# Plate Tectonics

A major paradigm shift in the earth sciences

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EIU Science and Technology Symposium
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10-10:30 am

- "Research thrives where smart people can work together and share data and ideas."
- Naomi Oreskes in Plate Tectonics: An Insider's History of the Modern Theory of the Earth

## Plate Tectonics

- This theory is global and unifying in our discipline.
- Rigid lithospheric plates move over plastic (silly putty-like) mantle.
- Mantle convection drives the movement of the plates.
- The theory is used by all earth scientists.

## Plate Tectonics

- Developed over the course of the 20th century
- Many scientists were involved
- A few institutions stood out:
  - Cambridge University,
  - Columbia University's Lamont Geological Observatory,
  - University of California's Scripps Institute of Oceanography,
  - Princeton University

## Data Sharing

- Rapid development of ideas
- Effective Interpretation of Data

## Federal Funding of Science

- Lots of funding of earth science throughout the 20th century by the U.S. government
- GI Bill → more people in higher ed
- Military funding of scientific research for national security involved large labs and team-oriented approaches

## Office of Naval Research

- Funded studies at WHOI, Scripps and Lamont
- Study physical oceanography related to:
  - Underwater sound
  - Magnetics
  - Bathymetry

## Unified, Global Theory

- Data driven
- Data collected as a result of oceanographic expeditions

# 1945-1970

- Collect diverse bathymetric and seafloor data
- Collect data regarding the physical and chemical properties of the water column
- Air-Sea interactions
- Generation of waves and currents
- Sediments
- Magnetics and gravity signals of solid rocks on the seafloor

# Important observations preceding Plate Tectonic Theory

- 16th century- jigsaw fit of continental edges
- 19th century- fossils and rock formation similar in far flung areas
- Early 20th century- Suess- Gondwanaland Theory

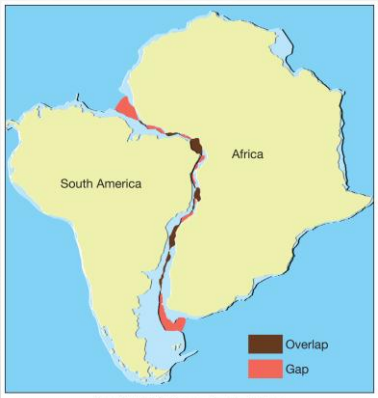
# Continental Drift Theory

- Alfred Wegener (1880-1930) meteorologist
- Paleoclimate

# ~250 million years ago


**A.** Modern reconstruction of Pangaea

Jigsaw Puzzle fit of the continents

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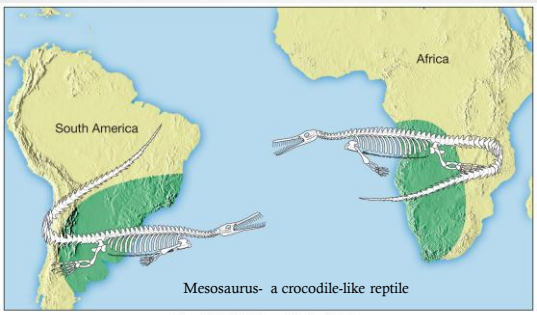
Mountain Belts that were continuous in the geologic past fragment as continents moved apart


Fossil Deposits of critters that couldn't swim across the ocean present today: How did they get on opposite sides of that ocean?

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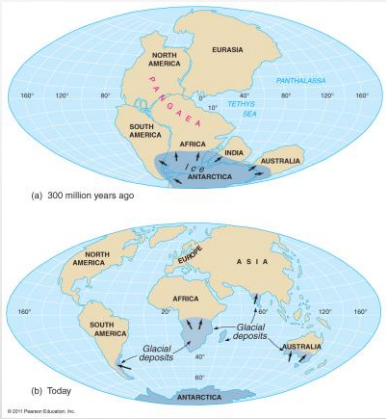
Differing climates were due to differing position of continents latitudinally

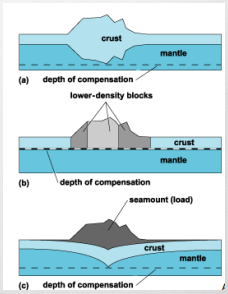


## North American Scientists reject it

- "Bad Science"
- Multiple Working Hypotheses
  - Democracy of ideas
  - Good science empirical, inductive and modest
- Incompatible with American theory of isostasy
- Legacy of Uniformitarianism

## Collecting Evidence for Plate Tectonics

- Gravity
  - Isostasy questions




## Technological Advances

- WWII contributes
- Submarine warfare
- World Wide Standard Seismograph Network (WWSSN)
- Geophysics and Oceanography
  - Help detect and avoid submarines
  - Imaging of the seafloor
  - Interpretation of magnetics

## Major contributors

- Harry Hess
  - Theory of sea floor spreading (with Dietz)
  - Navy officer –echo sounding of the Pacific
  - Princeton University

- Maurice Ewing
  - Director of Lamont
  - Collection of geophysical data

Bruce Heezen (1924-1977)
mapped ocean ridges in 1950s
geologist
Columbia University

Marie Tharp (1920-2006)
oceanographer
1948 started as Ewing's research assistant at Columbia
first to map details of the ocean floor on a global scale

Map of Heezen and Tharp

Fred Vine and
Drummond Matthews
Cambridge University
Magnetic Stripes of
seafloor

Lawrence Morley

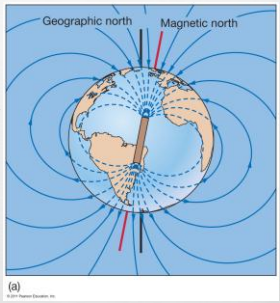
J. Tuzo Wilson (1908-1993)
Canadian Geophysicist
transform boundaries

## Evidence for the Theory of Plate Tectonics

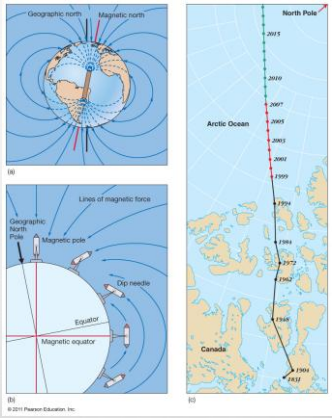
- Gravity data
- Earth's magnetic field and paleomagnetism
- Seafloor mapping
- Earthquake studies
- Heat Flow

## Paleomagnetism- Earth's magnetic field changes polarity

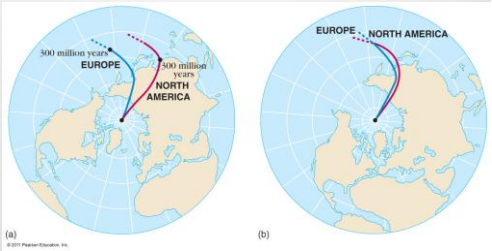
Magnetic minerals align according to the magnetic field existing when those minerals crystallize or are deposited on the seafloor in sediments.

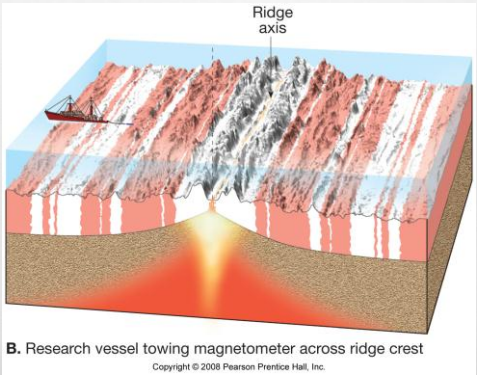



Magnetic signature in rocks as they form records their latitudinal position in the past

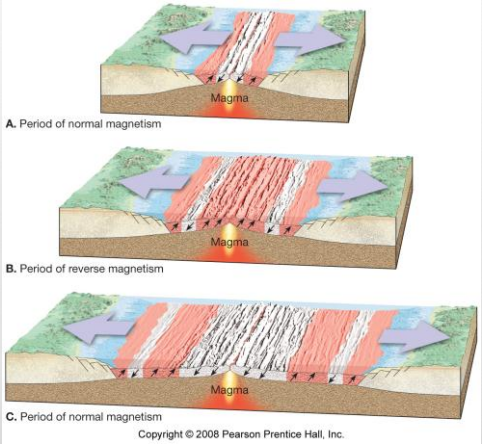



Apparent Polar Wander: Curves for 300 million years ago indicate that North America and Europe were closer together. If you move them accordingly, the curves match. Thus, continents were in different positions in the past.




**B.** Research vessel towing magnetometer across ridge crest


Magma
A. Period of normal magnetism
Magma
B. Period of reverse magnetism
Magma
C. Period of normal magnetism
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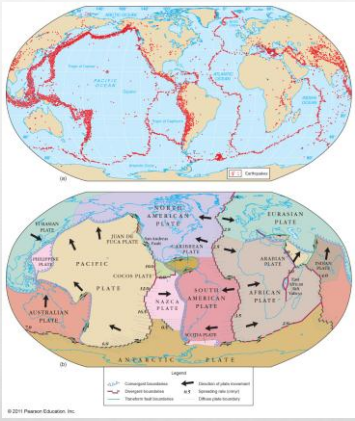
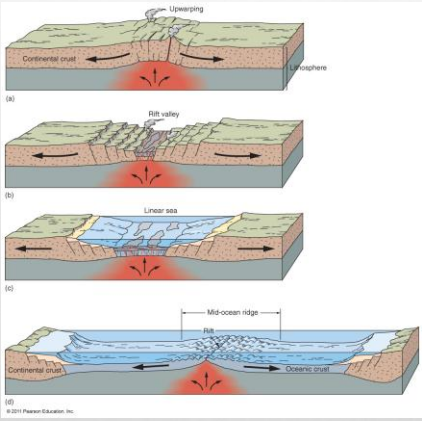
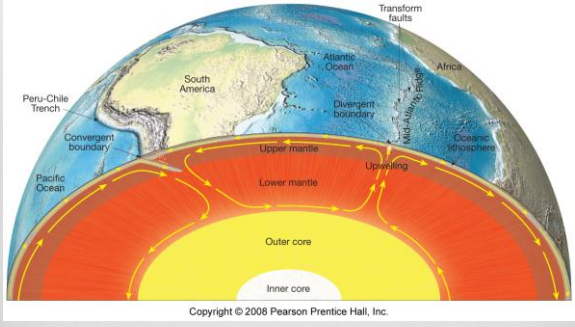

NORTH AMERICAN PLATE
EURASIAN PLATE
PACIFIC PLATE
SOUTH AMERICAN PLATE
AFRICAN PLATE
AUSTRALIAN PLATE
ANTARCTIC PLATE


Upwarping
Continental crust
Lithosphere
(a)
Rift valley
(b)
Linear sea
(c)
Mid-ocean ridge
Rift
Continental crust
Oceanic crust
(d)


Transform faults
Atlantic Ocean
South America
Africa
Peru-Chile Trench
Divergent boundary
Mid-Atlantic Ridge
Convergent boundary
Oceanic lithosphere
Upper mantle
Upwelling
Pacific Ocean
Lower mantle
Outer core
Inner core
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Deep Sea Drilling Project (DSDP)
Funded by National Science Foundation initially
1968-1983
investigate evolution of ocean basins
core the seafloor
R.V. Glomar Challenger
Leg 1-99

Ocean Drilling Project (ODP)
1985-2004
R.V. Joides Resolution
Leg 100-210

Integrated Ocean Drilling Project (IODP)
2005-