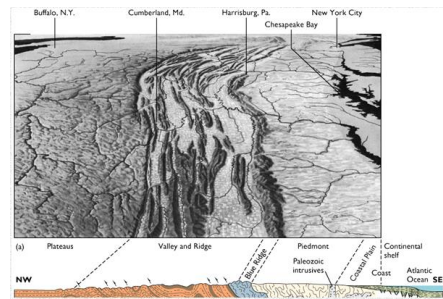


Plate Tectonics

The Unifying Theory That Brings
All of Geology Together

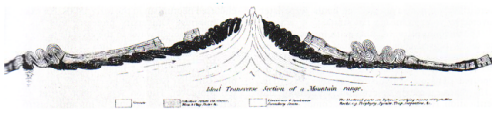
1



The modern theory of plate tectonics is rooted in early hypotheses of crustal movement, which centered around crustal deformation and mountain building

2

James Hutton (late 1700's)

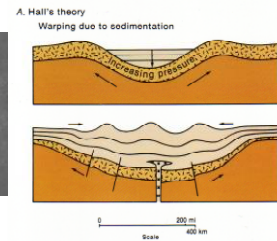


- James Hutton (Scottish farmer and naturalist) is regarded as the founder of modern geology
- Hutton envisioned Earth as having an internal heat engine that caused upheaval of the overlying crust:
 - Rising granite pushed crust upwards to form mountains
 - The overlying rock layers (strata) slid down sides of uplift and were deformed

3



James Hall (1857)

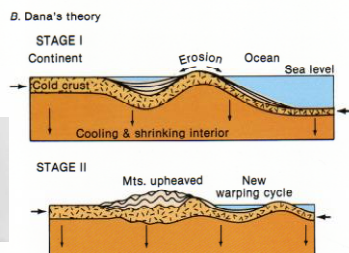


James Hall (American geologist and paleontologist) attributed mountain-building to the warping of crust due to sediment loading:

- Great loads of sediment depressed and bent crust until it crumpled to form mountains

4

J.D. Dana (1873)



- J.D. Dana, an American geologist, envisioned a shrinking Earth that caused the crust to bend and form mountains:
 - Bending concentrated along continental margins
- Coined term "Geosyncline" that has since been abandoned

5

Edward Suess

- Edward Suess (1831-1914), an Austrian geologist, disputed the idea of crustal upheaval from below
- Instead thought that the Earth has been cooling since its formation:

- As the planet contracted, its surface wrinkled like a drying apple
- Traverse forces pushed continental crust sideways rather than from below, producing large-scale movements that formed mountains



6

Continents As Pieces Of A Jigsaw Puzzle

As a global map of the world began to emerge in the 16th and 17th centuries...

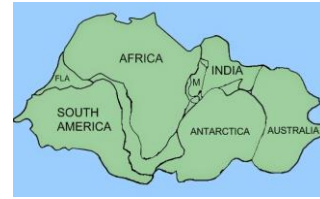
- Cartographers noticed that some continents seemed to fit together like pieces of a jigsaw puzzle
- The most obvious fit was between South America and Africa



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7

Gondwanaland



- Edward Suess (1800's) took note of the continental "pieces"
- Hypothesized that the present southern continents were once joined as a single landmass that he named *Gondwanaland*

8

Pangaea

Wegener's Pangaea, redrawn from his book published in 1912.

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Alfred Wegener, a famous German meteorologist and geophysicist of early 20th Century, fitted together separate continents to form a giant supercontinent of *Pangaea*

9

Wegener Discovered That When Assembling Continents Into the Supercontinent Pangaea...



A.
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10

...Mountain Belts Aligned



B.
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11

Continental Drift: An Idea Before Its Time



- Alfred Wegener proposed his continental drift hypothesis in 1915:
 - Published *The Origin of Continents and Oceans*
- Continental drift hypothesis:
 - Continents were at one time assembled into a supercontinent called Pangaea
 - Pangaea has since broken apart and the "pieces" drifted to their present positions to become modern continents

12

A. L. Du Toit (1878-1948)

- Alexander Du Toit was a geologist from South Africa
- Early supporter of continental drift
- Modified Wegener's hypotheses by suggesting that there were two primordial continents, Laurasia in the north and Gondwana in the south
- His hypothesis of continental drift was published in *Our Wandering Continents* (1937)

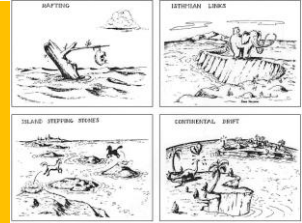


13

Fossil Evidence For Continental Drift

Du Toit and others identified ancient fossils on widely separated continents:

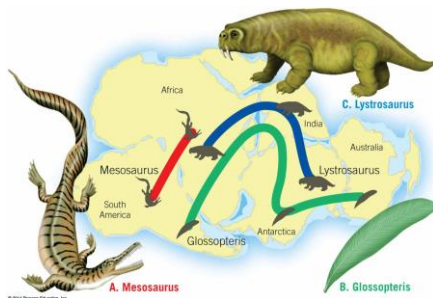
- Some fossils from different continents were remarkably similar to one another
- Geologists debated how similar animals could have crossed entire oceans
- Du Toit concluded that the now separated continents were at one time joined



Various explanations for the occurrence of similar species on different continents (Sketches by John Holden)

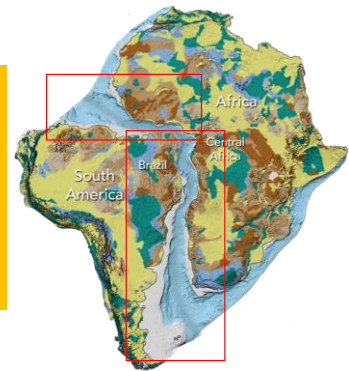
14

With Gondwana Joined (230 Million Years Ago), Ancient Plants And Animals Were Able To Migrate From One Continent To Another



15

Du Toit also noted the geologic matches of rocks and rock structures on opposite sides of the ocean in support of continental drift

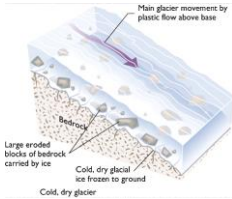


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03.08.01

16

Evidence of Past Glaciation



Glacial deposits



Close up of cobble

Grooves in bedrock



17

Paleoclimatic Evidence

- Glacial deposits found in South America, Africa, India and Australia:
 - Some in places where the climate is now tropical
- Grooves in bedrock at these locations may have been carved by ancient glaciers
- How do we explain such drastically different climates in the past for these areas?



Glacial deposits, Africa



Glacial Striations, Central Park, N.Y.

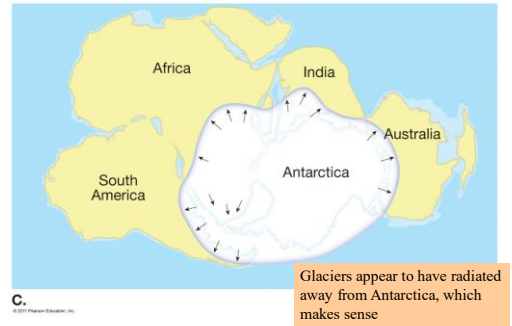
18

Ancient Ice Flow Directions As Determined Today From Grooves in Bedrock



19

Positions Of Continents 300 Million Years Ago



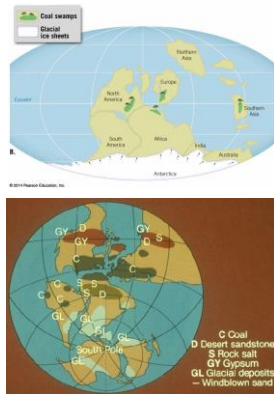
20

More Paleoclimate Evidence For Continental Drift

Ancient rocks and fossils do not match the climate at their present locations:

- Coal in Antarctica
- Reef-building corals in frozen Greenland
- Glacial deposits in Sahara Desert

Can be explained if continents were at one time at different latitudes and "drifted" to present positions



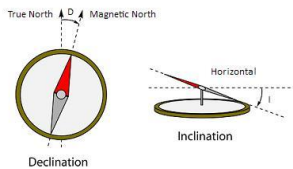
21

Paleomagnetism

Study of the Magnetic Properties of
Ancient Rocks Provide Further Evidence
That Continents Drifted Over Time

22

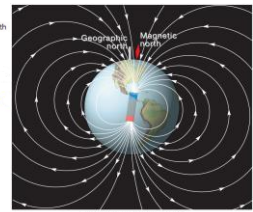
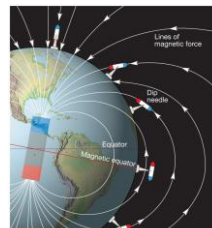
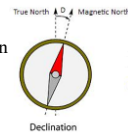
Earth's Magnetic Field



- Magnetic field discovered by Chinese (13th century) floating a lodestone on a piece of wood – it pointed north.
- Compass directions define two components of magnetism:
 - Declination: Horizontal swing
 - Inclination: Tilt of magnetization

23

Declination
Compass direction points to the magnetic north pole

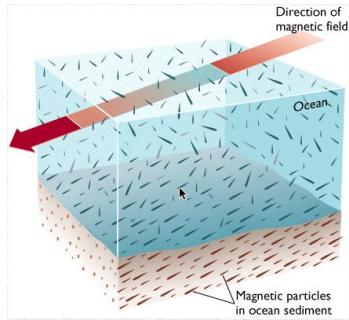


Inclination
Magnetic inclination is the angle a compass needle makes with Earth's surface and is a function of latitude

24

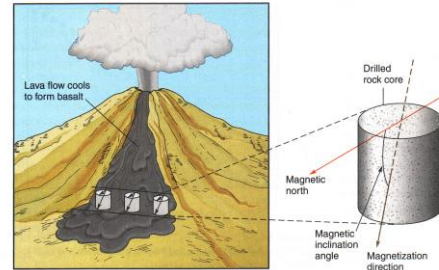
Acquiring Magnetism in Sedimentary Rocks

Magnetic minerals settling through the water column become aligned with the Earth's magnetic field



25

Acquiring Magnetism In Volcanic Rocks



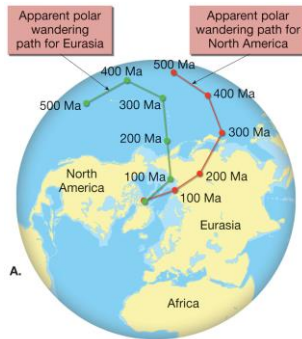
Magnetic minerals in volcanic rocks record the direction of Earth's magnetic field at the time the lava flow crystallized

26

Polar Wandering Paths for Different Continents

The magnetism of rocks on different continents point to different locations for the Earth's magnetic pole at various times in the past

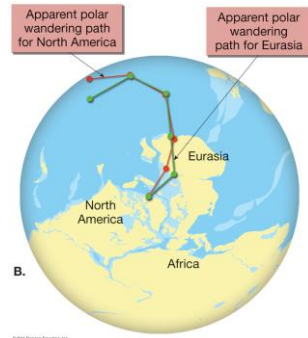
Did the Earth's magnetic poles migrate over time?



27

Assembling Continents to Their Former Positions Cause Polar Wandering Paths to Align

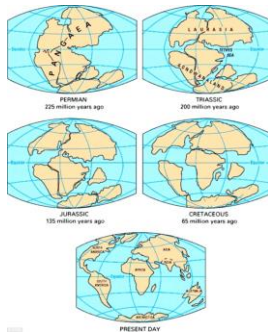
The magnetic poles didn't wander...
...THE CONTINENTS DID!



28

From Continental Drift To Plate Tectonics

Studies of ocean floor bathymetry throughout the 1950's and 1960's eventually led to the modern theory of plate tectonics



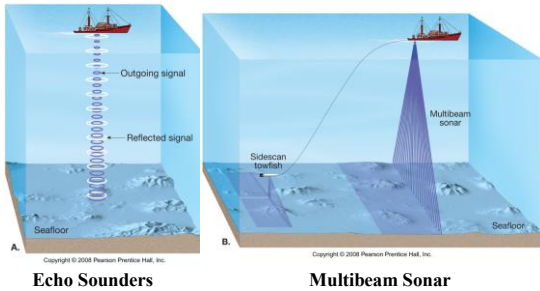
29

Mapping the Seafloor

The Bathymetry of Ocean Basins

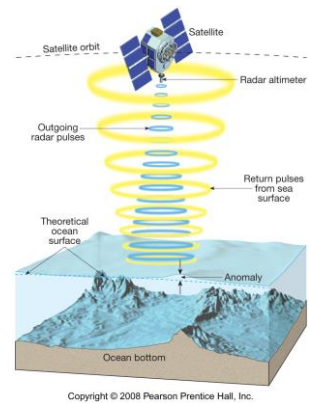
30

Extensive Shipboard Reflection Surveys After WWII Mapped Bathymetry Of The Seafloor



31

Satellite altimeter
measurements of
variations in sea-
level can be used to
interpret the seafloor
bathymetry



32

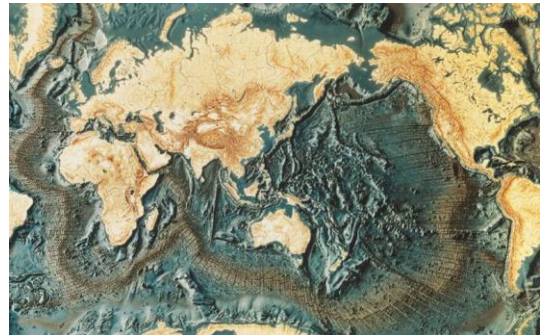
Seafloor Has
Complex
Bathymetry



- Deep trenches
- Immense fracture zones
- Countless submerged volcanoes
- Enormous submarine mountain ranges (mid-ocean ridges)

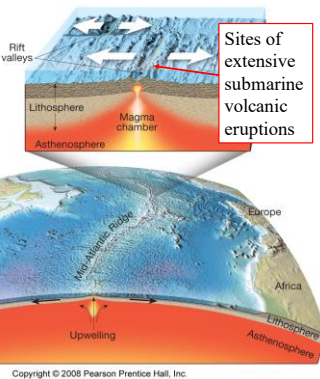
33

Immense Mid-Ocean Ridges Characterize Ocean Basins



34

Mid-ocean ridges
extend the length of
entire ocean basins and
can be hundreds to
thousands of
kilometers long

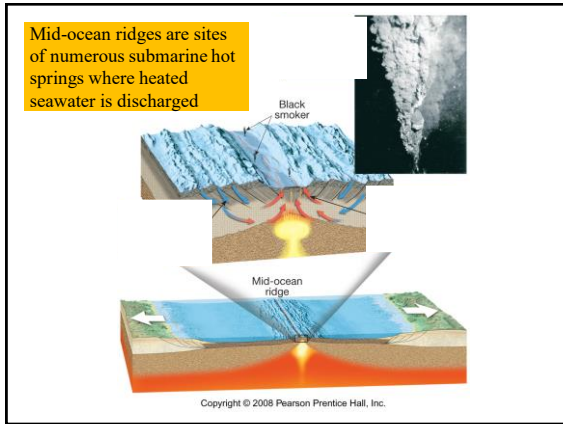


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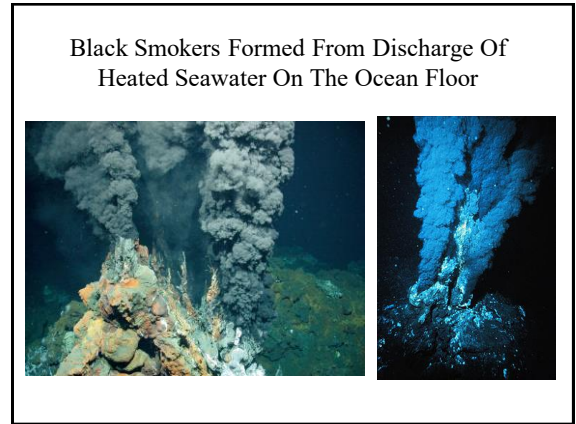
Undersea
Volcanic
Eruptions And
Pillow Lavas



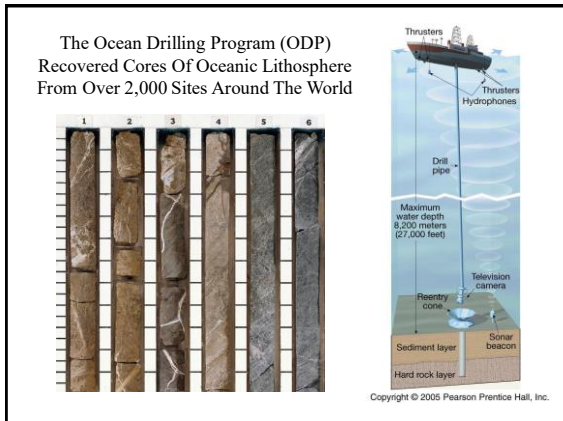
36



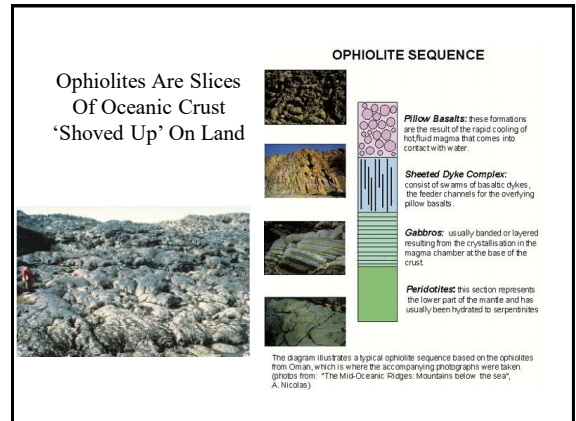
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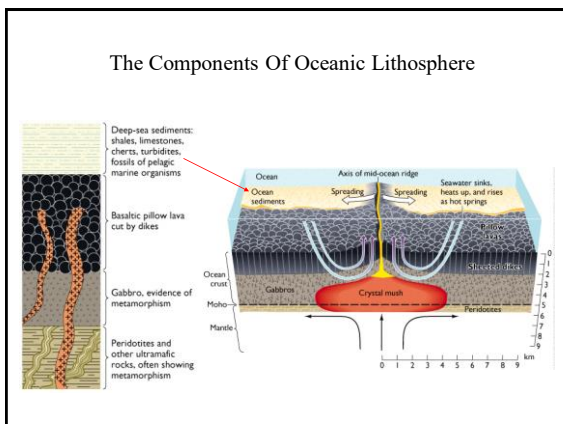
38



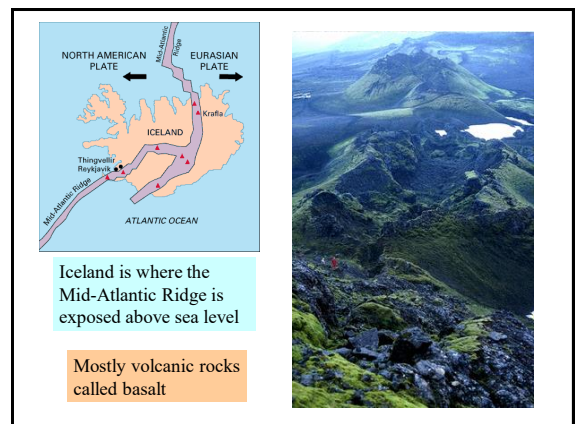
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42