ISOSTASY AND CROSS SECTIONS (4)

I Main Topics
- A Isostasy
- B Strike view cross sections
- C Fault mechanics
- D Dikes at Spanish Peaks, Colorado (time permitting)

II Isostasy
- A General comments
  1. Provides a physical rationale for the existence of mountains
  2. Based on force balance and buoyancy concepts
     $P = \int \rho(h) g(h) dh$
     P = pressure (convention: compression is positive)
     ρ = density
     g = gravitational acceleration
     For constant ρ and constant g
     $$P = \int_0^h \rho g dh = \rho g h|_0^h = \rho g h$$
  3. Assumes a "compensation depth" at which pressures beneath two prisms are equal and the material beneath behaves like a static fluid
     $P_1 = P_2$
  4. Flexural strength of crust not considered
  5. Allows gravity measurements to be used to infer crustal thickness and density variations; can be complemented by seismic techniques
  6. Roots go back to Leonardo da Vinci
  7. Term coined by Clarence Edward Dutton (USGS)
  8. Post-1800 interest triggered by surveying errors in India
- B Pratt isostasy

  Pratt, J.H., 1855, On the attraction of the Himalaya Mountains, and of the elevated regions beyond them, upon the Plumb-line in India. Philosophical Transactions of the Royal Society of London, v. 145, p. 53-100.
  1. John Henry Pratt (June 4, 1809 - December 28, 1871)
     - A British clergyman and mathematician
     - B Archdeacon of India
  2. Pratt model invokes vertical variation in density

C Airy isostasy

Airy, G.B., 1855, On the computation of the Effect of the Attraction of Mountain-masses, as disturbing the Apparent Astronomical Latitude of Stations in Geodetic Surveys. Philosophical Transactions of the Royal Society of London. v. 145, p.101-104.

1 Sir George Biddell Airy (July 27, 1801–January 2, 1892)

A British Astronomer Royal from 1835 to 1881

B Determined the mean density of the Earth from pendulum experiments in mines

C Contributor to elasticity theory (telescope deformation)

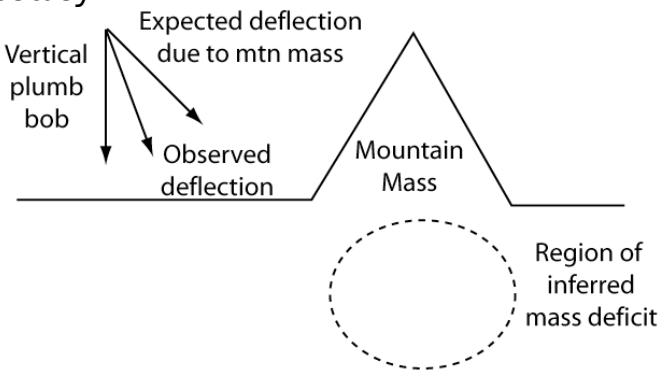
2 Airy model invokes vertical variation in density

D Thermal isostasy (e.g., Turcotte and Schubert, 2002)

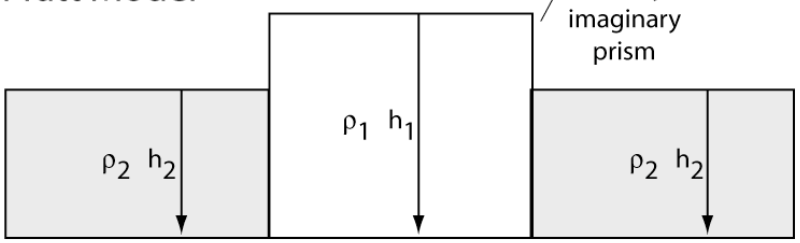
1 Oceanic crust thickens and increases in density as it cools with time

2 Oceanic crust thickens and increases in density with distance from ridge

Isostasy



Pratt Model



$\rho_1 < \rho_2$

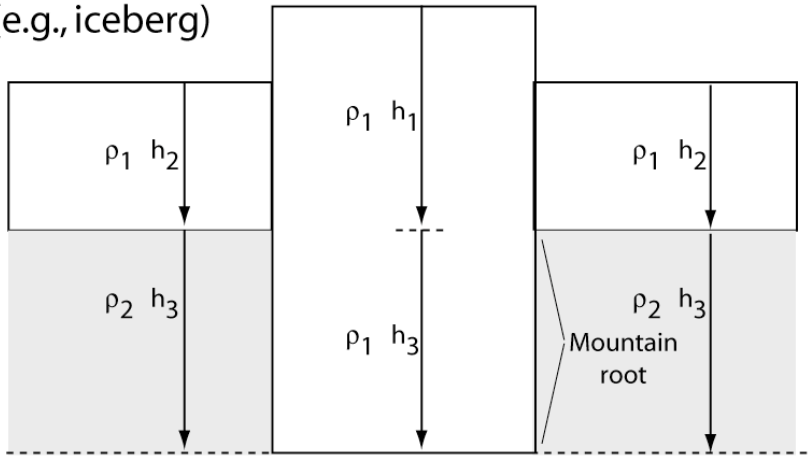
$\rho_1 g h_1 = \rho_2 g h_2$

$\rho_1 / \rho_2 = h_2 / h_1$

$(h_1)(\rho_1 / \rho_2) = h_2$

At isostatic equilibrium, P = constant at depth of compensation, so no flow

Airy Model (e.g., iceberg)



$\rho_1 < \rho_2$

$\rho_1 g h_1 + \rho_1 g h_3 = \rho_1 g h_2 + \rho_2 g h_3$

$\rho_1 (h_1 + h_3) = \rho_1 h_2 + \rho_2 h_3$

$(h_1 + h_3) = h_2 + (\rho_2 / \rho_1) h_3$

$(h_1 + h_3) - (\rho_2 / \rho_1) h_3 = h_2$

At isostatic equilibrium, P = constant at depth of compensation, so no flow

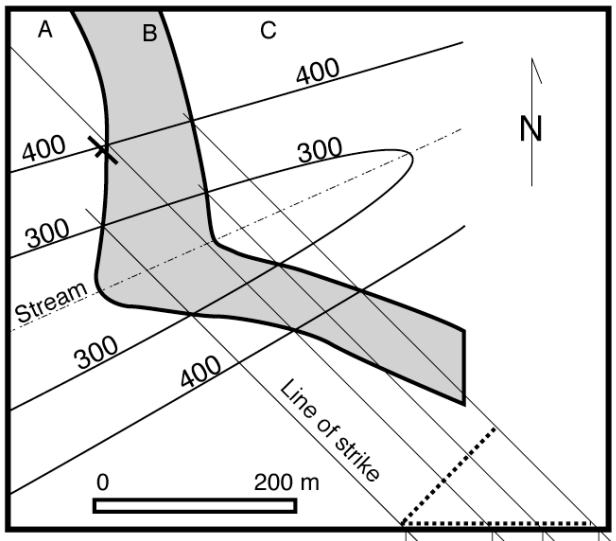
III Strike-view cross sections

A Prepared by projecting features along strike onto a cross section plane, where the cross section plane is perpendicular to strike

B Shows the true inclination and thickness of features

C Lines of strike lie in geologic planes and connect points of equal elevation

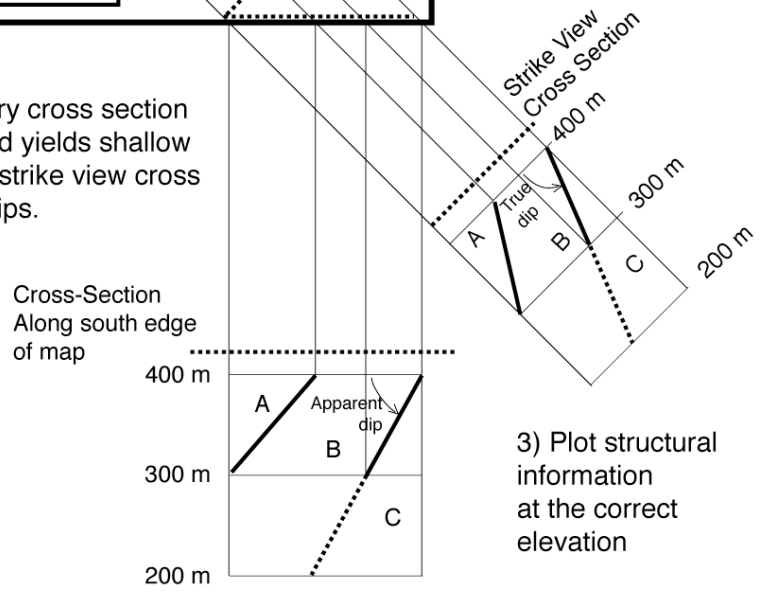
PROJECTION OF STRUCTURAL INFORMATION ONTO CROSS SECTIONS



1) Determine the direction of bed strike

2) Project structural information from the map along strike onto the cross section plane. The projection lines are parallel to lines of strike.

Note that the arbitrary cross section is "stretched out" and yields shallow apparent dips. The strike view cross section yields true dips.



3) Plot structural information at the correct elevation

In a strike view cross section the cross section plane is like a window that you look through and see along strike. In an arbitrary cross section the view is generally not along strike.

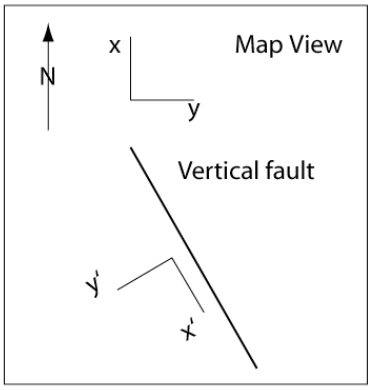
Note that the horizontal scale on the map is the same as the horizontal scale and vertical scale in the cross section.

IV Fault Mechanics

Fault Mechanics

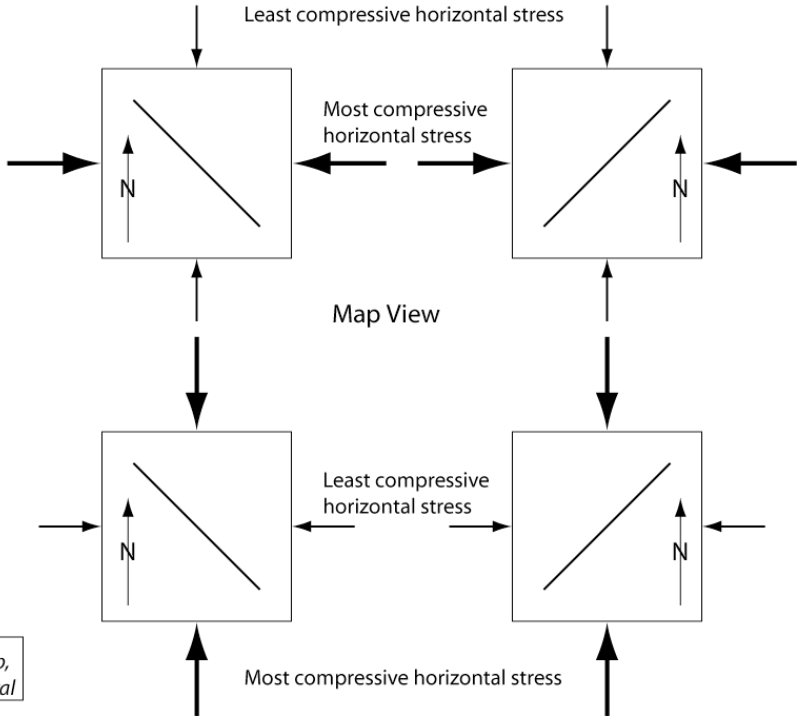
Vertical Strike-slip Faults

Assume one principal stress is vertical, two principal stresses are horizontal



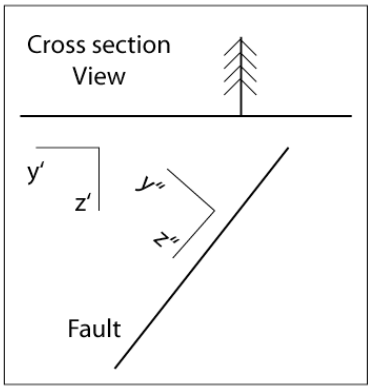
The x′ axis is parallel to fault strike
The y′axis is normal to fault strike
The z′ axis points down
If $\sigma_{y'x'} > 0$, left-lateral faulting
If $\sigma_{y'x'} = 0$, no faulting
If $\sigma_{y'x'} < 0$, right-lateral faulting

Draw the arrows showing how the faults would slip, and determine whether the slip is right- or left-lateral



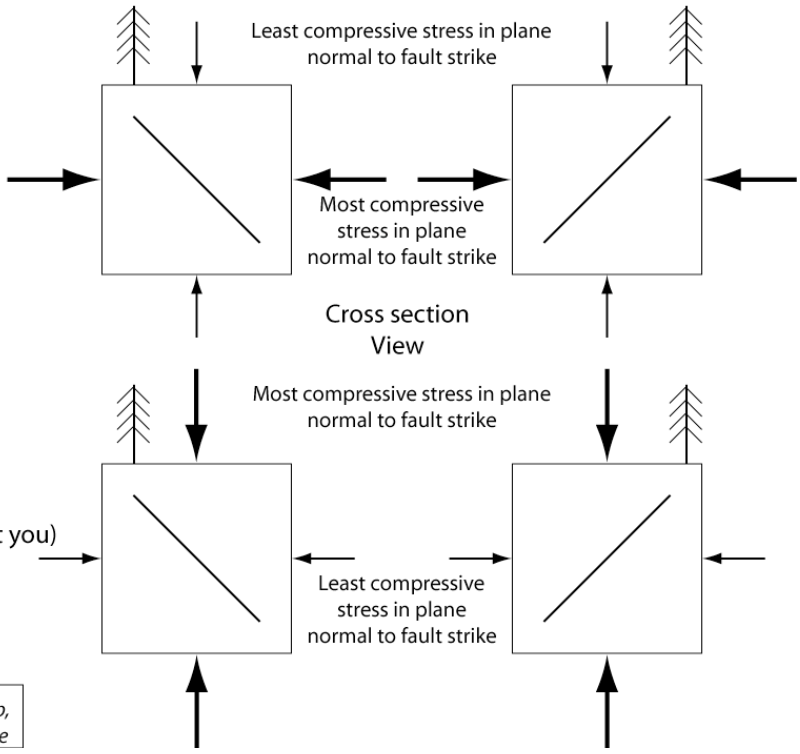
Non-vertical Dip-slip Faults

Assume one principal stress is vertical, two principal stresses are horizontal, and the horizontal principal stresses are parallel and normal to fault strike.



The x″ axis is parallel to fault strike (at you)
The y″ axis is normal to the fault
The z″ azis points down-dip
If $\sigma_{y''z''} > 0$, lnormal faulting
If $\sigma_{y''z''} < 0$, reverse faulting

Draw the arrows showing how the faults would slip, and determine whether the slip is normal or reverse



V Dikes at Spanish Peaks (see paper by Ode on GG303 web page)