DIGITIZING FIELD MAPS AND CONSTRUCTING BALANCED CROSS SECTIONS WITH AUTOCAD

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AutoCAD is a menu and command driven graphics package that can be used to construct geologic maps and balanced cross sections with a high degree of accuracy and a low degree of frustration. This very general and very basic guide is designed to minimize your frustration by pointing out some helpful hints.

AutoCAD contains many commands and routines which don't need to be considered when constructing geologic maps and cross sections. This guide points out steps and hints that *do* need to be considered when constructing these drawings. The commands mentioned here are scattered throughout the AutoCad tutorial and working through the tutorial before reading this guide is advised. This guide should be used in conjunction with the AutoCAD manuals, be familiar with them. **I've only included things that aren't immediately evident and can cause problems if you don't consider them when you first start out.** For other aspects, I've suggested checking the manual because they are helpful but not fatal if you don't use them.
It is assumed the reader is at the first COMMAND prompt in AutoCAD.

Digitizing a map into AutoCAD (advised initial steps):

　　　1) Before going near the computer, manually construct an accurate orthogonal grid over your map. This grid should consist of units of useful dimension (i.e. kilometers, miles). It is often helpful to orient the grid parallel to north-south and east-west directions on the map.
　　　2) In front of you now should be your map with a ruler-sketched orthogonal grid on it. Secure this map onto the digitizing board such that the lower left (usually southwest) corner is within the digitizing area. If the map is larger than the digitizing board, fear not, when you are ready to digitize portions of the map presently not on the board you can, provided your initial grid is accurate and consistent.
　　　3) Now you want to set the units you will be working in during this particular drawing. The units you select here will stay with this drawing during subsequent AutoCad sessions unless you change them. The UNITS command yields several subcommands all of which are self explanatory. I list some common responses here.

Type UNITS at the COMMAND prompt (enter).
　　　a) Select your preferred drawing units, usually decimal (enter).

b) Choose the number of digits you want to appear to the right of the decimal point in any number that hereafter comes into play. This is your resolution. I suggest using the same resolution as your filed data (enter).
c) Choose decimal degrees here, unless your work requires another form (enter).
d) Choose the number of fractional places for angles (i.e. 45.1234 degrees)(enter).
e) Choose the direction you desire for angle zero. If you want north to be zero, then select 90 at the prompt (enter).
f) Select the direction you want angles to be measured. This may vary from map to map (enter).

Now you have set the drawing units you will be working in. The trick now is to make these units correspond with your map units and field data.

4) Next you need to calibrate your map to the on-screen drawing. The TABLET command is the one you want. It has several subcommand choices, CAL is the one needed to calibrate.

Type TABLET at the COMMAND prompt (enter).
a) Choose CAL by typing CAL (enter).
b) At the "select first point" prompt, take the puck and center the cross hairs on the southwestern-most grid intersection on your map. Depress the puck button to select the point. You must be accurate here, lest error be propagated throughout.
c) Now enter the coordinates you want to define this point with (i.e. 0,0 for the origin of a Cartesian system)(enter).
d) With the puck, point to another grid line intersection (maybe the intersection of the fifth longitudinal line from the left with the fifth latitudinal line from the bottom- 5,5).
e) Enter the coordinates (5,5 if this is where you pointed).

Now you have calibrated the map with the screen. Hopefully the drawing units you chose correspond with the coordinates listed. That is, point (5,5) represents a point on the map 5 kilometers east and 5 kilometers north of the origin point (0,0). If not, you might have just created a problem for yourself that will become apparent when its too late. Everytime you begin an editing session, you must re-calibrate the map.

5) The LIMITS command will allow you to set the size of the grid in which your work can appear. For example, if you suspect the drawing will be 10 units long and 10 units high, and if the origin is in the lower left of the drawing, then (10,10) will give you enough space to work in. I suggest making these limits larger than you need them, AutoCad doesn't care. These limits can be altered later if you need to expand the drawing.

A word about modes:

AutoCAD can operate in several different modes simultaneously.

Tablet Mode: When digitizing you must be in tablet mode. If the word "tablet" appears in the upper left part of the screen you are in tablet mode which means the position of the puck on the digitizing board is calibrated to your map. "Ctrl T" or F10 activates and deactivates tablet mode, it is a toggle. *The pull down menus can not be reached when tablet mode is on.*

Display Mode (Coords mode): "Ctrl D" works this toggle. This turns the display of the coordinate position of the puck on and off. The coordinates are displayed in the upper central part of the screen.

Ortho Mode: "Ctrl O" or F8 controls this toggle. When in ortho mode, any line drawn will be oriented parallel to one of the axes of the orthogonal system in which you are working. This mode should be off when you are "sketching" polylines. If ortho is on, the words Ortho appear on the upper line of the screen.

Making sure Tablet mode is on, you can begin digitizing:
There are several commands you will be using over and over to draw lines and curves.

1) SKETCH command is the first, and it can hurt you if your not careful. Before using SKETCH type SETVAR for "set variables" (enter). You are now asked which variable you want to set. Type SKPOLY to set the important variable for sketching (enter). (I'm going to stop telling you when to "enter" things now, you've got the idea.) Turn skpoly on by typing 1. This is now set until you change it. This makes all your "sketched lines" polylines. Polylines are entities which can be treated as a whole. In other words, if you do not use polylines your sketch lines will be a series of incremental entities which must be dealt with individually. If you want to move a sketched line, it is easier to move it as a whole rather than having to move its many components individually.

2) PLINE command lets you draw straight lines that can also be treated as a whole, say if you want two non-parallel straight lines to be connected and later treated as one entity.

3) To turn polylines into individual increments use the EXPLODE command and select the entity you wish to "explode", or reduce to its components.

Now you can really begin digitizing:
1) Type SKETCH. I assume you've turned SKPOLY ON. The record increment prompt asks you how much resolution you desire for your sketch lines (or how large the increments defining a curve will be, the smaller the record increment, the less space between vertices). .1 is usually good enough and anything less than this eats memory and causes the machine to slow down. But, if you need real precision, then choose .01. Choose a contact with your puck (are you in tablet mode?). Now move the puck along the contact you've drawn on your field map. See what happens on the screen? If you move too fast the machine will tell you to slow down. Picking the "pen" up and putting it down is controlled by either the puck button or the "p" key on the keyboard. When your done with this line, hit enter and the command is entered. If you screwed up you can type UNDO and the sketched polyline is removed. You can also erase the line by typing ERASE and selecting the sketched polyline with the puck.

2) Line drawing can be done by typing PLINE and choosing two points you wish to connect with a line. There are several ways to choose points: (a) by pointing the puck and selecting 2 points; (b) by typing the coordinates of one point or both; (c) by typing END and selecting the end of a pre-existing line on the screen as one or both of your points; (d) by typing MID and selecting the midpoint of a line on the screen. note: both END and MID cause the cross hairs of the pointer on the screen to change to a box. The point you choose will be the nearest end or mid point to the center of this box. It is advisable to use END, MID, or enter coordinates for PLINE drawing because these are more accurate than simply pointing to a spot on the screen. END is also the command which saves your work and ends your session, so only use it to choose an endpoint of a line when you are prompted: "end of"...

3) The ZOOM command allows you to zoom into an area or zoom out to a larger field of view. ZOOM is followed by a prompt for what kind of zoom you desire:

ZOOM window (w) allows you to zoom into an area designated by puck driven selection.

ZOOM all (a) zooms you to the limits of the drawing area. If the limits are not large enough see LIMITS command in the manual.

ZOOM previous (p) zooms you to your previous screen.

ZOOM extents (e) zooms you to the extents of the space currently occupied by your drawing.

4) LAYERS: On the pull down menu under "settings" and then under "modify layer" is where you can create and modify layers. It is best to allow contacts, faults, text etc. to have their own layer. Make as many layers as you need, let AutoCAD keep track of them. Definitely see the manual on these, they really help.

5) BLOCKS: See manual, these are indispensible for importing the same object (a BLOCK) over and over. Blocks can be input at any angle or size using the INSERT command. Also, BLOCKS can be exploded so you can manipulate their components.

The essential setup criteria have now been established. Making geologic maps with AutoCAD is made much simpler and quicker by making full use of the commands listed below. If you find that you're *never* using some of these commands, then you're experiencing unnecessary hardship and should learn what the command can do for you.

Commands that come into play often when effieciently constructing a Geologic map with AutoCAD:

BLOCK
CHPROP
CIRCLE
COPY
DIM
DIVIDE
DIST
DTEXT
ERASE

4

<u>Constructing a Balanced Cross Section</u>:
   Constructing a section at the same scale as the base map and with zero vertical exaggeration.

   1) Choose your line of section as you normally would.
   2) Since most contour intervals are in feet, I suggest calibrating your drawing in feet.
        a) Calibrate the drawing to your map using one end of the line of section (the left end) as point (0,0).
        b) Choose the 1 mile point from (0,0) as point (0,5.280). So 1 drawing unit equals 1000 feet on the map. I'll desribe a section using 1 unit = 1000 ft. throughout the rest of this guide. Use the scale that best suits your needs.
   3) Digitize a PLINE on the line of section.
   4) Now draw a PLINE from (0,0) upward, perpendicular to the line of section. You now have an orthogonal coordinate system on the screen.
   5) Construct tick marks at 1,000 foot intervals on the vertical by making a BLOCK called "tick" that is a simple Pline which can be repeated as tick marks. Use the MEASURE command insert the tick marks at 1 unit spacings (1,000 ft.).
   6) Now you can input the topography along the line of section:
        a) Make a temporary layer called "points".
        b) Using Ortho and Tablet mode, move to a point of intersection between a contour line and your line of section.
        c) Note the elevation
        d) Note the X-Coordinate from the coords display on the upper line of the screen.
        e) Use the POINT command and enter the point as (x,y) coordinates where
                x = the X-Axis coordinate on the screen
                y = the elevation
        f) Repeat this tedious process for every point where a contour line intersects the line of section and keep telling yourself that this is easier than drawing by hand.
        g) Make a layer called TOPO and using a sketched polyline, connect the points.
        h) Freeze layer POINTS and hopefully you are left with a scaled outline of the topography along the line of section.

   make sure you're using many blocks and layers to help you throughout

   7) Input all your stike and dip data that lies on the line of section. Make sure you account for apparent dip when the strike of a measurement is not perpendicular to your line of section. Use:

EXPLODE
EXTEND
HATCH
LAYER
LINE
LINETYPE
LIST
LTSCALE
MEASURE
MIRROR
OFFSET
PAN
PEDIT (Join, Width, Edit)
PLINE
POINT'
PURGE
REDRAW
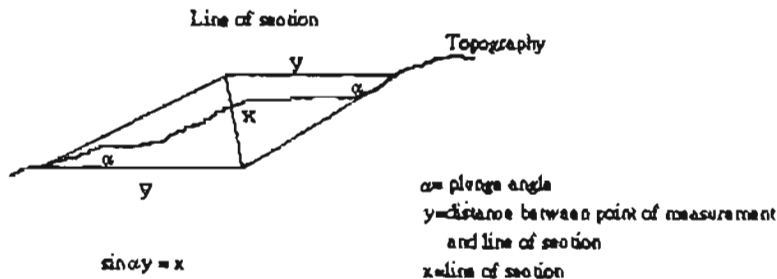REGEN, ROTATE,SAVE
SCALE, SKETCH, TRIM
UNITS
ZOOM

GEOLOGIC MAP FEATURE TO IMPORT	AUTOCAD COMMAND (and associated commands) THAT HELP
Lithologic contacts	Sketch (skpoly=1)
Infered lithologic contacts	Sketch (skpoly=1, layer setting linetype=hidden)
Map symbols (structure, benchmark, etc)	Block, insert, (copy, circle, arc)
Borders, legends or any straight lines	Line, pline (pedit), trim, extend
Measured (on the screen) dimensions (angles, distances, etc..)	Dim (ang), Dist,
Map patterns, hatch patterns	Hatch (hatch inside of ploylines!)
Scales	Measure, divide, block, offset, copy

$$\delta' = \tan^{-1}(\tan\delta \sin\theta)$$

Where δ = true dip, δ' = apparent dip and θ = angle between the strike direction and the line of section. To represent the strike and dip symbol for cross section quickly, consistently, and easily, it is wise to make a BLOCK entity for it.

8) To project data on to the line of section:
   a) Use ortho and tablet mode
   b) Go to the strike and dip mark on the map and immediately solve for apparent dip, see 7) above.
   c) Note elevation of measurement
   d) Note X-Coordinate on the display line at the top of the screen.

Line of section
Topography
α= plunge angle
y=distance between point of measurement and line of section
x=line of section
sinαy = x

e) Measure the distance y between the line of section and the point where the measurement was taken. This can be done using the DIST command and digitizing the strike and dip point and the line of section as points at the "from" prompt. The imaginary line (y above) joining the line of section must be perpendicular to the line of section.
f) Use sinαy=x for a profile section at plunge α.
g) The y-axis position of the data point on the line of section is going to be x units (from equation in f) above or below the elevation of the point of measurement depending on whether the measurement was taken up or down plunge from the line of section.

9) If that didn't all make sense, consult your local structural geology text on projection techniques (Ramsay and Huber, 1983 is a great source - they also describe this process for use in areas of high relief). Lithologic contacts can also be projected in to the plane of section using similar techniques.

10) To determine interlimb angles, use DIM (Ang).

11) To determine dip use LIST (LIST will not display angles if the line you choose is a polyline, so you may have to either: 1) trace a line over the pline in question, then do a LIST on it; or 2) explode the pline then type LIST).

12) Once you've got all your data onto the cross section and you're ready to begin the balancing process. Set up another orthogonal section to house your restored section.

Balancing the line lengths:

1) All your layer contacts can be connected (if they're not already) as a polyline by using PEDIT (Join). Do a LIST on these layer contacts to get their lengths. Also, to determine the distance along a contact to a fault (or other feature), trace a pline over the contact along the section of the contact you wish to measure. A LIST on this section will list the length.

Balancing the areas:

1) Area balancing is done simply by traceing the cross-sectional area boundaries of the unit in question and typing AREA (Entity). To actually make the areas balance requires knowledge of the local geology.