

Lecture 4 Sea-Floor Spreading

POLAR WANDERING CURVES

We have learned that rock samples containing magnetic minerals (commonly magnetite) provide information (direction and inclination) on where they were formed relative to the north magnetic pole.

Turning this around – if we collect recent volcanic rocks from different places around the world, measurement of their **magnetic direction and inclination** will converge on the **present** magnetic north pole.

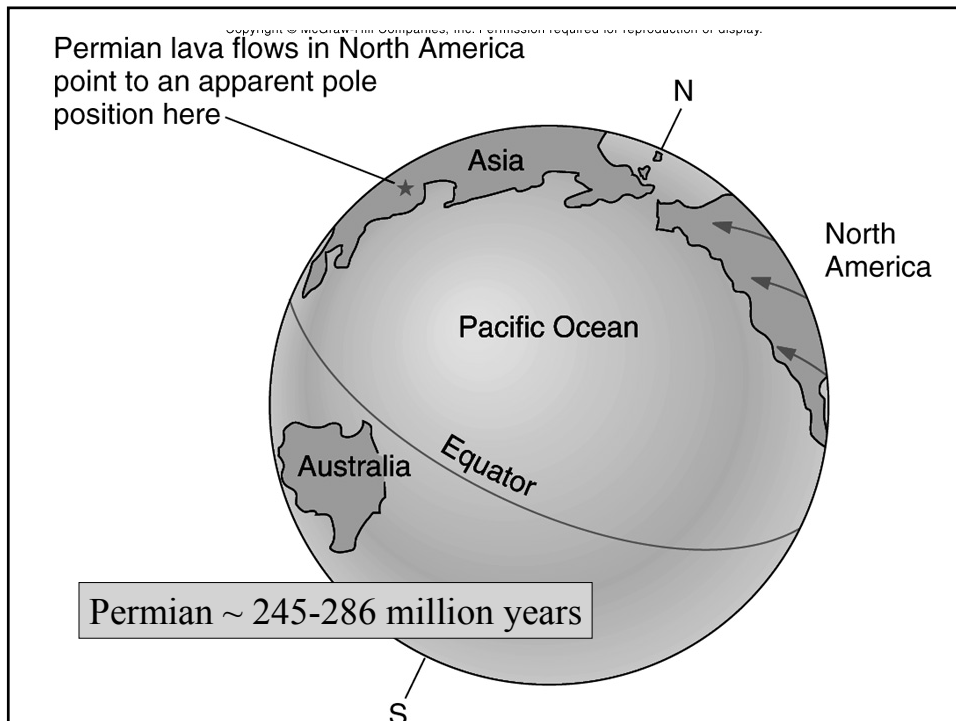
$$\text{POLE POSITION} = 90^{\circ} - \text{INCLINATION}$$

Does this happen with ancient rocks?

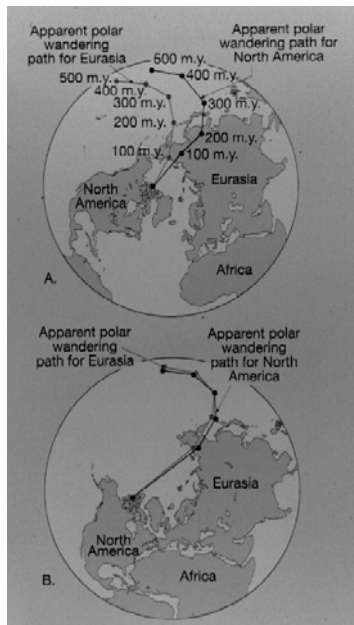
If we measure their magnetic inclination and direction, we might expect that rocks of the same age on different continents would give identical polar positions, which should correspond with the present polar position.

They Don't!

- Rocks of different ages give different polar positions
- Rocks of the same age but on different continents give different polar positions
- The older the rock the further the calculated polar position is from the present position



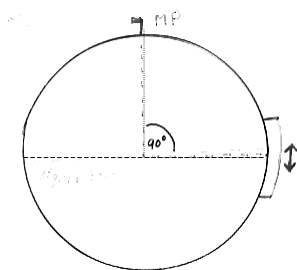
Examples of so-called “Polar Wandering Curves”



Plotting the apparent polar positions for rocks of different ages from North America and Eurasia produces two curves, the so-called “polar wandering curves”. Note that as the curves get younger they converge.

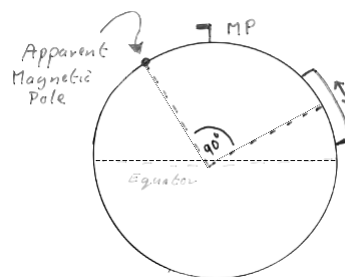
Fitting the continents back together results in a single curve. Nonetheless, the positions still do not correspond with the current magnetic position. To account for this, the continents would have had to move northwards as well.

Explanation of “Polar Wandering Curves”



300 million years ago

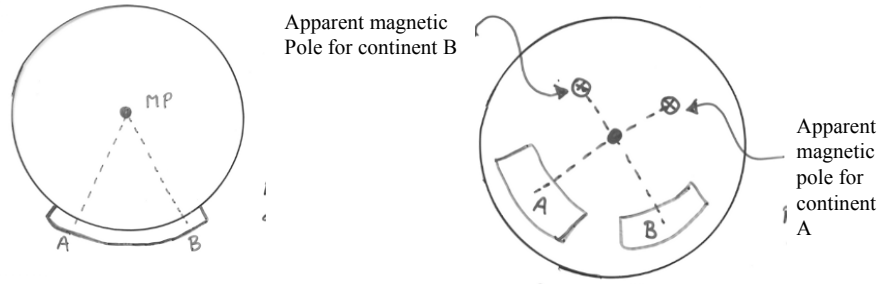
Sideways view of earth with continent astride the equator



Today

Continent moves northwards resulting in an “apparent” magnetic pole that is displaced from the true pole

Another example - View looking down onto the magnetic pole



Two locations on large continent astride the equator

Continent splits apart and moves to the north

CONCLUSION

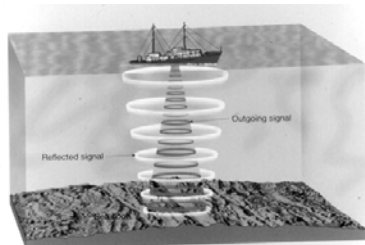
- Paleomagnetic studies appear to provide support for Wegener's ideas of continental drift.
- The continents appear to have been joined over 200 million years ago.
- Paleomagnetic evidence also suggests the continents have moved northwards.

SEA-FLOOR SPREADING

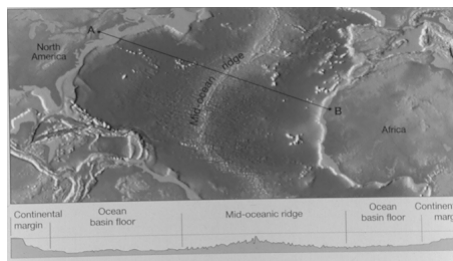
In the 1950's and early 1960's detailed study of the oceans revealed the following surprising information:-

- ❑ Detailed bathymetric (depth) studies showed that there was an extensive submarine ridge system that extended around the globe. These became known as MID-OCEAN RIDGES.
- ❑ Sampling by dredging showed that these mid-ocean ridges were formed of young volcanic rock (basalt).

Mid-Ocean Ridges



Echo Sounding



Mid-Atlantic Ridge

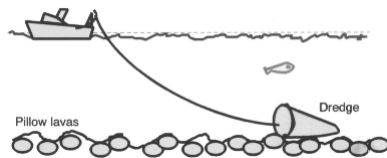


The entire Mid-Atlantic Ridge

The World-Wide Ocean Ridge System (65,000 km in length)



Sampling Mid-Ocean Ridges



The basic idea behind dredging.



Launching a dredge



Launching a camera

Basalts on Mid-Ocean Ridges

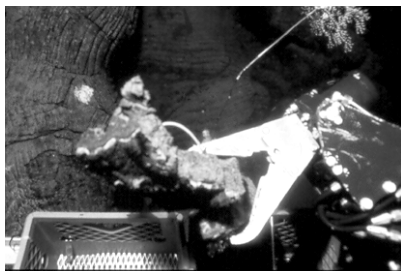


These types of basaltic lava are called “pillow lavas”



Video of pillow lavas

Exploring Mid-Ocean Ridges with the Alvin Submarine



These observations led Harry Hess of Princeton University to propose in 1960 the “Sea-Floor Spreading Hypothesis”

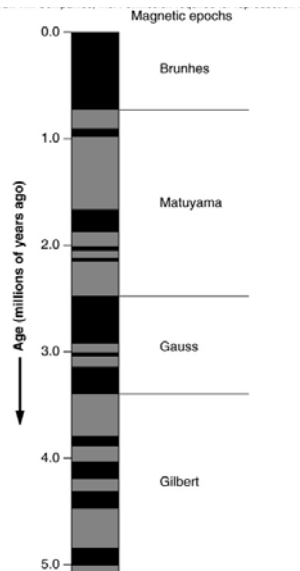
- Volcanic eruptions at mid-ocean ridges create new oceanic crust.
- The newly-formed crust pushes the older crust apart causing the sea-floor to spread.
- Sea-floor spreading creates the ocean basins, moving the continents apart.

Hess was so uncertain of these ideas that he called them “geo-poetry”.

The next step in understanding came from a study of reversal in the earth’s magnetic field

MAGNETIC REVERSALS

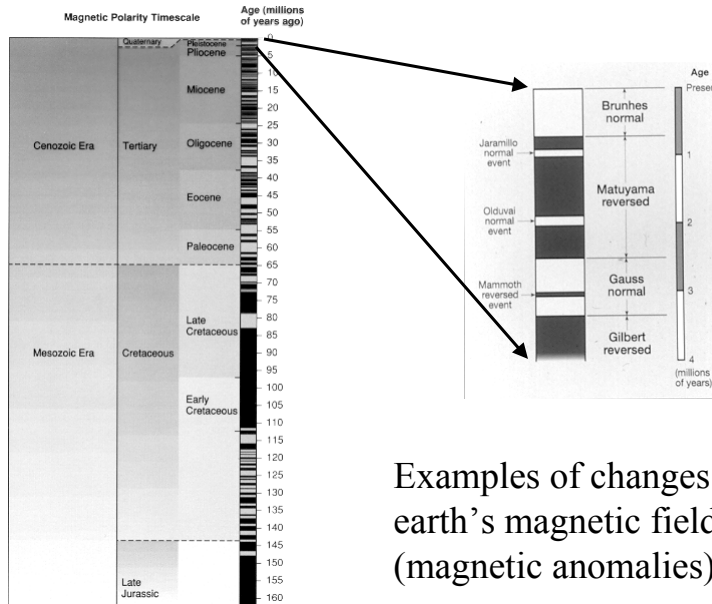
- Once every million years or so the earth's magnetic field reverses itself (it is not clear why).
- Under "normal" conditions a compass points to the north, whereas under reversed conditions it would point south.
- The present "normal" conditions have been in effect for the last 700,000 years
- By carefully determining the ages of rocks, geologists have been able to correlate these reversals in the earth's magnetic field with time.
- In other words the magnetic reversals provide information on the time of formation of rocks (like tree rings).



Details of magnetic reversals over the last 5 million years

Black is positive, blue is negative. The names are given after famous physicists

Marine Magnetic Anomalies

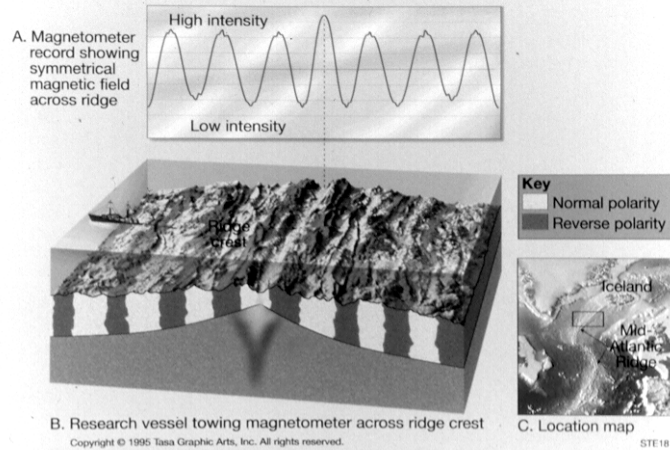


Examples of changes in the earth's magnetic field (magnetic anomalies).

Sea-floor Magnetic anomalies

- Research ships towing magnetometers found stripes of alternating high and low magnetic intensity running parallel to ocean ridges.
- The high intensity stripes were produced by normally magnetized rocks amplifying the earth's magnetic field.
- The low intensity stripes were produced by reversibly magnetized rocks weakening the earth's magnetic field.

Atlantic Ocean South of Iceland



Older ← | → Older

Linear Magnetic Anomalies

- We have just seen that magnetic reversals (or anomalies) can be correlated with age.
- Also, that a Mid-Ocean Ridge is a center of young volcanic activity.
- Thus the rocks on the ocean floor appear to be getting older on either side of a Mid-Ocean Ridge as one moves away from the ridge .
- Similar linear magnetic anomalies are associated with ALL mid-ocean ridges.
- These observations helped confirm the theory of **SEA-FLOOR SPREADING.**