GG612
Structural Geology Section
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Lecture 1

Philosophy

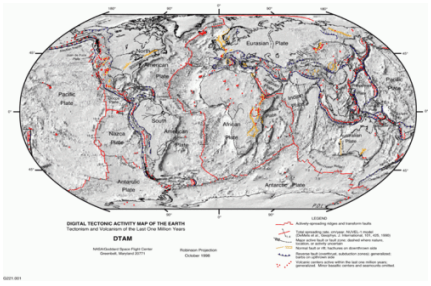
Orientation of Lines and Planes in Space

Lecture Topics

1 Introduction
   A. Philosophy
   B. Orientation of lines and planes in space
2 Rock structures
   A. Fractures
   B. Folds
3 Stress and strain
4 Isostacy

Class Themes

- The crust of the earth is deformed at many scales, locations, and times; this deformation produces identifiable structures in the crust such as fractures and folds.

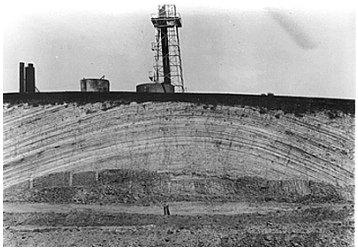


http://upload.wikimedia.org/wikipedia/commons/thumb/b/b4/Plate_tectonics_map.gif/500px-Plate_tectonics_map.gif

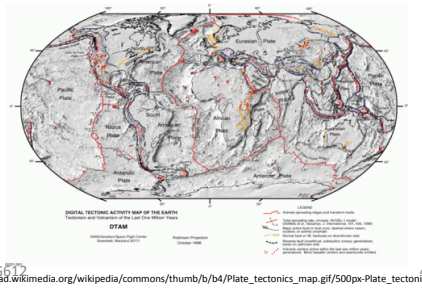
http://en.wikipedia.org/wiki/File:Caledonian_orogeny_fold_in_King_Oscar_Fjord.jpg

Class Themes

- An appreciation of earth structures has both enormous practical value and profound intellectual implications for how we view this planet.



http://rst.gsfc.nasa.gov/Sect5/OilAnticline.jpg



http://upload.wikimedia.org/wikipedia/commons/thumb/b/b4/Plate_tectonics_map.gif/500px-Plate_tectonics_map.gif

Class Themes

- Recognition and characterization of major structures in the earth's crust and ways to gain insight into how these structures form.

http://www.teachingboxes.org/mountainBuilding/lessons/foldImages/anticline.jpg

http://www.rockcanyonutah.com/wp-content/uploads/2010/10/Studying-Geology.jpg

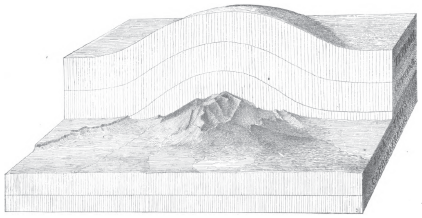
http://irapl.altervista.org/com/albums/geolus-09/06897-Wax-model-of-mountain-making-experiments-by-Bailey-Willis--1891-.jpg

Class Themes

- Earth's crust as a mechanical system

G.K. Gilbert (1843-1918)

http://www.esacademic.com/pictures/eswiki/71/Grove_Karl_Gilbert.jpg

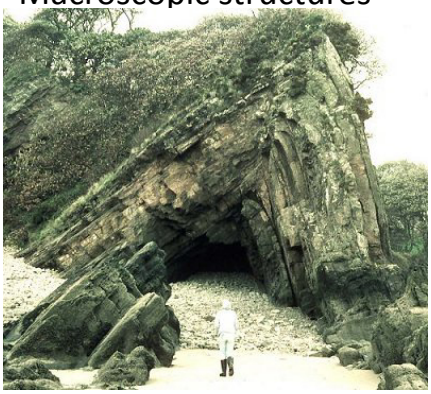


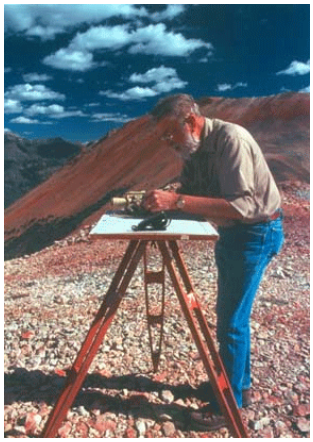
http://www.public.asu.edu/~mjungers/HenryMountains_frontispiece.PNG

http://3dparks.wr.usgs.gov/pp1515/chapter6/fig6-8.jpg

Class Themes

- Macroscopic structures

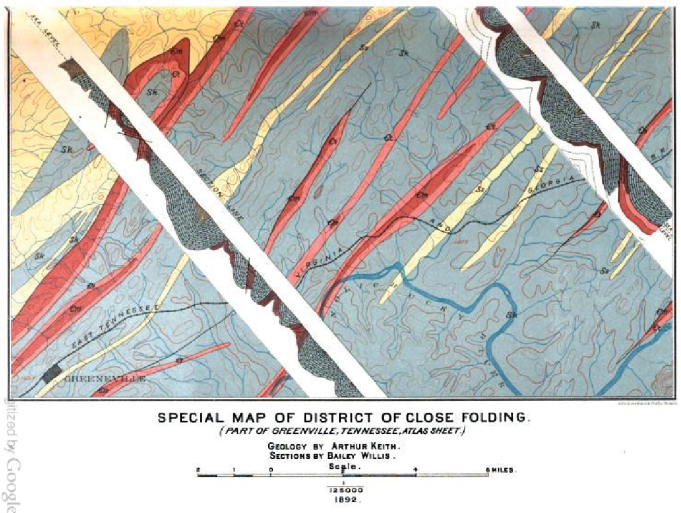




http://www.rci.rutgers.edu/~schlisch/structureslides/chevron.jpg

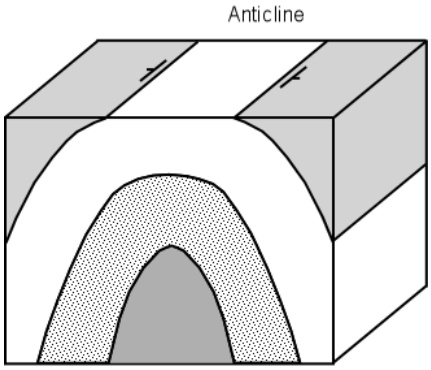
http://www.ouraycountyhistoricalsociety.org/dropped_image.gif

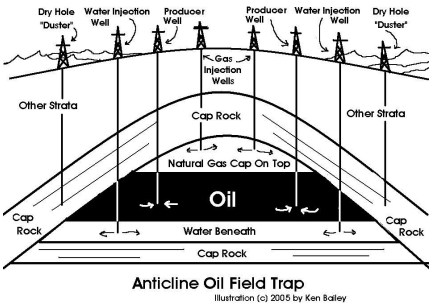
Class Themes Visualization



From Willis, B., 1894, The Mechanics of Appalachian Structure

Class Themes
Visualization





http://www.tulane.edu/~sanelson/images/anticline.gif

http://picasaweb.google.com/maryhefley4/HistoricRangelyOilField#

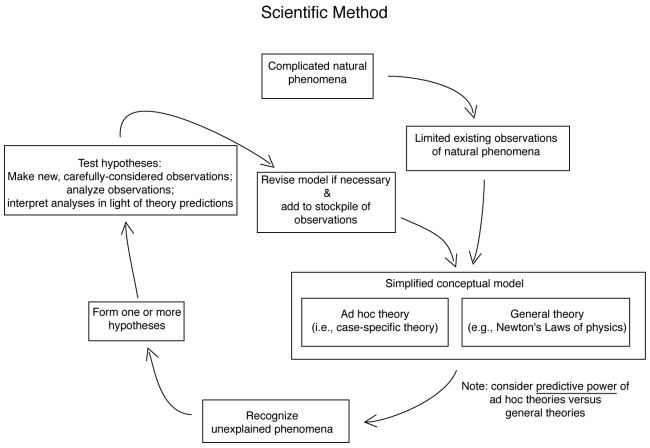
Introduction/Philosophy/Science

- Science
  - Possession of knowledge as distinguished from ignorance or misunderstanding;
  - Knowledge attained through study and practice
  - Knowledge covering general truths or the operation of general laws especially as obtained and tested through the scientific method
- Scientific Method

  Principles and procedures for the *systematic* pursuit of knowledge involving the *recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses.*
- Fundamental concepts vs. vocabulary; critical thinking vs. cookbooks
- Quantitative predictions (Where, when, how big?)

The Scientific Method

Fig. 1.1



Mechanistic Approach to Structural Geology

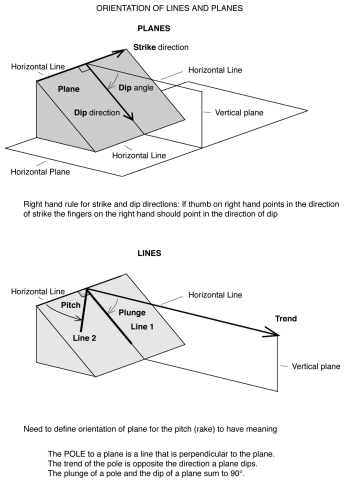
Topic	Definition	Application to structural geology
Descriptive geometry	The representation of the spatial relationships of points lines and planes by means of projections	Used to describe the geometry of deformed or undeformed bodies. Relies on good field work (e.g., preparation of geologic maps)
Kinematics	The study of the position of bodies through time without regard to the causative forces	Used to describe how a body changes shape and/or position through time
Mechanics	The study of forces and their effects on bodies, and in particular how bodies deform in response to forces	Used to understand and predict how bodies deform

Key Steps in Structural Analyses

- Geometric analysis
  - Establish location, size, orientation, shape of individual elements
  - Establish relative positions and orientations of a collection of elements
- Kinematic analysis
  - Establish sequence of deformational events
  - Establish (or infer) initial, intermediate, and final geometry of bodies (e.g., undeformed and deformed states; initial and final positions, etc)
- Mechanical analysis
  - Conceptual model
  - Establish boundary conditions (e.g., pressure on boundaries)
  - Set governing equation (reflect rheology of material)
  - Find general solution of governing equation
  - Solve governing equation to fit boundary conditions
  - Compare with field observations

Geometry of Lines and Planes

- Lines
  - Trend: Bearing of the projection of a line into the horizontal plane
  - Plunge: Inclination of a line below the horizontal plane
- Planes
  - Strike
    - Bearing of a horizontal line contained in a plane
    - Bearing of a line connecting two points of equal elevation in a plane
  - Dip
    - Inclination of a plane below the horizontal plane
    - The maximum inclination of any line contained in a plane
- Pole to a plane: A line that is normal to a plane



Geologic Conventions for Measuring Orientations

Compass Bearings

- By quadrant (relative to north or south). The angle does not exceed 90°
- By 360° azimuth (0° - 360°)

Examples

N0°E	N45°E	N90°E	S45°E	S0°E	S45°W	S90°W	N45°W
0°	45°	90°	135°	180°	225°	270°	315°

Lines

Trend: A compass bearing

Plunge: An inclination below horizontal

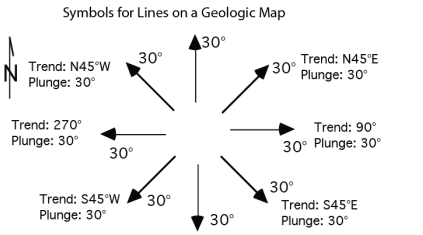
The lines to right all plunge at 30°. Their trends vary according to the table.

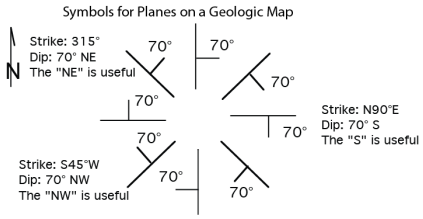
Planes

Strike: A compass bearing along a horizontal line in a plane

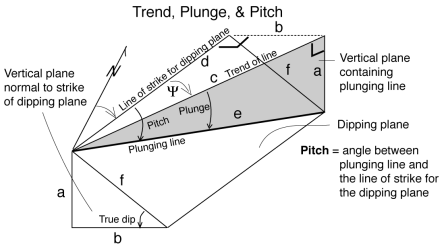
Dip: An inclination below horizontal

The planes to right all dip at 70°. Their strikes vary according to the table.





Trend, Plunge, & Pitch of a Line



	plunge (ϕ)	pitch (Ω)	dip (δ)	Ψ
sin	a/e	f/e	a/f	b/c
cos	c/e	d/e	b/f	d/c
tan	a/c	f/d	a/b	b/d

(1) Trend = θ = strike + Ψ = strike + $\cos^{-1}$ (d/c) = strike + $\cos^{-1}${(cos Ω)/(cos ϕ)}

(2) Trend = θ = strike + Ψ = strike + $\tan^{-1}$ (b/d) = strike + $\tan^{-1}${(cos δ)(tanΩ)}

(3) Plunge = ϕ = $\sin^{-1}$ (a/e) = $\sin^{-1}$ {(sin δ)(sinΩ)}

(4) Pitch = Ω = $\sin^{-1}$ (f/e) = $\sin^{-1}$ {(sinϕ) / (sin δ)}