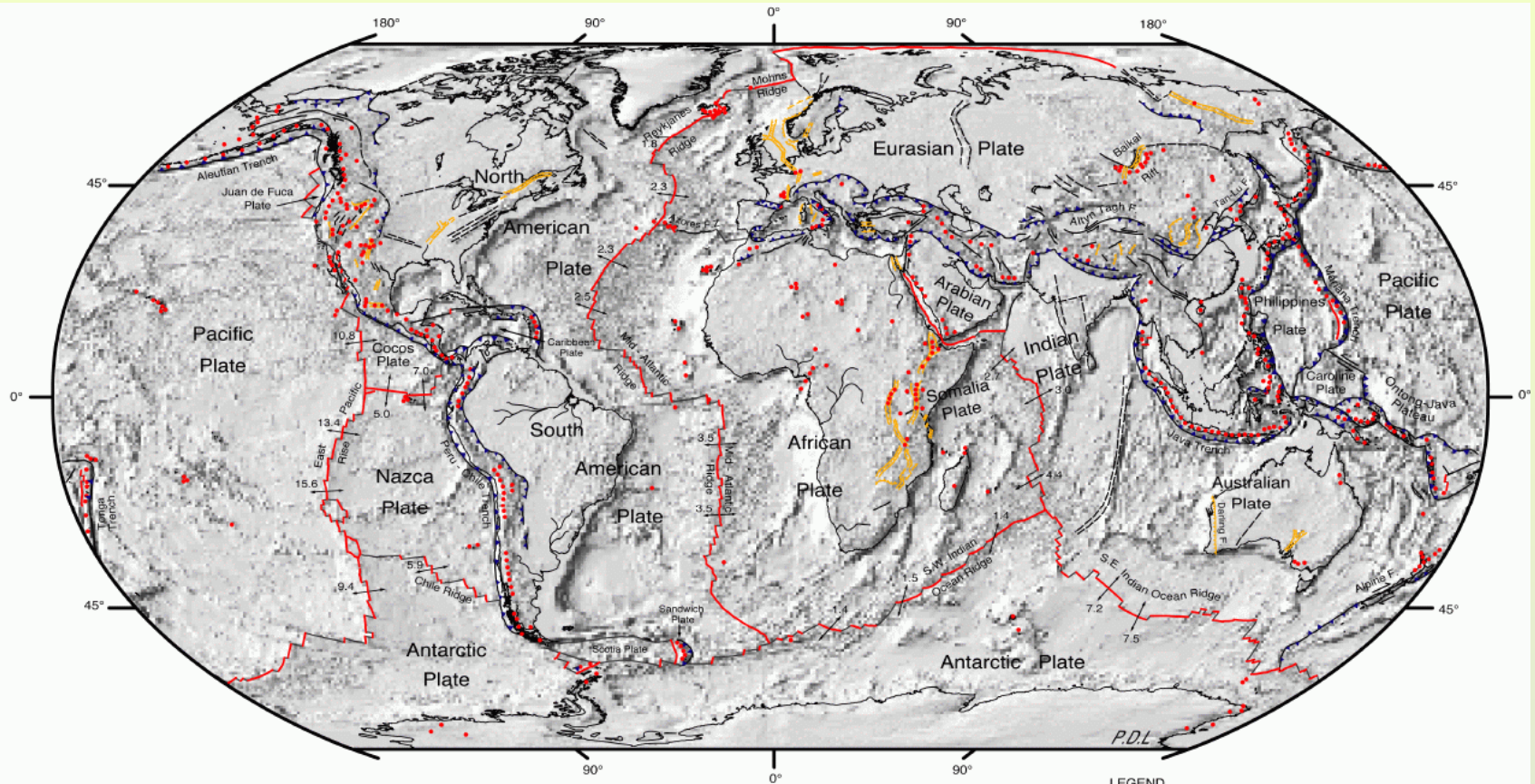


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12.001 Introduction to Geology
Spring 2008

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Plate Tectonics



DIGITAL TECTONIC ACTIVITY MAP OF THE EARTH
Tectonism and Volcanism of the Last One Million Years

DTAM



NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771

Robinson Projection
October 1998

- LEGEND**
- Actively-spreading ridges and transform faults
 - Total spreading rate, cm/year, NUVEL-1 model (DeMets et al., Geophys. J. International, 101, 425, 1990)
 - Major active fault or fault zone; dashed where nature, location, or activity uncertain
 - Normal fault or rift; hachures on downthrown side
 - Reverse fault (overthrust, subduction zones); generalized; bars on upthrown side
 - Volcanic centers active within the last one million years; generalized. Minor basaltic centers and seamounts omitted.

G221.001

With thanks to John Eiler, CalTech

Image courtesy of NASA.

Alfred Wegener proposes continental drift ca. 1912

The earth is divided into continents and oceans

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The continents fit together

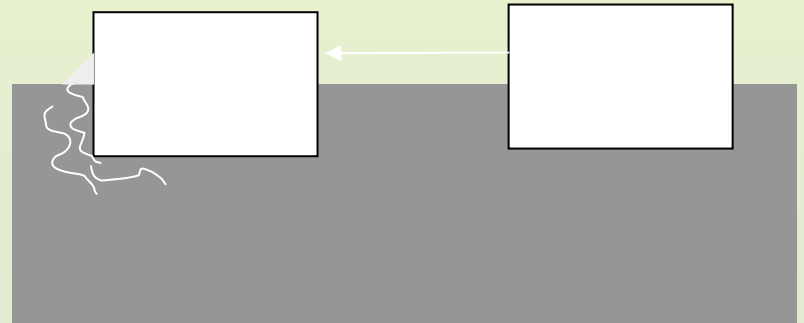
The distribution of fossil animals and plants reenforces the fit

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Continents once must have been together

... but have
drifted apart by 'sliding' over
or 'plowing' through the ocean floor

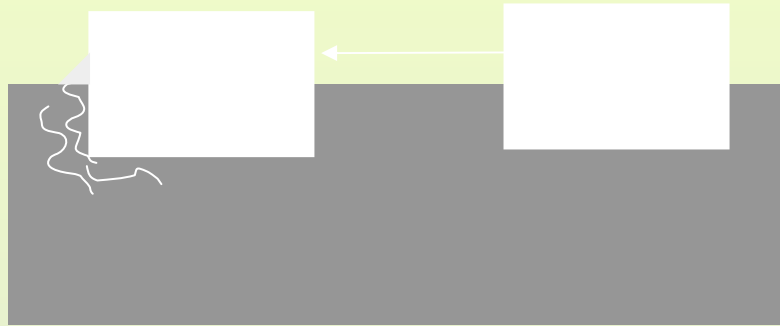
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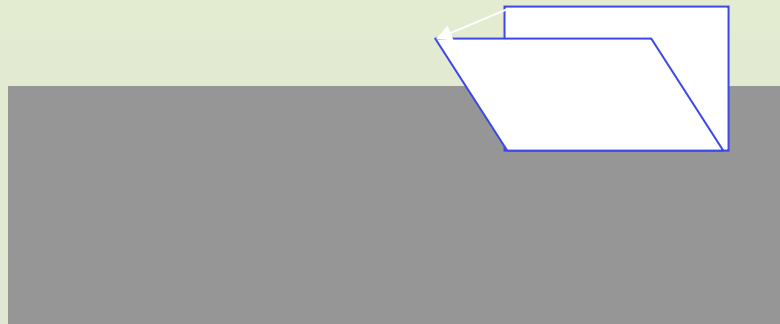
*Driving force: mystery, or
centrifugal force, or both*

Counter arguments

This is just stupid



Any force strong enough to 'push' a continent over a bed of ocean floor would internally deform the continent instead



Counter arguments

Many continental margins don't even fit geometrically

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Breakthrough

Harry Hess and the exploration of the ocean floor: *A ridge*

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- Led to discovery that the ocean floor is the active part of the plate system, not the passive medium through which continents move.

Magnetization of rocks

Preservation in rocks
of the orientation of
the magnetic field

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The planet's magnetic field periodically reverses direction

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Magnetic reversals in a single volcano

The rocks record not just north and south,
but also a *direction* to an apparent pole.

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Apparent polar wander

Phanerozoic records of magnetic polar wander from Europe and North America disagree (LEFT)...unless the continents have moved relative to each other (or, the shape of the Earth's magnetic field has varied) (RIGHT)

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Contrast: Magnetic polar wander, true polar wander

Earth's major plates

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Note: Boundaries rarely correspond to the contact between oceans and continents!

Plate motion

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Plate motion in mm per year

Why do plates move: *Ridge Push* and *Trench Pull*

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Types of plate boundaries

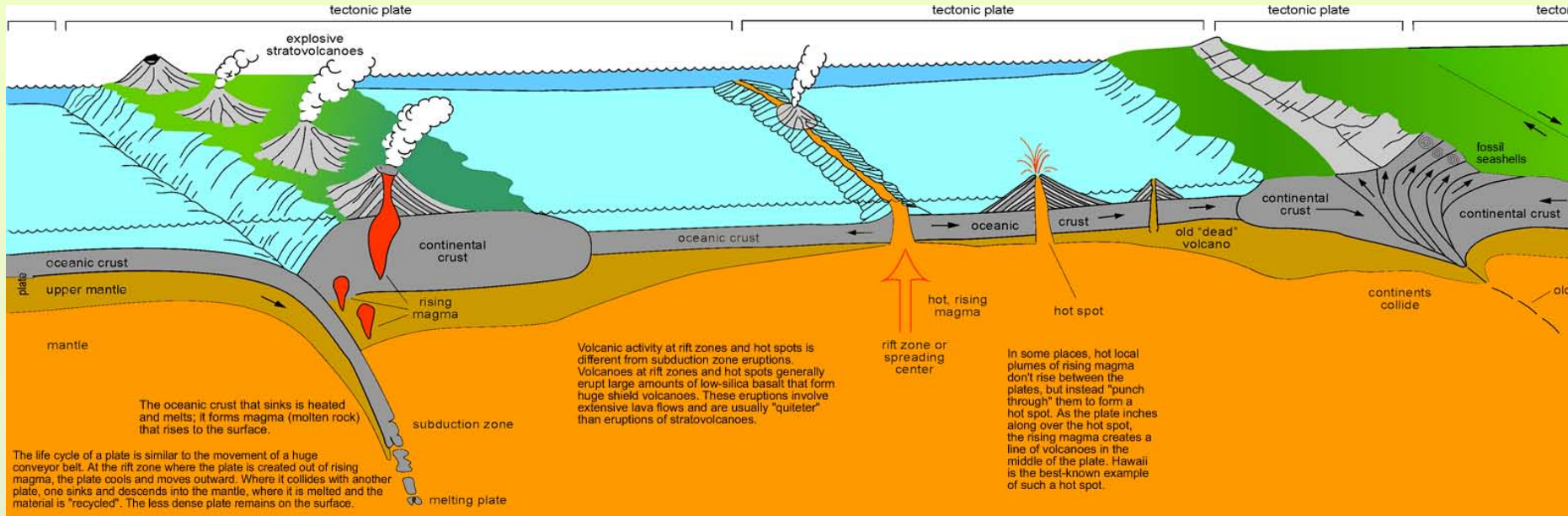
3 types

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Continental rifts: Divergent boundaries in threes

- Best examples East Africa
- Beginning of ocean formation, although it may not get that far
- Rifting often begins at a triple junction, but two spreading centers get together to form ocean basin, and one left behind (“failed”)

Convergent boundaries



1. Ocean-continent

3. ??

2. Continent-continent

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Institute of Natural Resource Sustainability, University of Illinois at Urbana-Champaign.

Image: Illinois State Geological Survey

Benioff-Wadati zones

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Principle of tomography

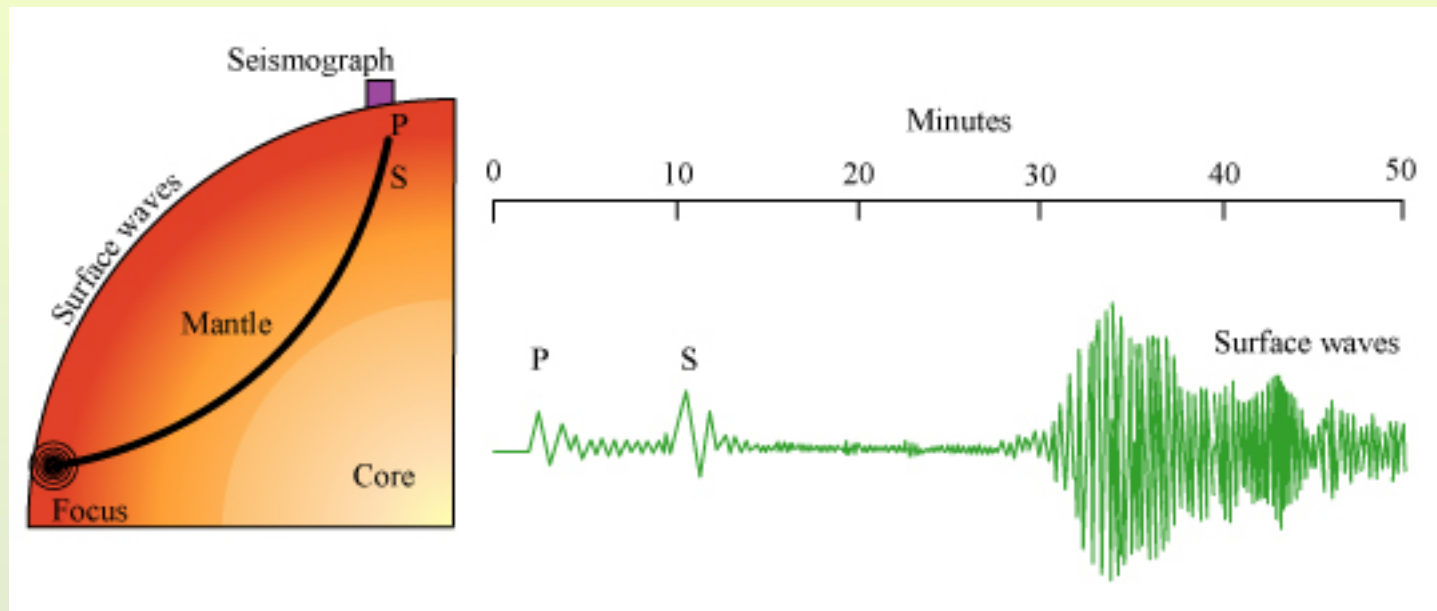


Figure by MIT OpenCourseWare.

1 of 3: Ocean–Ocean convergence: Island arcs

- Tectonic belts of high seismicity
- High heat flow arc of active volcanoes
- Bordered by a submarine trench

Pacific island arcs

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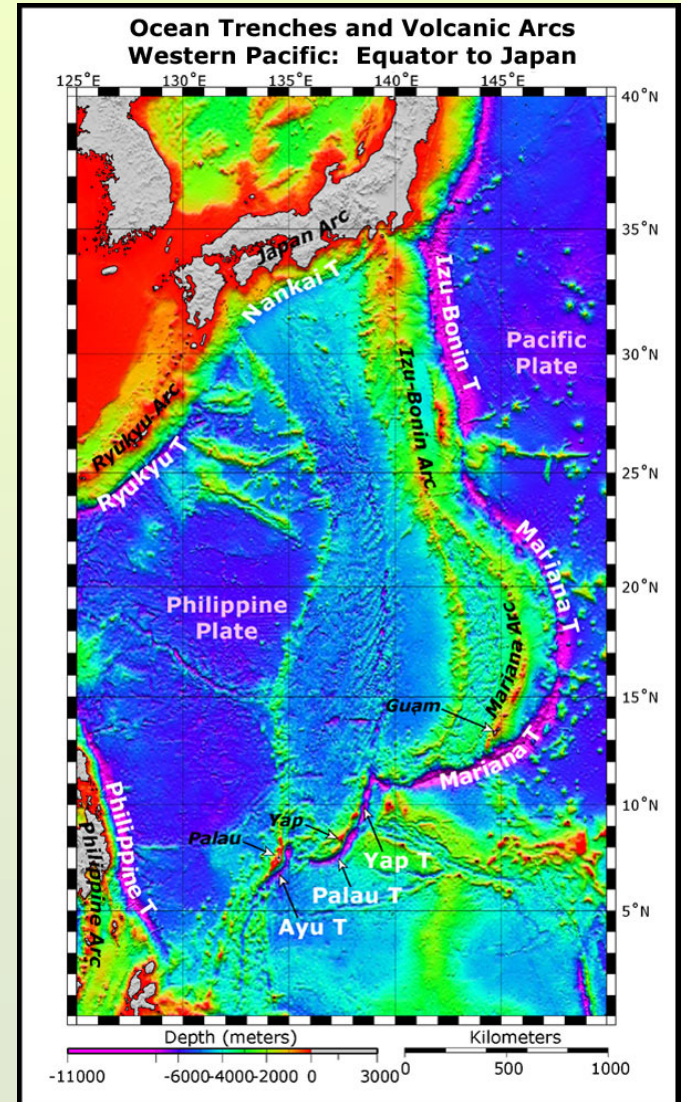


Image courtesy of NOAA.

2 of 3: Ocean–Continent convergence: Continental arcs

- Active volcanoes
- Often accompanied by compression of upper crust

3 of 3: Continent–Continent convergence: Major mountain-building

- In ocean–continent boundaries, collision convergence is taken up by subduction
- In continent–continent boundaries, convergence is accommodated by deformation of the crust without subduction (both plates are too buoyant to be subducted)

PLATES 2002
Atlas of Plate Reconstructions
(750 Ma to Present Day)

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