GG611
Lecture 3
Geologic Maps and Cross Sections
GEOLOGIC MAPS AND CROSS SECTIONS

I Main Topics
A Why make geologic maps?
B Construction of maps
C Contour maps
D Introduction to geologic map patterns
E Structure contours
F Strike of beds on a geologic map
G Appearance of planar beds on a geologic map
H Appearance of folded beds on a geologic map
The First Geologic Map of Britain by William Smith, 1815

http://upload.wikimedia.org/wikipedia/commons/9/98/Geological_map_Britain_William_Smith_1815.jpg
Portion of the Geologic Map of the Bright Angel Quadrangle

http://facweb.northseattle.edu/tbraziunas/geol101tb_partial/images/bright6a.gif
Geologic Map of Kauai

http://www.flickr.com/photos/59798762@N00/5384685047/in/set-72157626858828635/lightbox/
Geological Map of the Confluence of the Rio Patuca and Rio Wampu, La Mosquitia, Honduras

http://geology.csustan.edu/rrogers/honduras/map2v1c.jpg
GEOLOGIC MAPS AND CROSS SECTIONS

II Why make geologic maps?
A Documentation of structural geometry (and sequence of events)
B To force us to look closely; maps act like a tool for observation
C Pattern recognition at a useful and appropriate scale. Many structures are too large or outcrop is too poor to see otherwise.
D To develop conceptual models for kinematic and mechanical reconstructions of how structures form
E To help define boundary conditions for mechanical models
III Construction of maps

A Establish control points on ground and map

B Transfer geologic information at or near control point to map

C Link information between control points
IV  Contour maps: Maps that represent surfaces in terms of a series of curves
A  An individual contour represents a part of the surface along which the surface "value" is constant.
B  Topographic contour map: contour lines represent points of equal elevation of the ground surface.
   1  Streams flow downhill (contours vee upstream)
   2  Contours for a ridge "point" down the ridge
GEOLOGIC MAPS AND CROSS SECTIONS

C Structure contour map: contour lines represent points of equal elevation along a geologic surface (e.g., the top of a geologic unit) that commonly is buried. If the values of a structure contour map are subtracted from the values on a corresponding topographic map, the difference gives the depth from the ground surface to the top of the geologic unit.

D Isopach contour map: contour lines represent points of equal thickness of the geologic unit

E Given a data set \((x, y, z)\), one can prepare a contour map of \(z\) (e.g., concentration of contamination in ground water) vs. \((x, y)\)

- See last page in notes of Lec. 4 -
V Introduction to geologic map patterns

A Geologic maps show the intersection (trace) of geologic features with the ground surface, a surface that is generally subhorizontal but irregular (i.e., with 3-D relief).

B Geologic maps are not top views of subsurface features as projected into a horizontal plane.

http://facweb.northseattle.edu/tbraziunas/geol101tb_partial/images/bright6a.gif
V Introduction to geologic map patterns

C The strike of a geologic surface is obtained by determining the azimuth between two points on the geologic surface that have the same elevation (i.e., that lie along the intersection of the geologic surface and a horizontal plane).
V Introduction to geologic map patterns

D The contacts of horizontal layers parallel elevations contours.

http://facweb.northseattle.edu/tbraziunas/geol101tb_partial/images/bright6a.gif
V Introduction to geologic map patterns (cont.)

E The contacts of vertical geologic surfaces appear as straight lines on geologic maps with a topographic base.

http://facweb.northseattle.edu/tbraziunas/geol101tb_partial/images/bright6a.gif
VI Structure contours

A A line or curve (contour) that marks the intersection of a horizontal plane with a geologic surface. Strike lines are tangent to structure contours (see Fig. 5.1).
VI Structure contours (cont.)

B  A geologic map can be thought of as the collection of points marking the intersections between structure contours (red) and the corresponding black topographic contours.

C  A strike view cross section is taken perpendicular to the strike of a geologic unit. It shows the true dip and true thickness of the unit.
VII Strike of beds on a geologic map

A Lines of strike are horizontal (i.e., a series of points of equal elevation). For a surface (or layer) of constant strike, a line of strike (i.e., a traverse at equal elevation) lies along the surface (or layer) rather than cutting across the surface (or layer); (see Fig. 5.3).
VII Strike of beds on a geologic map (cont.)

B Lines of strike can be determined by locating where a contact intersects a given contour line in more than one point; these points of intersection lie along strike. This is easiest where a contact is steep.
VIII Appearance of planar beds on a geologic map

A Planar beds have a constant strike and a constant dip

B Strike lines along structure contours are parallel and straight

C Strike lines along structure contours are evenly spaced

D Dip direction is constant
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IX  Appearance of structure contours along a folded bed

A  The strike and/or dip of a folded bed varies with position

B  Strike lines along structure contours might or might not be parallel; the strike of folded layers does not necessarily change.
   1  If strike lines are parallel, then the strike is constant (±180°) and the axis of the fold is horizontal
   2  If strike lines are not parallel, then the strike is not constant and the axis of the fold plunges (e.g., fold with a vertical fold.
IX Appearance of folded beds on a geologic map (cont.)

C If a folded layer changes dip, then strike lines along structure contours with a uniform contour interval will not be evenly spaced.

D Dip direction and magnitude may or may not be constant (e.g., fold with a horizontal fold axis).

E Cross sections and maps together are powerful 3-D visualization tools, whether on paper or on a computer.
% Matlab script for producing contour map examples
x=-2:0.2:2; % Values of x range from –2 to +2;
y=-2:0.2:2; % Values of y range from –2 to +2;
[X,Y]=meshgrid(x,y); % Makes grid of x and y at each point;
z=peaks(X,Y); % Matlab’s “peaks” function;
clf % Clears any prior plots;
subplot(2,2,1) % First plot of 2 rows and 2 columns
surf(X,Y,Z); % 3-D perspective plot;
xlabel('x') % Labels the x-axis as ‘x’;
ylabel('y') % Labels the y-axis as ‘y’;
title('Surface Plot of the Peaks Function')

clf
subplot(2,2,2) % Second plot of 2 rows and 2 columns;
c=contour(X,Y,Z); % Calculates the contour line positions;
clabel(c) % This plots and labels the contour map;
xlabel('x') % Labels the x-axis as ‘x’;
ylabel('y') % Labels the y-axis as ‘y’;
title('Contour Plot of the Peaks Function')

[Dx,Dy]=gradient(Z,.2,.2); % Computes the gradient
subplot(2,2,3) % Third plot of 2 rows and 2 columns;
contour(X,Y,Z) % Plot the contour lines
hold on % Allows arrows to plot on contour plot;
quiver(X,Y,-Dx,-Dy); % This plots the arrows;
colormap hsv % Assigns the hsv color scheme to plot;
grid off % Turns off plotting of grid;
hold off
xlabel('x') % Labels the x-axis as ‘x’;
ylabel('y') % Labels the y-axis as ‘y’;
title('Contour Plot and Negative Gradient of Peaks Function')

clf
subplot(2,2,4) % Fourth plot of 2 rows and 2 columns;
contour(X,Y,[0 0]) % Plots one contour line (here it's 0);
xlabel('x') % Labels the x-axis as ‘x’;
ylabel('y') % Labels the y-axis as ‘y’;
title('Zero Contour of Peaks Function')