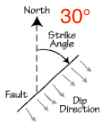
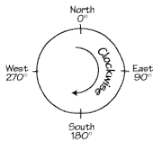
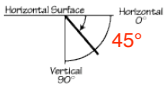


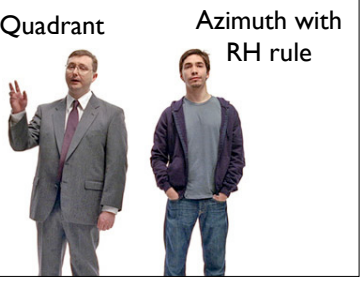


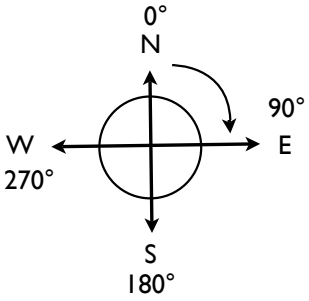


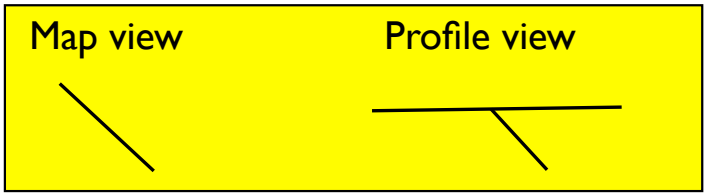
Strike and dip notation
(a) N30 E, 45 SE ("Quadrant"): the bearing of the strike direction is 30 degrees east of north and the dip is 45 degrees in a southeast (SE) direction. For a given strike, there are only two possible dip directions, one on each side of the strike line. Hence it is necessary only to identify which side by two letters. If the strike direction is nearly N-S or E-W, then a single letter is appropriate; if the strike direction is close to the 45 degree directions (NE or NW) then two letters are preferred.
(b) 30, 25 S or 45 SE ("Azimuth"): the azimuth of the strike direction is 30 degrees measured clockwise from north and the dip is 45 degrees toward the southeast. Usually the trend of the northernmost end of the strike line is given, but the azimuth of the opposite end of the line may also be used, as in 210, 45 S.
(c) 030, 45 ("Azimuth with right-hand rule") As above but choose azimuth so layer dips down to your right. Then no letters are needed, which is good for GIS data entry. Three digits are used for azimuth to avoid confusion of this number with dip.
(d) there are other conventions, including "left hand rule", and various ways of using just the dip azimuth and direction to indicate the plane's orientation.

Conventions used in Recent Textbooks (Structural Geology or Field Techniques)
Rowland et al 2006 - mostly quadrant (in problems) also Azimuth without RH rule
Barnes 2004 - several conventions, prefers Azimuth with RH rule
Freeman 1999 - several conventions, calls RH rule an "American convention"
Pollard and Fletcher 2005 - Azimuth w/ RH rule
Ramsay et al. 1987 - Azimuth, without RH rule
Groshong 2006 - Quadrant and Azimuth with and without RH rule

Conventions used in online course notes from other universities
U Arizona: Quadrant and Azimuth without right-hand rule (+ 2 other conventions)
U Calgary, U Saskatchewan U Maryland, Leeds U, Oxford U: azimuth convention without right-hand rule
UBC, MIT, Penn State: azimuth convention with right-hand rule
U Tennessee, U Colorado: quadrant convention

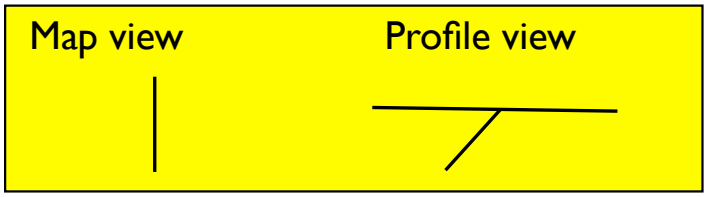






Strike?
Dip?

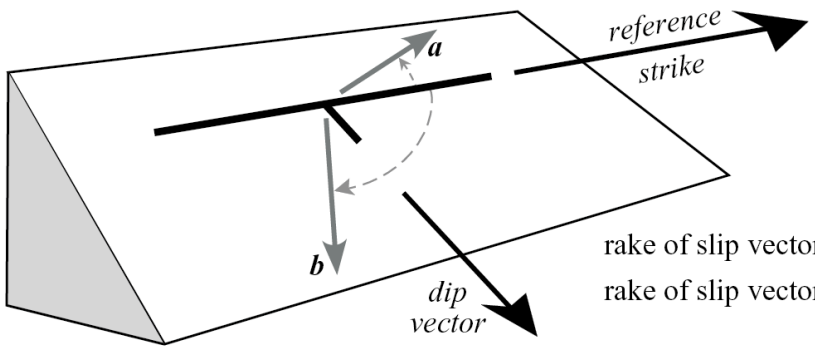
Quadrant N 45 W
Azimuth 45° NE
Azimuth with RH rule



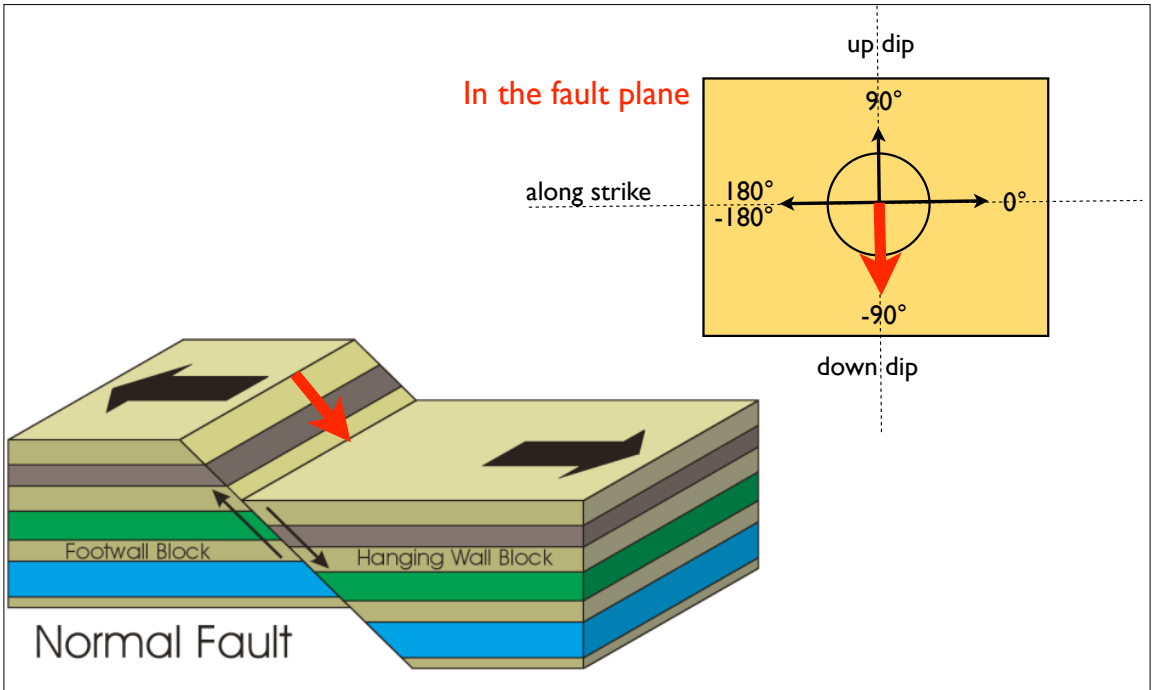
Strike?
Dip?

Quadrant N
Azimuth 45° W
Azimuth with RH rule

Indicating direction of slip quantitatively: the slip vector



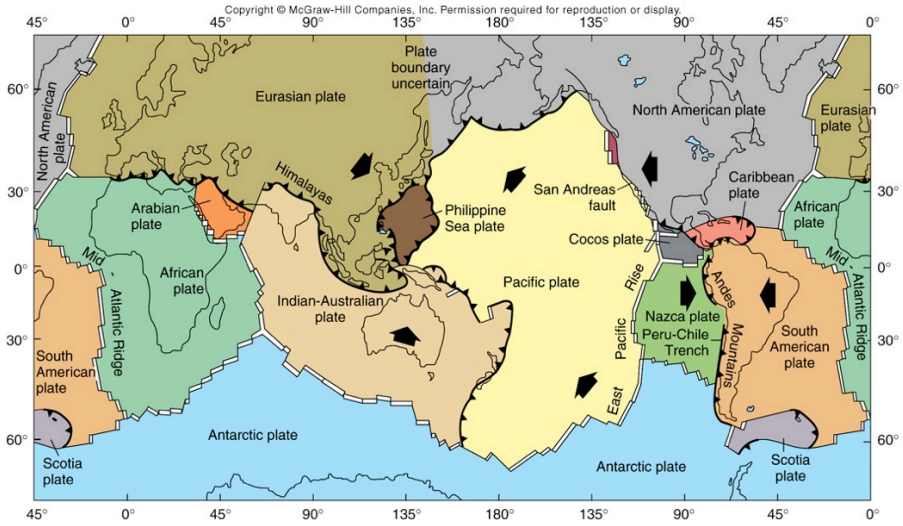
- let's define the slip direction (vector) in terms of the slip plane itself: "rake" of the slip vector, often just called "slip vector"
- convention: slip vector shows displacement of the hanging wall relative to the footwall, and values are from -180° to 180°



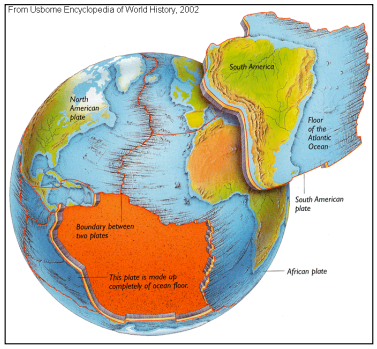
- 90° for a pure reverse fault
- -90° for a pure normal fault
- 0° for a left-lateral strike-slip fault
- 180° (or -180°) for a right-lateral strike-slip fault

Reference: Cronin 2004
This is the geophysical/seismological convention

New topic: types of faults at tectonic plate boundaries



Two ways to describe the shallowest 100 to 200 km of the Earth:



- crust
- mantle

} based on composition

- lithosphere
- asthenosphere

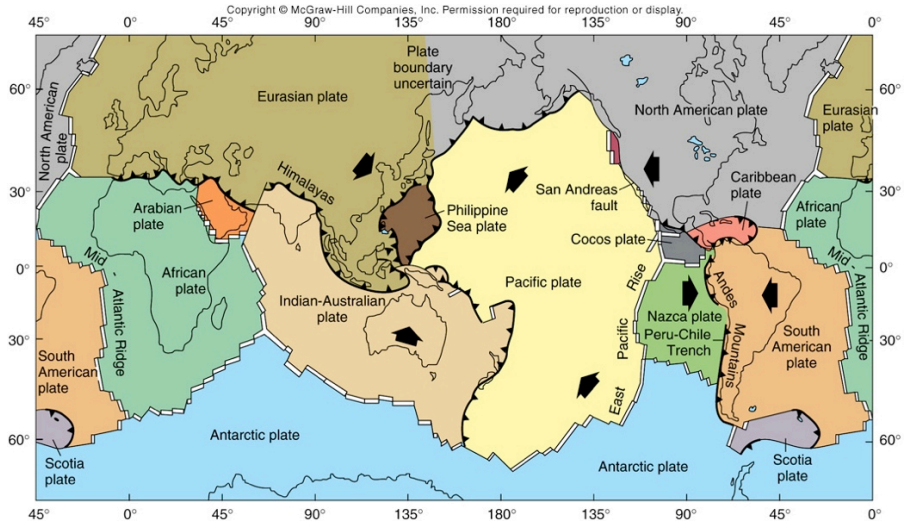
} based on strength

When we say "plate" we mean the lithosphere

Most faulting occurs in the upper part of the crust: that is, the shallowest part of the lithosphere

In the upper crust, the steady relative motion of plates is allowed by the episodic, relative motion of parts of their boundaries in earthquakes. Below this, the relative motion is aseismic.

Types of faults at tectonic plate boundaries



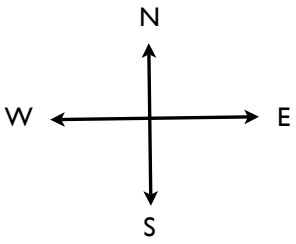
These cartoon vectors are relative to mantle hotspots (Earth's deep interior)

"No Net Rotation" reference frame

Compare the orientation of the relative plate motion vector to the strike of the the plate-boundary fault(s).

Vector subtraction gives motion of one plate relative to the other.

Relative motion can vary along a plate boundary, as can strike of the plate-boundary fault.



Finding the Pacific plate velocity relative to North America where they meet in NW BC

(Pacific Plate, NNR frame) — minus — (North American Plate, NNR frame) — equals — Pacific Plate relative to the North American Plate (in NW BC)

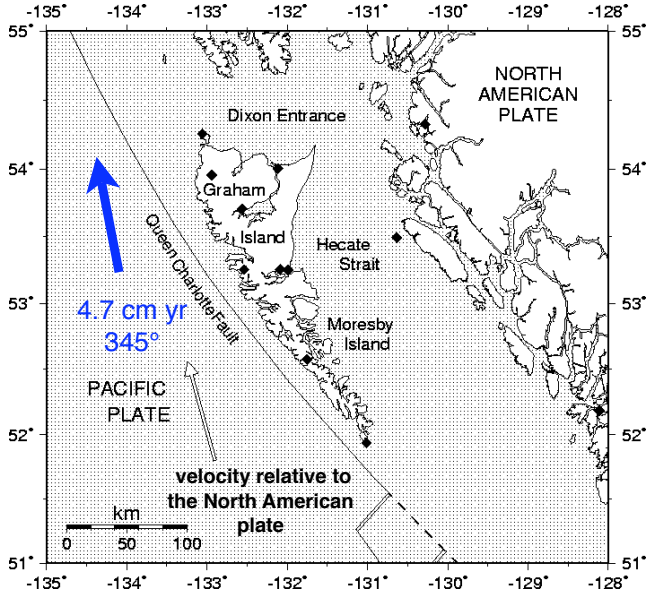
3.8 cm yr
318°

2.1 cm yr
220°

4.7 cm yr
345°

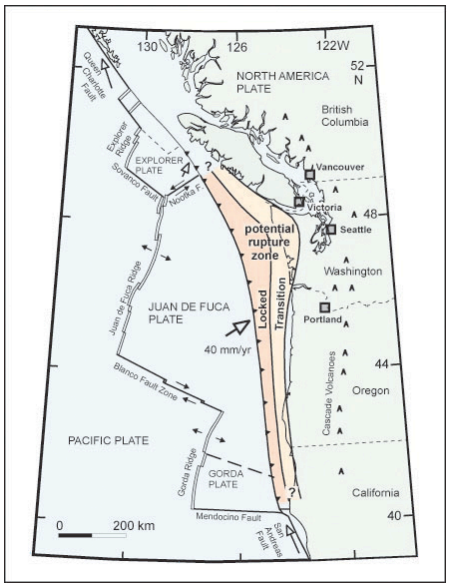
$$\begin{bmatrix} -2.5 \\ 2.8 \end{bmatrix} \text{ minus } \begin{bmatrix} -1.3 \\ -1.6 \end{bmatrix} \text{ equals } \begin{bmatrix} -1.2 \\ 4.4 \end{bmatrix} \text{ (cm/yr)}$$

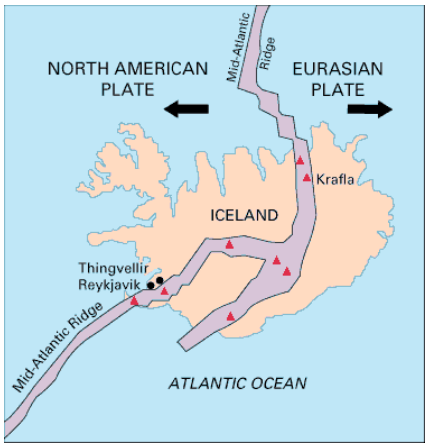
(Mostly) transform boundary

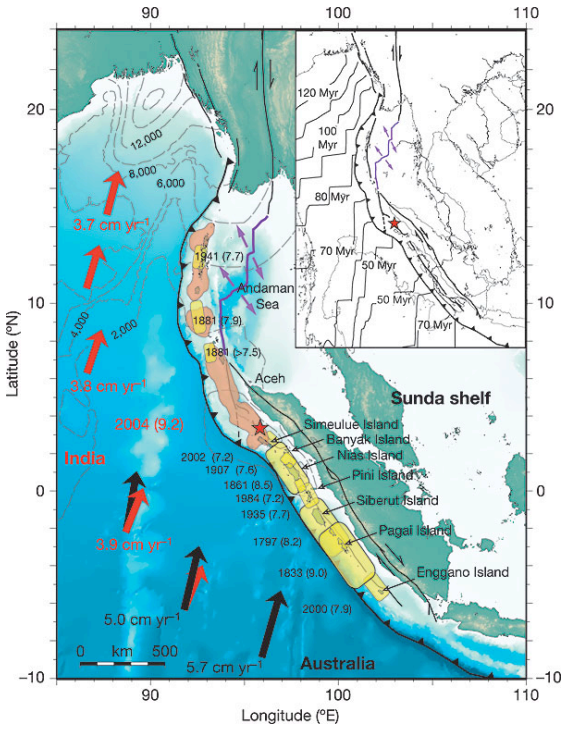


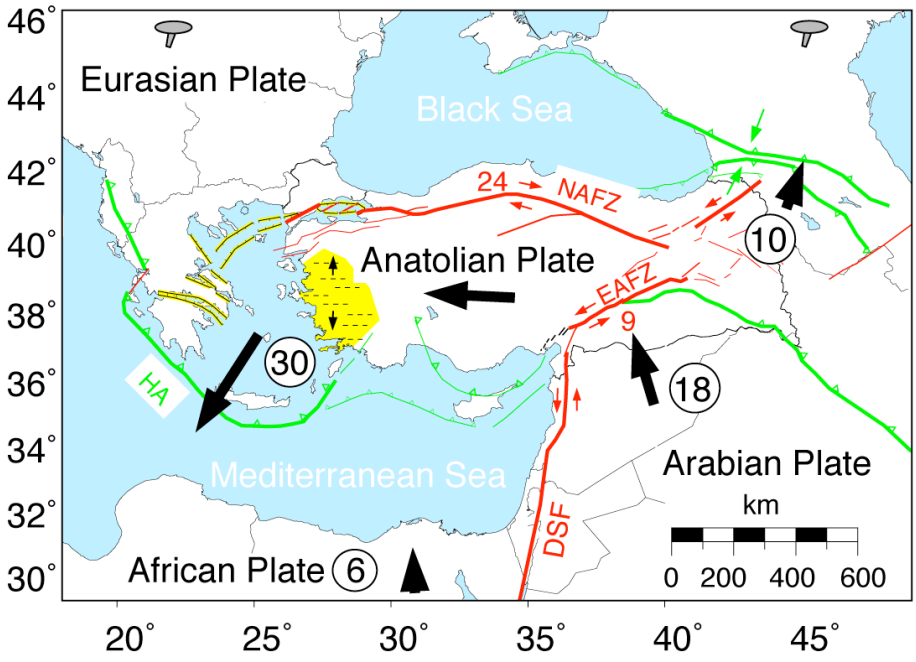
Images are from the Geological Survey of Canada

Motion of Juan de Fuca plate relative to North America (40 mm/yr arrow)



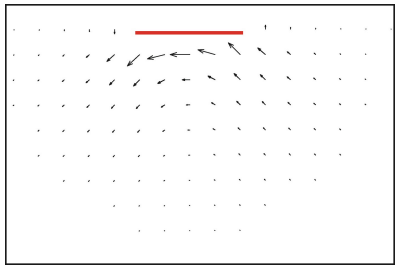

NORTH AMERICAN PLATE
EURASIAN PLATE
Mid-Atlantic Ridge
Krafla
ICELAND
Thingvellir
Reykjavik
Mid-Atlantic Ridge
ATLANTIC OCEAN


90
100
110
20
10
0
−10
Latitude (°N)
Longitude (°E)
12,000
8,000
6,000
4,000
2,000
3.7 cm yr−1
2.8 cm yr−1
3.8 cm yr−1
5.0 cm yr−1
5.7 cm yr−1
0 km 500
India
Australia
Andaman Sea
Aceh
Sunda shelf
Simeulue Island
Banyak Island
Nias Island
Pini Island
Siberut Island
Pagai Island
Enggano Island
1941 (7.7)
1881 (7.9)
1861 (>7.5)
2004 (9.2)
2002 (7.2)
1907 (7.6)
1861 (8.5)
1984 (7.2)
1935 (7.7)
1797 (8.2)
1833 (9.0)
2000 (7.9)
120 Myr
100 Myr
80 Myr
70 Myr
50 Myr
50 Myr
70 Myr

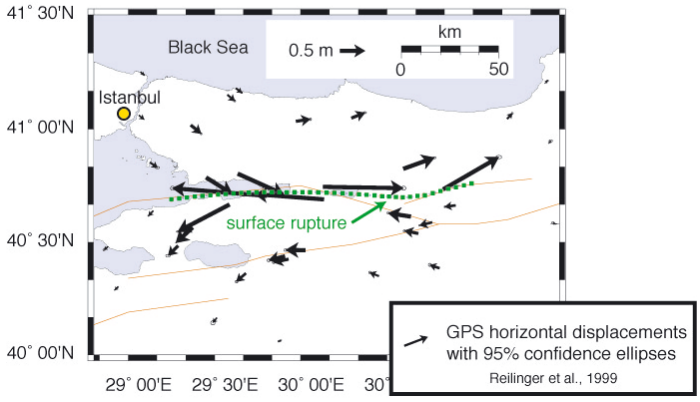


Here are horizontal surface displacements from a typical, large strike-slip earthquake.

the displacement pattern, from a model

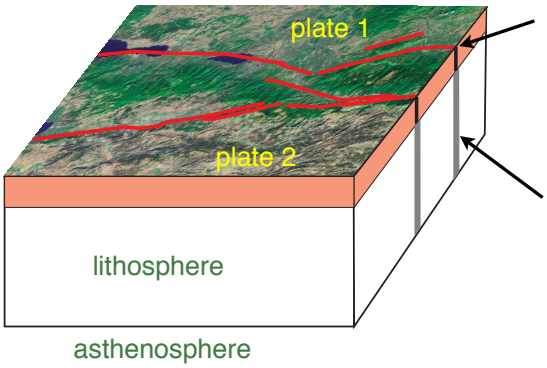


GPS surface displacements: 1999 Izmit, Turkey earthquake



Does this look like the relative motion of two non-deforming plates (or blocks)?

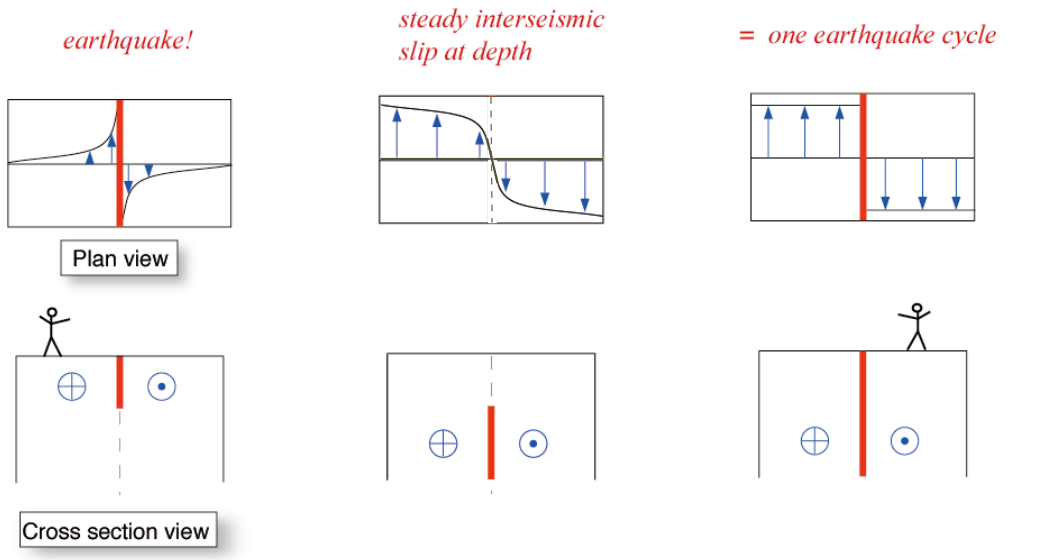
One idea about how faults work at depth



faults and earthquakes in the upper crust
plates are STUCK together in the top 15 km, except when an earthquake allows relative motion

slowly flowing (creeping) narrow zone at depth:
extends plate boundary down to the asthenosphere
STEADY "interseismic" relative motion of plates at this depth

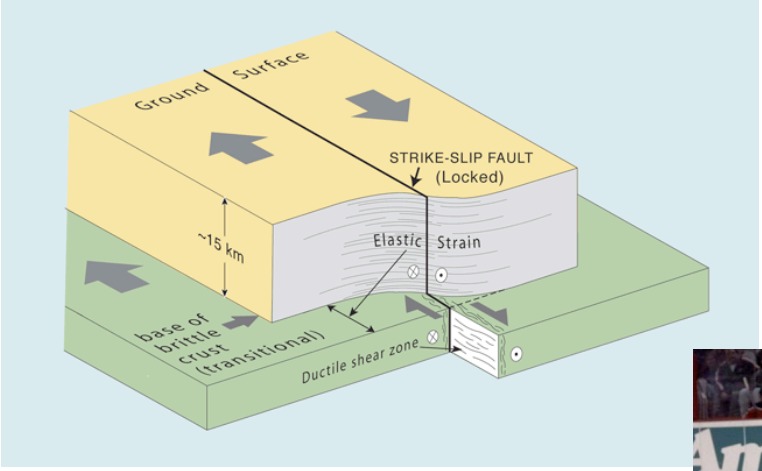
SAF model based on survey data in the Lawson Report



(1906 displacements)

slow steady motion in this sense (seen before 1906)

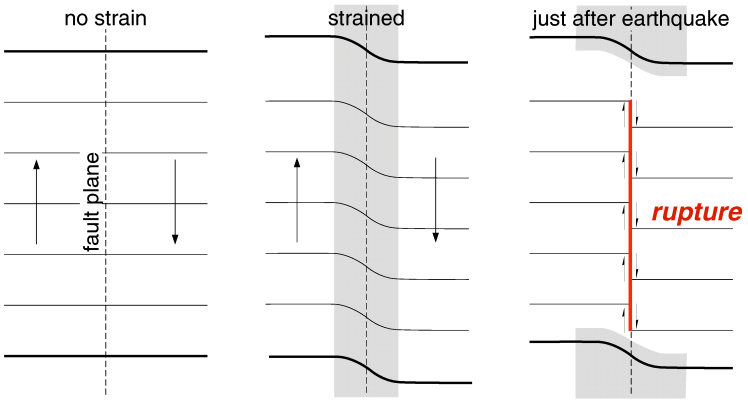
relative motion of rigid plates



If the lithosphere is elastic, then stresses build up as it warps.

Recall Hooke's Law from 1st year (or high school) physics

Elastic Rebound Theory of Reid (1908), based on survey data from the 1906 Lawson Report



Elastic stresses build up as rock deforms slowly over time

Rupture occurs when elastic stresses exceed what the fault can bear (friction).

Rocks along fault spring back to undeformed state ("elastic rebound")