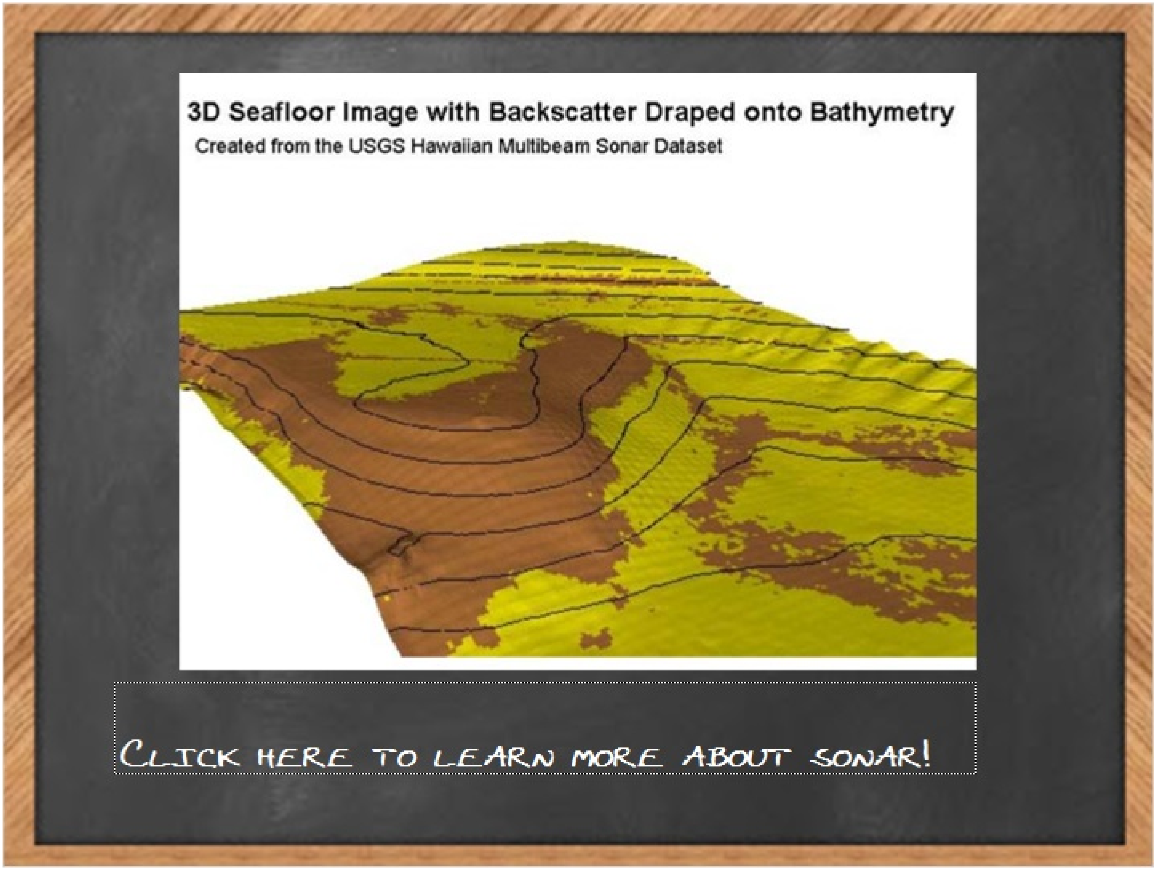

How does sonar work? Sonar technology uses reflected sound waves to help form a picture of what the seafloor looks like. For the first time, scientists could produce highly detailed maps of the seafloor. To learn more about sonar, click where indicated. You'll visit an interactive demonstration of the process.

Image credit: NOAA: Public Domain

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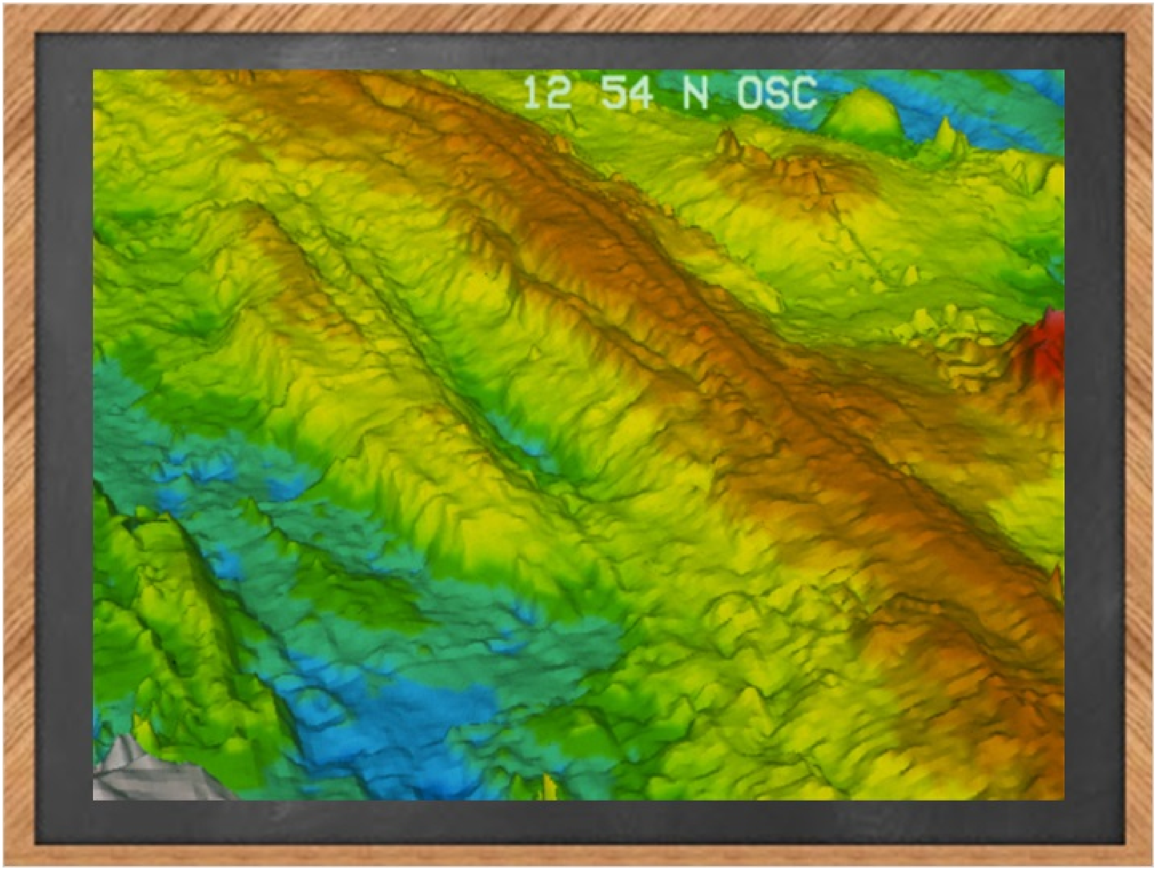
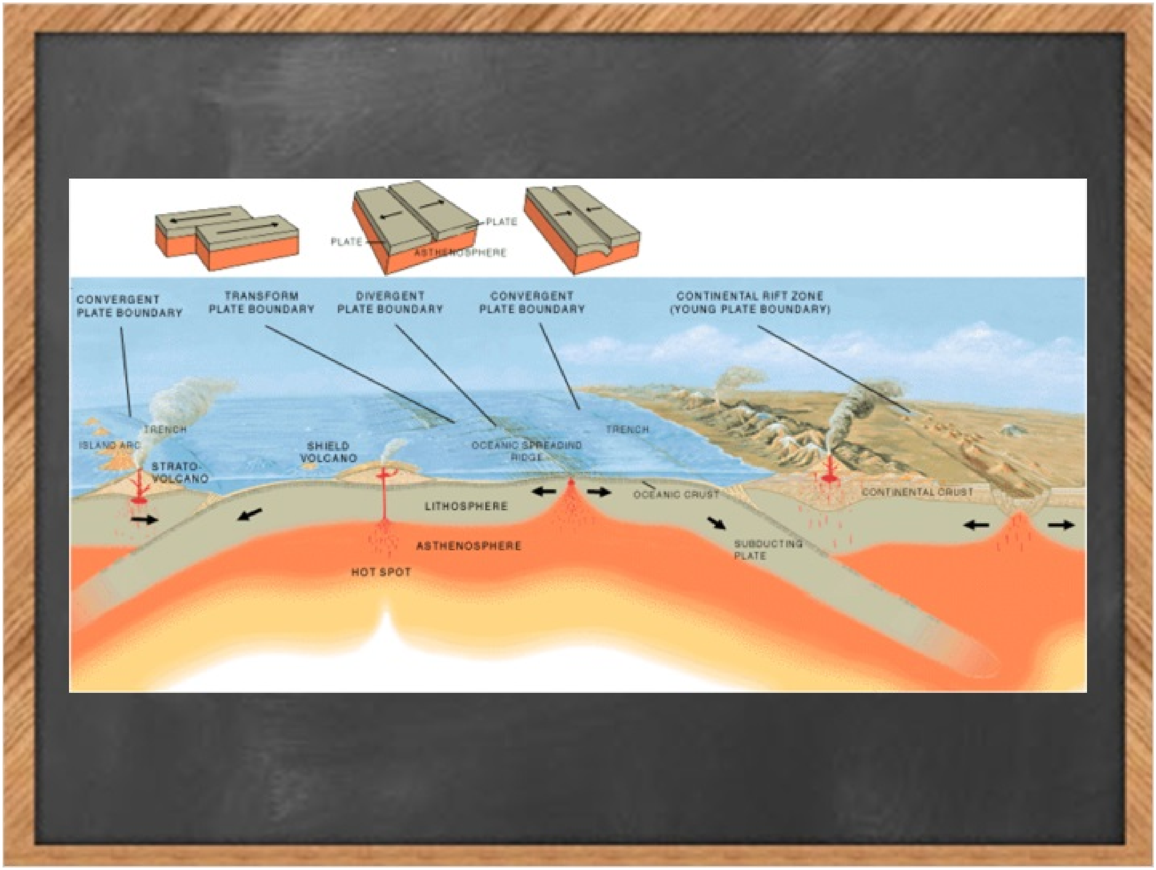


One of the most important discoveries made with sonar was a 40,000-mile long system of underwater mountain ranges extending through the Atlantic, Indian, and Pacific oceans. Scientists call this system the mid-ocean ridge. Notice the detail in this NOAA sonar image of the East Pacific Rise. Why was this discovery so important? Let’s find out.

Image credit: NOAA, WHOI: Public Domain



In 1960, two scientists, Harry Hess and Robert Dietz, proposed a theory about how a process called seafloor spreading created and destroyed seafloor features. In their theory, Hess and Dietz suggested that magma from the mantle's asthenosphere rises through the mid-ocean ridge, solidifies, and spreads on either side of the ridge. This process creates new seafloor at a rate of one-half to four inches per year, or about the same length that your fingernails grow annually.

As shown in this illustration, oceanic crust eventually sinks and melts back into the mantle at a point far from the mid-ocean ridge. Hess and Dietz believed that as distance increased from the ridge, so did the age of the oceanic crust.

Image credit: USGS: Public Domain

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Although Hess and Dietz had their theory, how do scientists know that the rocks are really older away from the mid-ocean ridge and younger closer to the ridge? In 1968, scientists aboard the D/V *Glomar Challenger* drilled into the seafloor and extracted samples of rock at various distances from both sides of the Mid-Atlantic Ridge between South America and Africa. Then, the scientists examined the samples using a process called radiometric dating to provide an absolute age of the samples.

Radiometric dating is a process that uses a device called a mass spectrometer to measure the amount of original and decayed radioactive isotope in a sample of rock. By comparing the two amounts, scientist can determine the length of decay of the sample, or its absolute age.

Image credit: USGS: Public Domain

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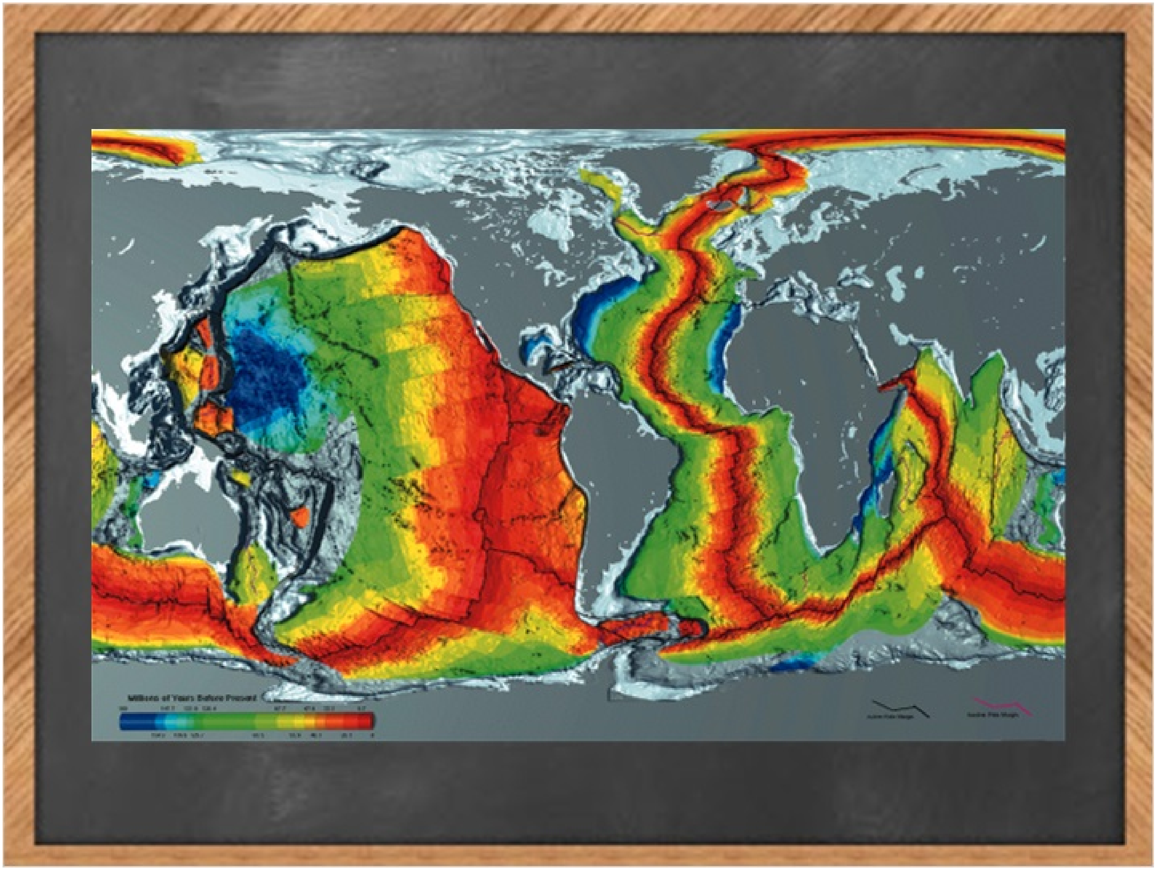

Based on their findings, the scientists aboard the *Glomar Challenger* concluded that pairs of rock samples extracted from equal distances but on opposite sides of the Mid-Atlantic Ridge were of the same age. The scientists' conclusions supported the theory of seafloor spreading because they obtained younger rock samples near the Mid-Atlantic Ridge and progressively older samples as the extraction distance increased away from the ridge.

Based on radiometric dating, scientists now estimate the age of the seafloor to be around 200 million years old, while the continents are around 3.9 billion years old. Without seafloor spreading constantly creating new material and recycling old material, scientists would expect the age of the seafloor and the continents to be the same. We can see the age of oceanic crust in this radiometric image from NOAA. The red areas depict new crust forming along the mid-ocean ridge, while the thin blue edges depict the old crust about to recycle into the mantle. Notice that the blue edges trace along the shape of the continents.

Image credit: NOAA: Public Domain

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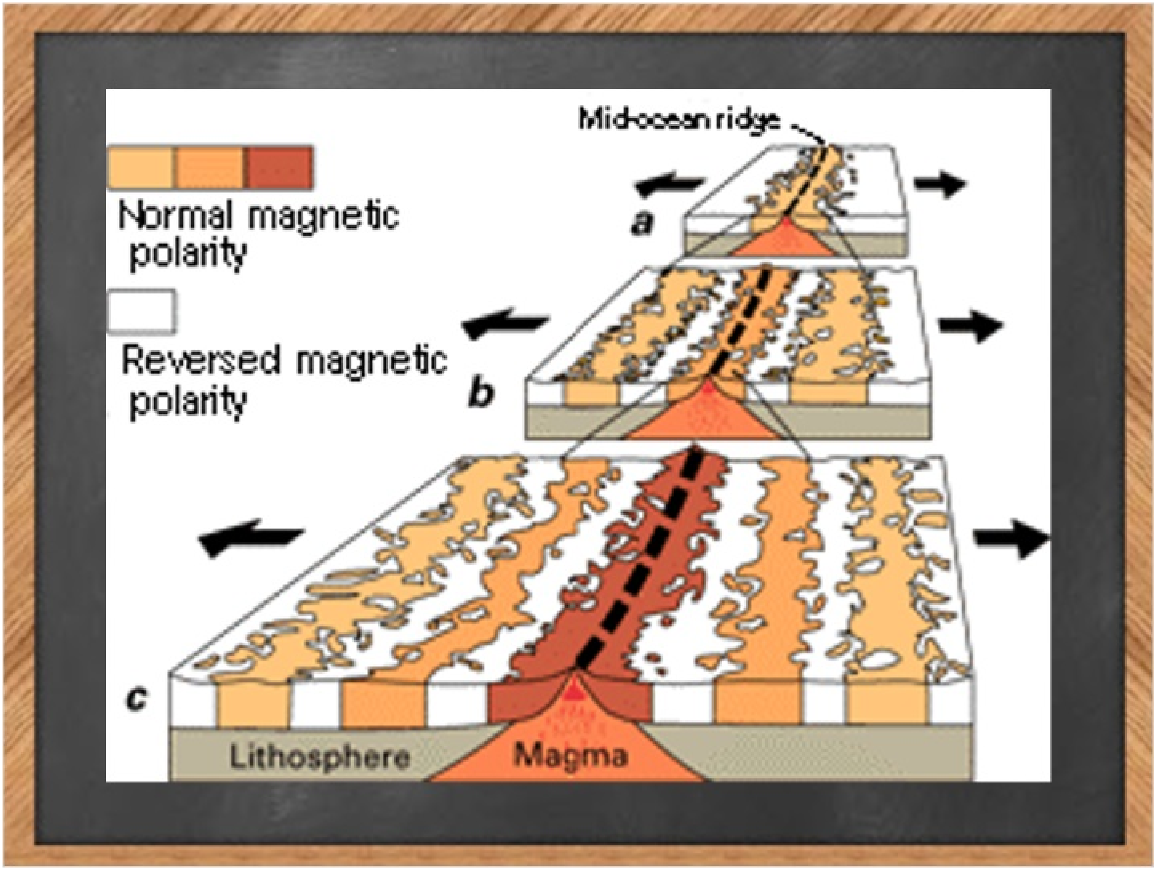


A device called a magnetometer collected the final piece of evidence to support the seafloor spreading theory. A magnetometer measures the magnetic field of objects, such as the rocky material of the seafloor. Rocky material often contains metallic minerals including iron, nickel, cobalt, copper, zinc, and manganese. When rock solidifies, its metallic minerals “freeze” in alignment with the Earth’s geomagnetic field, like a snapshot in time.

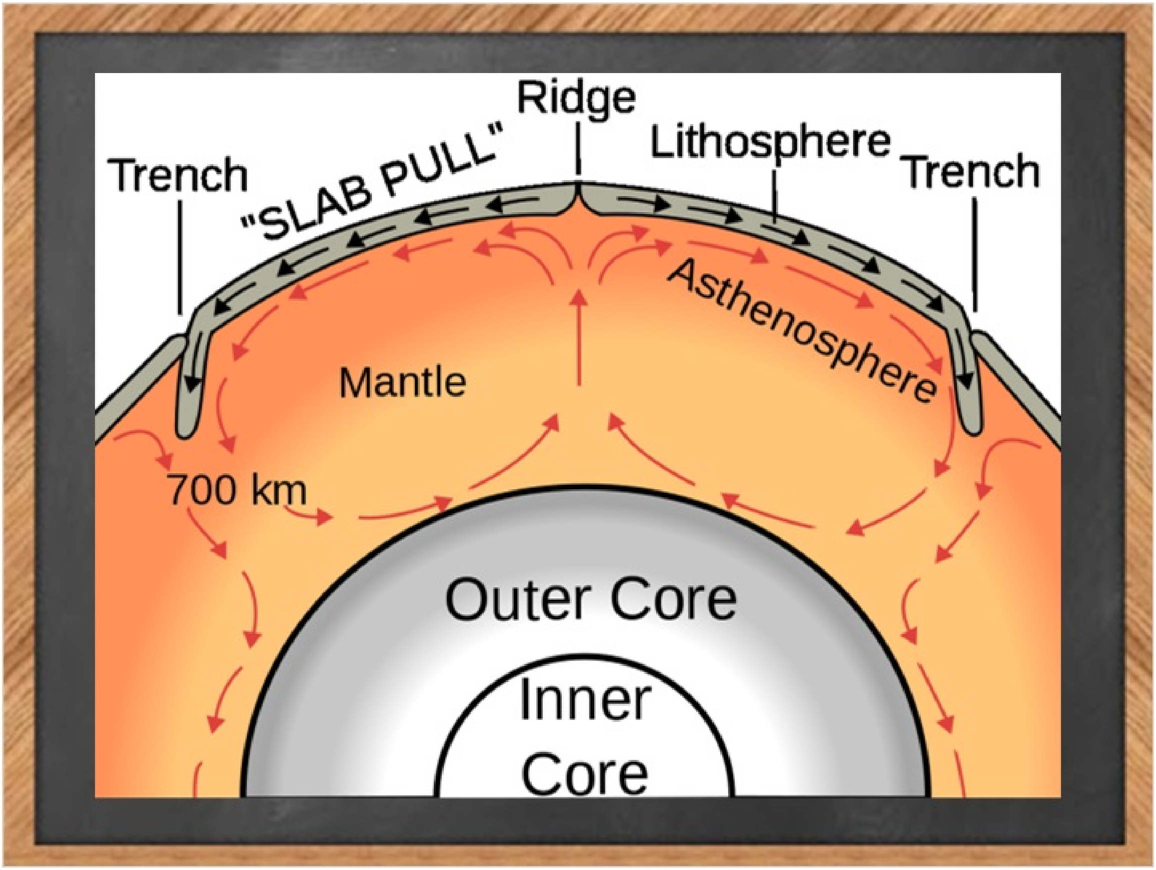
Using magnetometers, geologists can measure changes in the Earth's geomagnetic field recorded in rocks. Based on such measurements, scientists discovered that periodically, the Earth reverses its geomagnetic field polarity. In effect, all the world’s compasses that point toward magnetic North would flip to point South.

Knowing this, two scientists, Fred Vine and Drummond Matthews, believed that basaltic rock on opposite sides of the mid-ocean ridge would record the Earth’s polarity at the moment it emerged and solidified. Vine and Matthews expected that the rock would then carry the recorded polarity in alternating bands as it traveled away from the mid-ocean ridge.

As shown by the dark orange band in this illustration, rock forming at the mid-ocean ridge has a normal polarity. When the Earth's geomagnetic field reverses, the rock that solidifies during the reversal period (shown by the white bands) records the reversal in its metallic minerals.

To test Vine and Matthews’ idea, scientists aboard the *Glomar Challenger* lowered a magnetometer to the seafloor and measured the polarity along both sides of the Mid-Atlantic Ridge. What they discovered was exactly as Vine and Matthews predicted; the bands of alternating polarity at equal distances but on opposite sides of the Mid-Atlantic Ridge matched perfectly.

Image credit: USGS: Public Domain



The theory of seafloor spreading expanded to include more than just the seafloor. Geologists theorize that the Earth's lithosphere moves due to convection in the mantle. This continuous circular motion in the mantle causes magma to rise up and solidify at the mid-ocean ridge, only to sink and return to the mantle some distance away. The points at which crust recycles back into the mantle are subduction zones. This new, expanded theory became known as plate tectonics.

Image credit: Surachit: Creative Commons 3.0