Learning goals - January 16, 2012

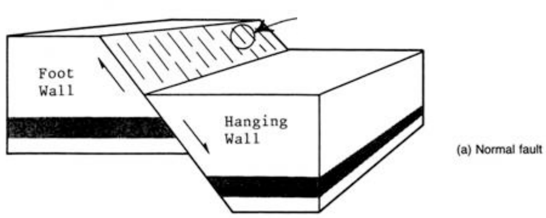
You will understand how to:

Describe the geometry of a fault
(1) orientation of the plane (strike and dip)
(2) slip vector

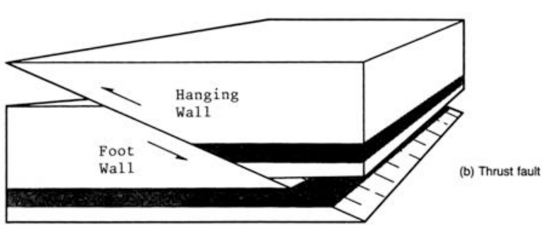
Understand concept of slip rate and how it is estimated

Describe faults (the above plus some jargon we'll need)

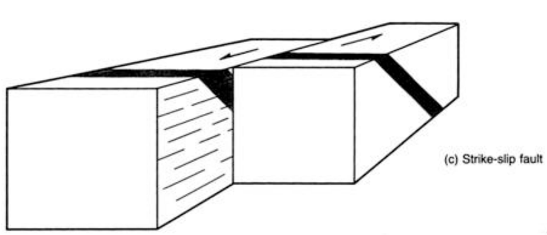
Categories of Faults (EOSC 110 version)



"Normal" fault

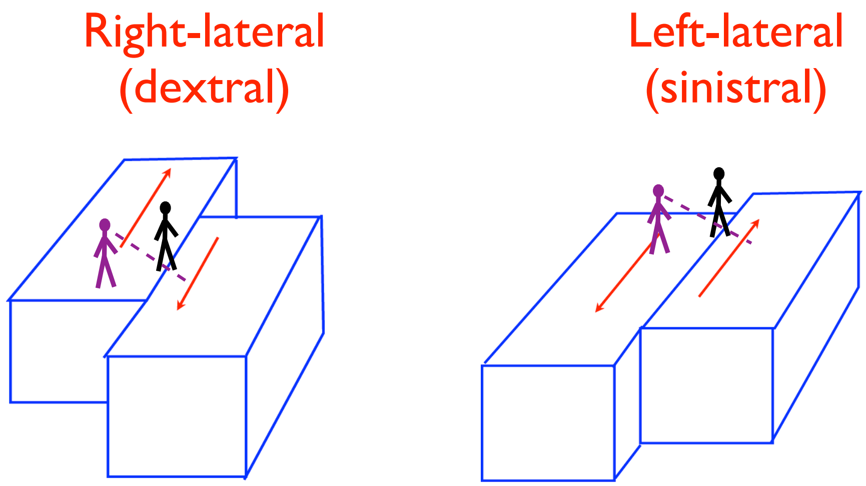


"Thrust" or
"reverse" fault



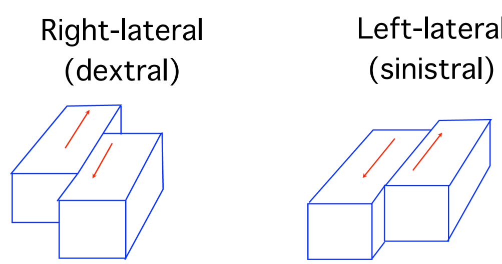
"Strike-slip" or
"transform"
faults

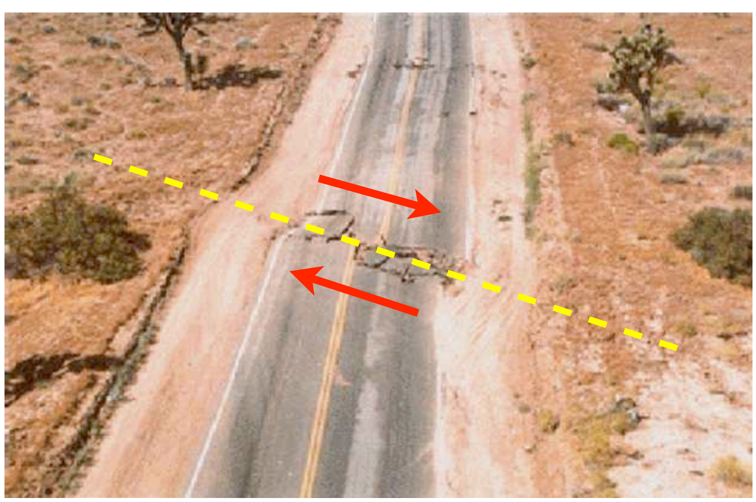
Two kinds of strike-slip faults



Stand with your feet on either side of the fault. Which side comes toward you when the fault slips?

Another way to tell: stand on one side of the fault looking toward it. Which way does the block on the other side move?





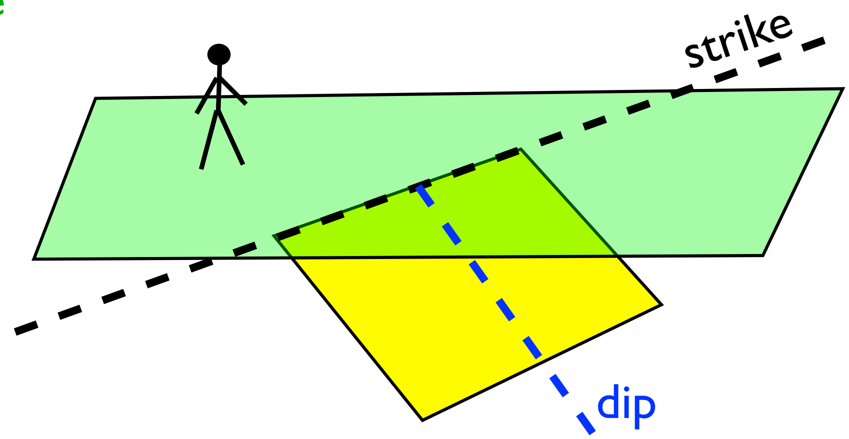
1992 M 7.4 Landers, California Earthquake rupture (SCEC)

Describing the fault geometry: fault plane orientation

How do you usually describe a plane (with lines)?

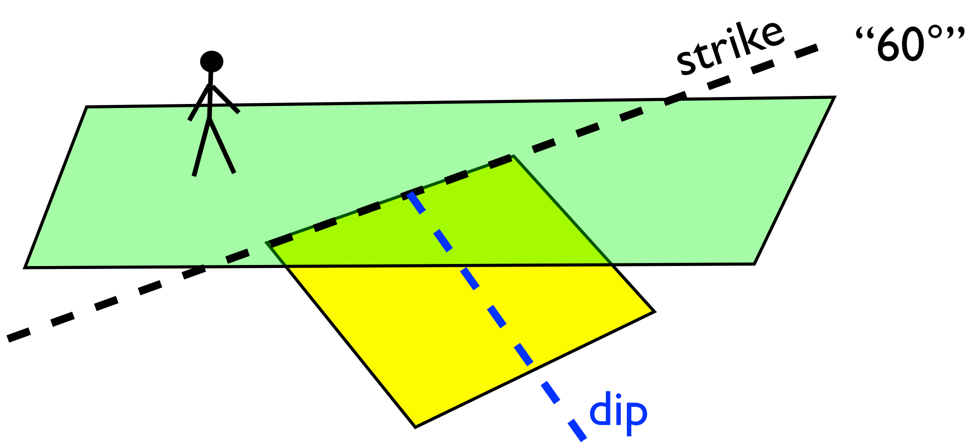
In geology, we choose these two lines to be:

- strike
- dip

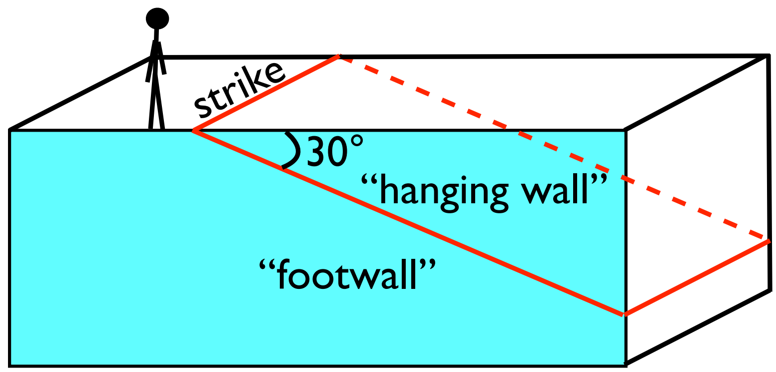


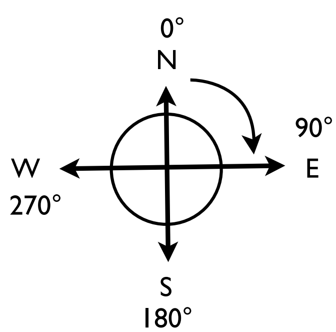
- strike is the azimuth of the line where the fault plane intersects the horizontal plane. Measured clockwise from N.

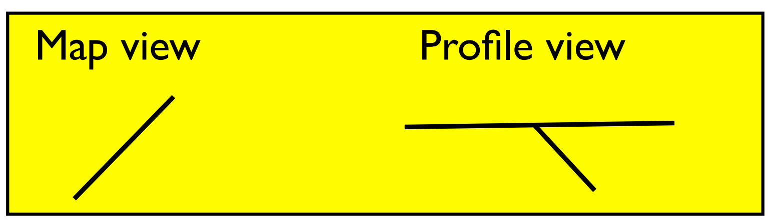
- dip is the angle with respect to the horizontal of the line of steepest descent (perpendic. to strike) (a ball would roll down it).



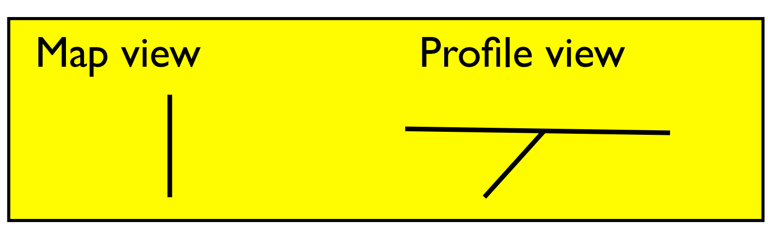
Profile view, as often shown on block diagrams





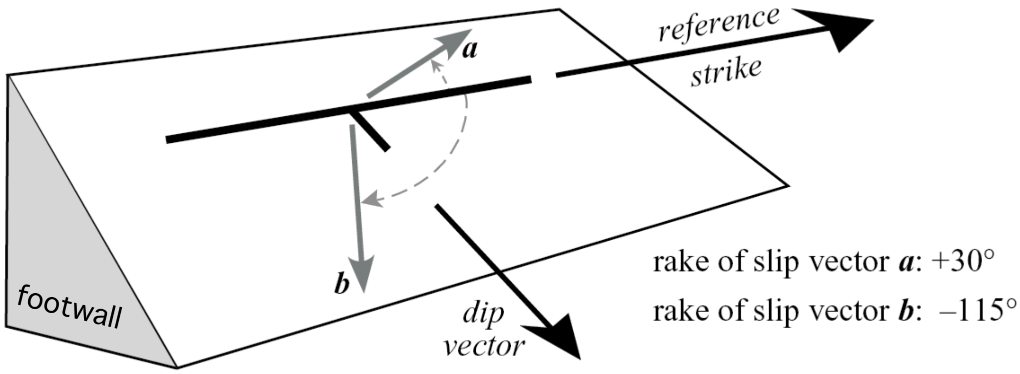


Strike? 45° | Dip? 45°



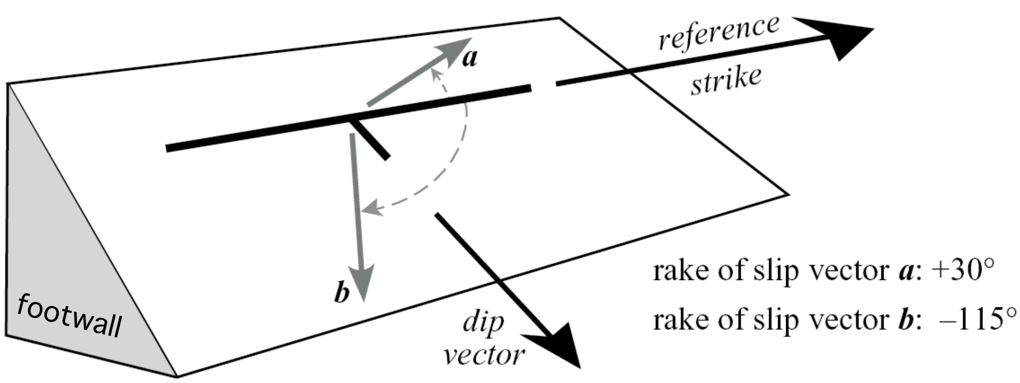
Strike? 0° | Dip? 135°

Indicating direction of slip quantitatively: the slip vector



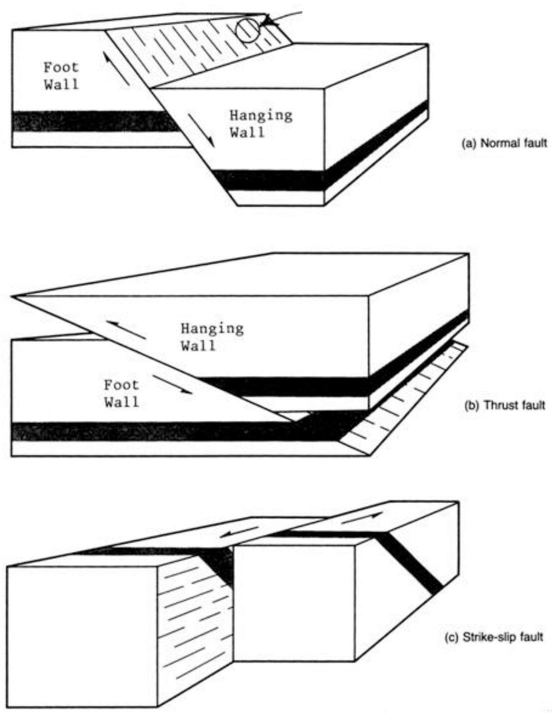
- let's define the slip direction (vector) in terms of the slip plane itself: "rake" of the slip vector, often just called "slip vector"
- convention: slip vector shows **displacement of the hanging wall relative to the footwall**, and rake values are from -180° to 180°

Indicating direction of slip quantitatively: the slip vector



- convention: slip vector shows **displacement of the hanging wall relative to the footwall**, and rake 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 faul

Categories of Faults: EOSC 256 version



"Dip-slip" faults:

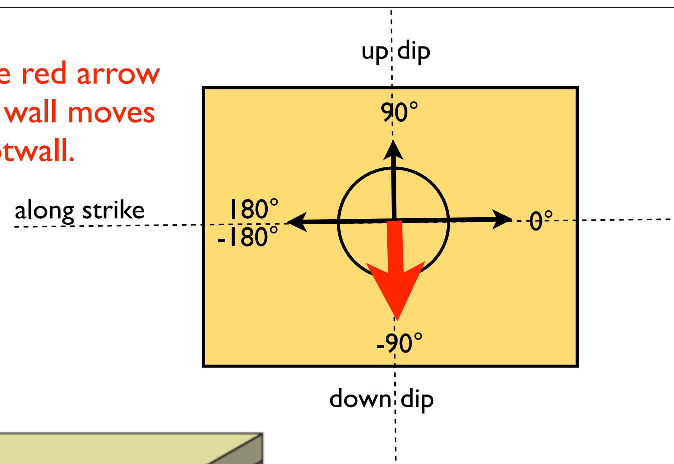
slip is parallel to <u>fault dip</u>

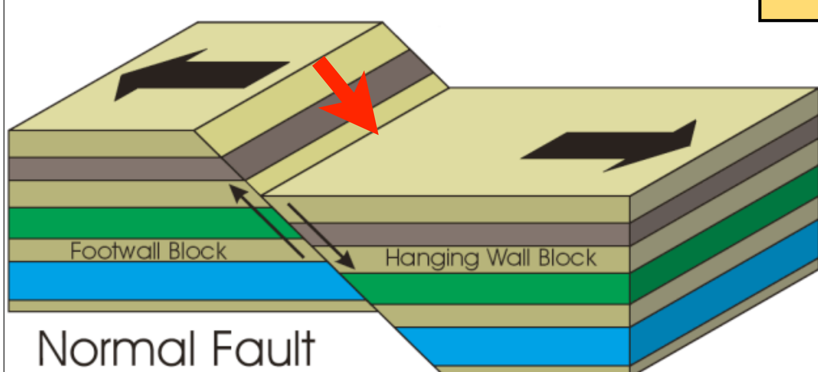
- "Normal" fault
- "Thrust" or "reverse" fault

"Strike-slip" or "transform" faults

slip is parallel to <u>fault strike</u>

In the fault plane, the red arrow shows how hanging wall moves relative to footwall.

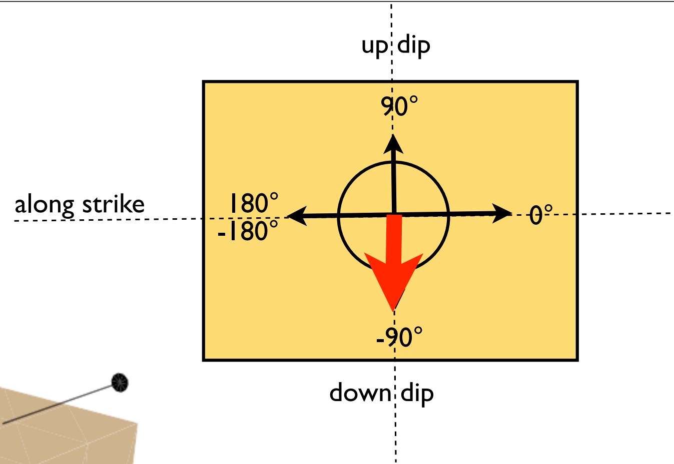


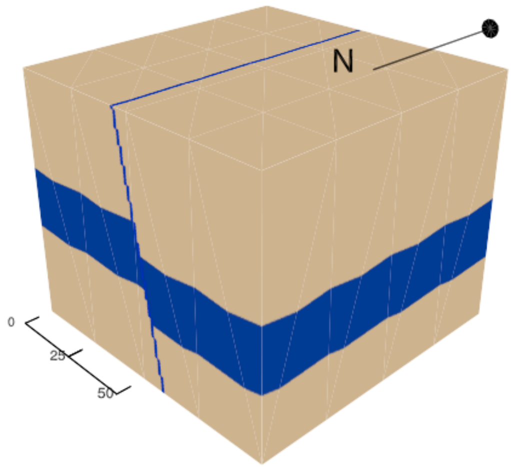


- 90° for a pure reverse fault
- -90° for a pure normal fault
- 0° for a left-lateral strike-slip fault
- 180° (or -180°) for a right-lateral strike-slip fault

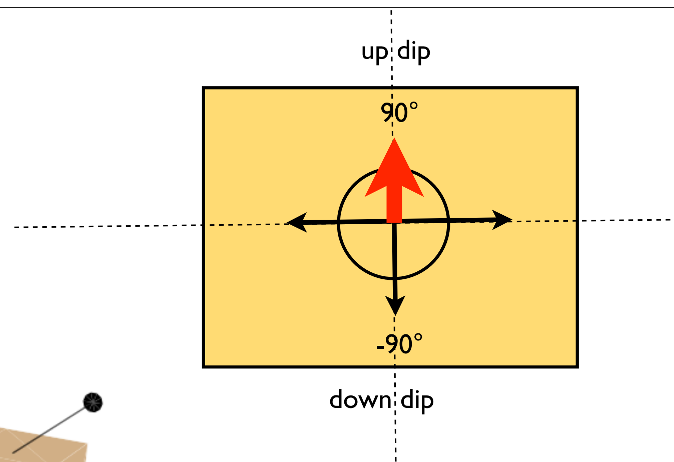
Reference: Cronin 2004
This is the geophysical/seismological convention

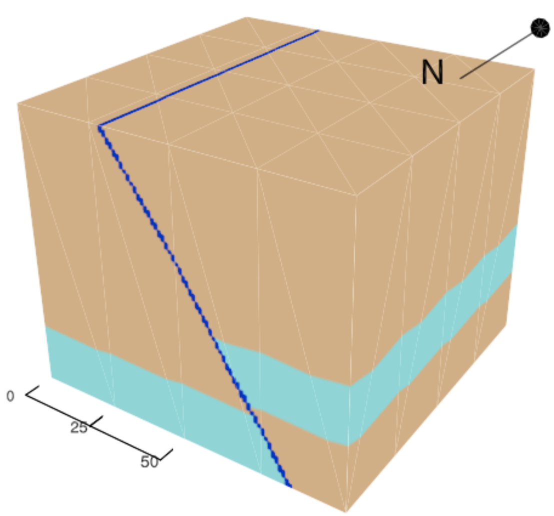
strike?
dip?
hanging wall?
footwall?



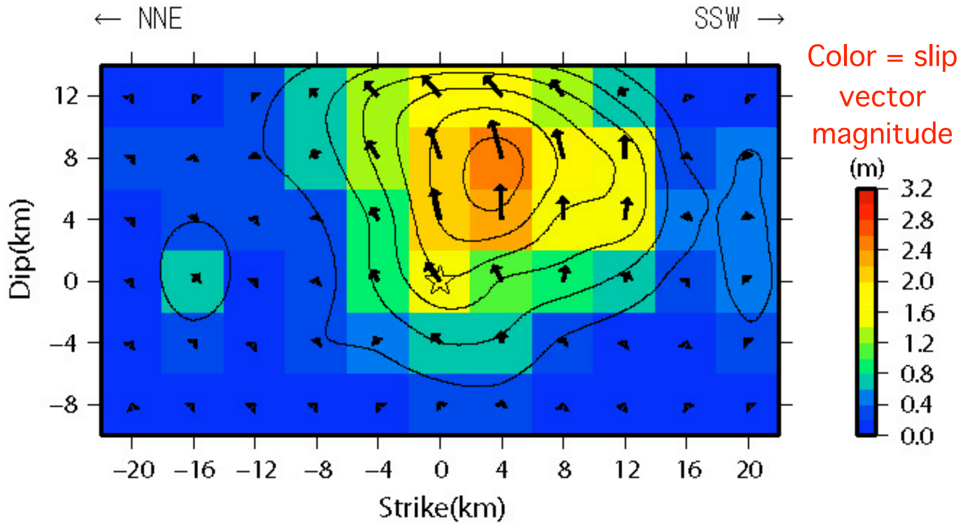


strike?
dip?
hanging wall?
footwall?





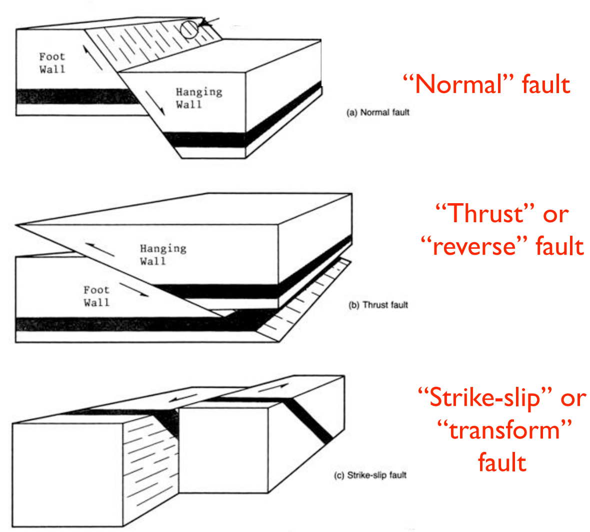
Slip distribution (with slip vectors!)
M 6.8, June 2008 earthquake in Japan



What kind of earthquake was this?

http://geology.csupomona.edu/janourse/TectonicsFieldTrips.htm

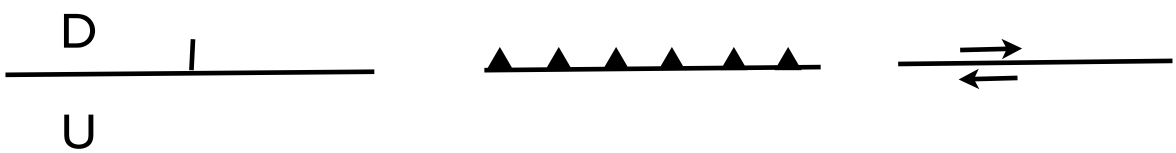
Assume we are looking along strike (like the diagrams)



This one may be an "oblique" fault: normal AND strike-slip (in and out of the screen)

Categories of Faults: map symbols

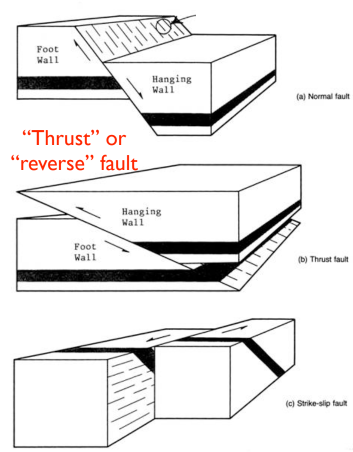
Normal fault | thrust fault | strike-slip fault



Assume we are looking along strike (like the diagrams)

"Normal" fault

"Thrust" or "reverse" fault

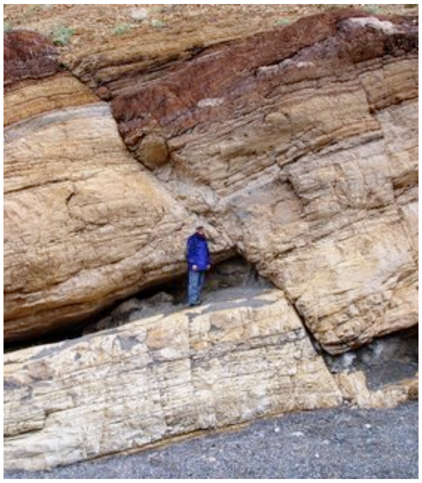


"Strike-slip" or "transform" fault

“Strike-slip” or
“transform”
fault?

“Normal” fault?

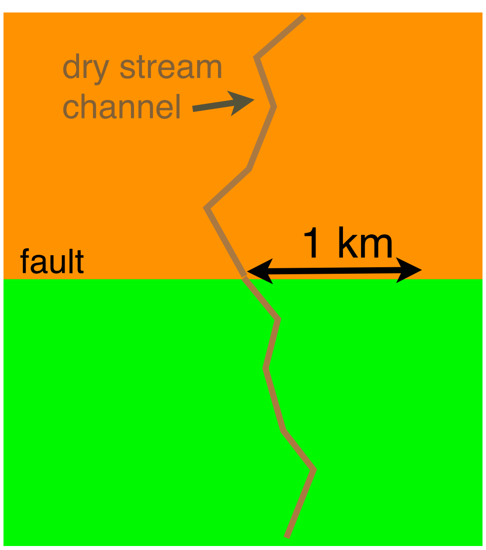
“Thrust” or “reverse” fault?



there’s just one answer

here, can we really tell?

Fault slip over geologic time



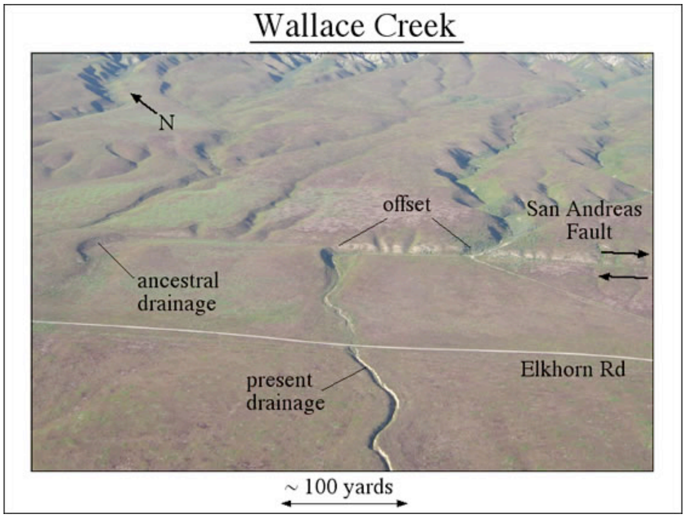
LL or RL?

1 km in 50,000 years
“slip rate” = 20 mm/yr

during this time, ~200
major earthquakes

San Andreas Fault from above

right lateral or left-lateral?



cumulative offset from many earthquakes can be tens of kilometers or more

strike-slip faults can be hard to see from above - why?

offsets of features with different ages...

How can we tell whether the fault is <u>active</u>?

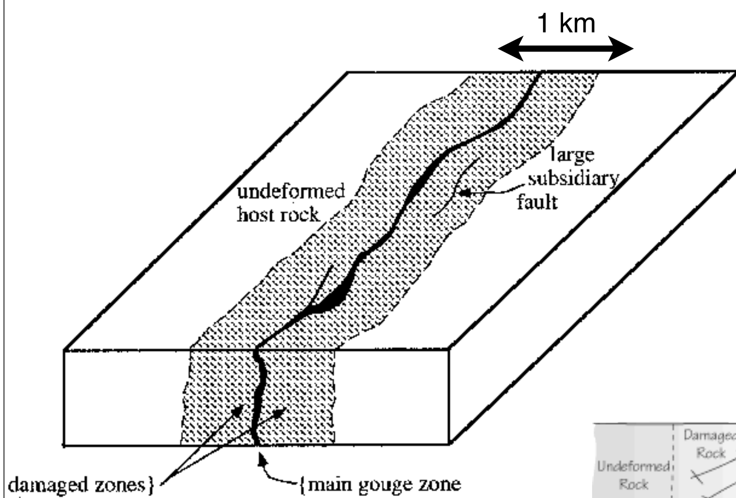
Close-up view: gouge and breccia in the fault zone (major, <u>active</u> fault)

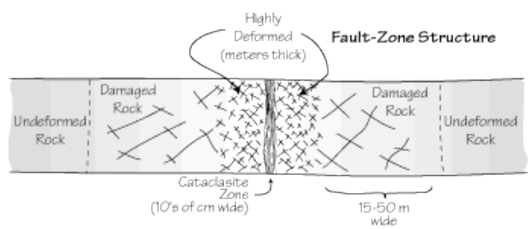
The Elsinore fault, a strike-slip fault in California: powdery <u>gouge</u> in bedrock

Close-up of <u>breccia</u>: broken up and re-cemented rock. Not as powdered as gouge.

Fault structure - major fault

(below top few hundred meters, most slip is accommodated across a zone just mm's thick!)





minor faults may lack these features

Fig. 1. Fault Zone Structure. Generalized fault zone structure showing main gouge zone along which most fault displacement occurs, surrounded by damaged zones, characterized by subsidiary deformational features (faults, fractures, cataclasis), and surrounding undeformed host rock (after Chester and Logan, 1986).