GENERATING GEOLOGIC CROSS SECTIONS WITH AUTOCAD MAP AND ARCVIEW GIS

Introduction

Generating geologic cross sections with AutoCAD Map and ArcView GIS requires the use of 3D geometry commands within AutoCAD to produce the proper perspective view of the topographic profile and geologic subsurface structures. The following discussion outlines this process step-by-step. The assumption is made that the geologic map and cross section line (A-A') have already been prepared, and that a DRG quadrangle is loaded for topographic control.

STEP 1: Insert topographic block markers in base map

The first step consists of designing a topographic marker block that will be inserted where ever a contour line crosses the cross section reference line (A-A'). The block should be designed to have an easily identified center point, and it should be visible from any 3D perspective. For example, a good design would be 3 mutually perpendicular lines intersecting at midpoints (i.e. "Jumping jacks"). In this example the block will be named "3DCROSS". Zoom into the drawing in the region on the "A" side of the cross section line. Where the first contour line crosses the A-A' line, use the insert command to place the "3DCROSS" block exactly at the point of intersection. To do this use the ".xy" coordinate override. Also, indicate from the insert dialog that you will specify the insertion point from the command line. **Figure 1** displays the correct setup for the insert dialog. Note that the scale factor is set to 20 meters, appropriate for the 1:12,000 RF in this example. When the OK button is clicked the user will be prompted for the insertion point of the block:

Specify insertion point or [Scale/X/Y/Z/Rotate/PScale/PX/PY/PZ/PRotate]: .xy

Respond with the ".xy" coordinate dot command. This allows you to specify the x and y coordinates of the block with the pointing device, but then set the z coordinate with an elevation typed in at the command line. Use the "nearest" object snap to set a point on the cross section line where a topographic contour crosses the line. You will then be prompted for the Z coordinate value:

(need Z): 7200

This procedure will put the block marker at the correct elevation and exactly on the A-A' cross section line. Continue until all topographic contours are accounted for along the A-A' line. When all of the contour line intersections are accounted for, the block markers will form the topographic profile along A-A' even though you cannot see the profile because your viewpoint is parallel to the plane of the cross section.

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In addition to contour line intersections, you may also wish to mark where geologic contacts cross the A-A' line. These markers should be a different color than the topographic markers. **Figure 2** displays an example base map with inserted block markers on contour line intersections and on geologic contact intersections.

STEP 2: Export topographic block markers to an external file

The next step will export the topographic profile block markers to an external AutoCAD file. This file will eventually contain the geologic cross section. Start the process by typing the "WBLOCK" command at the command prompt. **Figure 3** displays the dialog window generated by this command. You should select just the topographic control blocks and the A-A' cross section line as objects for the WBLOCK command. In this example the objects are exported to the external file "BoxCanyon_CrossSection.dwg", which will become the geologic cross-section. Make sure that you retain the original objects before selecting the OK button. When the OK button is selected, the information will be written to the indicated external file. You can know quit the base map and load the external file just created.

STEP 3: Setting up the UCS coordinate system

All operations completed so far in AutoCAD have been in the default coordinate system named the "world" coordinate system (WCS). You may have notices the coordinate system orientation icon in the lower right portion of the AutoCAD window indicating that positive X increases to the right, positive Y upwards. When the topographic profile marker blocks were exported to an external file the WCS is unchanged. Verify this fact by loading the external file into AutoCAD at this time.

At this point you need to define a user coordinate system (UCS) that makes the current Z axis (i.e. elevation axis) the new Y axis. Another way of visualizing this would be to rotate the current WCS about the X axis by 90 degrees. In effect, this will correctly orient the A-A' cross section so that we are viewing the vertical plane passing through A-A'. Before we can define the new UCS of the cross section we need two lines originating from the "A" point, one being the X axis of the new UCS, the other being the Y axis. The already existing A-A' line will serve as the X axis, but we need to construct the Y axis line of the new UCS. To do this correctly we need to view the entire drawing from a 3D perspective. Select the menu sequence "View > 3D view > Vpoint". You will then see a dynamic "bullseye" type graphic. Move the pointer to the interior circle at the southeast quadrant and then click the left mouse button. You should then see something similar to **Figure 4**. Note that the marker blocks are too far above the A-A' cross section line. This reason for this is that the X and Y coordinate system is UTM, which uses meters for units, but the elevation contours are in feet above M.S.L. The inconsistency in units will be corrected in a later

step.

Next we need to draw a 3D polyline to define the orientation of the new UCS Y axis. Zoom in on the "A" end of the cross section line, and then used the "Draw > 3D polyline" command. For the start point, use "endpoint" snap to snap to the end of the existing cross section line, and then for the second vertex type:

Specify endpoint of line or [Undo]: @0,0,1500

This sets the endpoint directly above the "A" end of the cross section line at an elevation of 1500 units. The value 1500 was chosen because it exceeds by a small proportion the total topographic relief of this specific cross section line. You should make this value appropriate for your situation.

Now the new UCS can be defined. Type the command "UCS" and hit the "enter" key. Use the following responses (bold type):

Enter an option [New/Move/orthoGraphic/Prev/Restore/Save/Del/Apply/?/World]
<World>: **new**

Specify origin of new UCS or [ZAxis/3point/OBject/Face/View/X/Y/Z] <0,0,0>: **3point**

Specify new origin point <0,0,0>: **'zoom** *{zoom into the "A" end of the cross section}*

>>Specify corner of window, enter a scale factor (nX or nXP), or
[All/Center/Dynamic/Extents/Previous/Scale/Window] <real time>: **window**

>>Specify first corner: >>Specify opposite corner:
Resuming UCS command.

Specify new origin point <0,0,0>: **end**
of *{select the "A" end of the cross section as the UCS origin}*
Specify point on positive portion of X-axis <446001.0000,4016842.6050,0.0000>: **end**
of *{select the "A'" end of the cross section line as the UCS X axis}*
Specify point on positive-Y portion of the UCS XY plane
<446000.0000,4016843.6050,0.0000>: **end**
of *{select the end of the 3D poly line directly above the "A" end of the cross section line as the new Y axis direction}*

The comments surrounded by braces {} above explain which points are being selected. Note that

until we finish the above UCS command all coordinates refer to the original WCS, therefore, we select the WCS Z axis to define the new UCS Y axis. Your drawing should appear something like **Figure 5** after completing the UCS command. Note that the UCS icon now indicates the Y axis direction as being parallel to the WCS Z axis direction.

After completing this command type the command "plan" at the command prompt. This aligns the viewport to the X and Y axis plane of the indicated UCS:

Command: **plan**
Enter an option [Current ucs/Ucs/World] <Current>: **<enter>**
Regenerating model.

You should now see a diagram similar to **Figure 6**. Note that the block markers are much too high along the Y axis. This is because the block elevations were set using feet units, but the UTM map coordinate system uses meters. You should now save the newly defined UCS:

Command: **ucs**
Current ucs name: *NO NAME*
Enter an option [New/Move/orthoGraphic/Prev/Restore/Save/Del/Apply/?/World]<World>: **save**
Enter name to save current UCS or [?]: **cross-section**

The new UCS now is named "cross-section". Use the UCS command to return to the WCS in plan view so you can erase the text "A" and "A'". Then return back to plan view in the "cross-section" UCS.

STEP 4: Convert elevations from feet to meters

The elevation units must be converted to meters before the topographic profile can be sketched. Each Y coordinate of each block marker should adjusted by dividing by 3.28 (feet per meter) to convert the elevation units to meters. Do this by first selecting one of the marker blocks. Then use the menu sequence "Modify > Properties". You will then see a window similar to **Figure 7**. Calculate the elevation in meters by dividing the current Y coordinate value by 3.28. You can use AutoLISP expressions at the command line to process the calculation:

command: (/ 8000 3.28) <enter>
2439.02

If you activate the text window with <F2> you can copy the result to the clipboard, and then paste it into the "modify > properties" Y coordinate value for the marker block. Proceed to

convert all of the topographic block marker Y coordinates to meters.

STEP 5: Construct the topographic Profile and Elevation Grid

The next step constructs the topographic profile. Using a grid and snap mode construct the desired elevation reference grid. In this example every 50 meters beginning at 1500 meters above M.S.L. are constructed up to 3000 meters. After the grid is constructed, use the "polyline" command to draw the topographic surface profile through the marker blocks. After completing these steps your drawing should appear similar to **Figure 8**, which has the grid and topographic profile already constructed.

STEP 6: Constructing the Geology of the Cross Section

Before actually attempting to construct the geology on the cross section there are several preliminary calculations to process. Unless the geologic contacts are perpendicular to the line of the cross section, you will need to calculate the apparent dip of each contact that crosses the A-A' profile. This is usually done with the aid of a stereonet. Plot a preliminary hard copy of the cross section and then draft in the apparent dip of each contact in pencil. Label the geologic code of each unit that intersect the profile. Proceed to sketch in pencil the subsurface structure contacts below the topographic profile. You should then proceed to digitize the contacts onto the cross section drawing file, and then create a lithologic polygon topology in the same manner as any geologic map. **Figure 9** is an example of a completed geologic cross section (this is a different cross section than the previous example). Note that you should be careful to allow enough extra space below and above the topographic profile to display fold and fault structures. Plunging folds should be analyzed before attempting to construct the cross section so that you can calculate how deeply into the cross section the hinge of the fold plunges.

The AutoCAD Map commands for generating polygon topology always work in the WCS, therefore, if you are using AutoCAD Map and wish to use its GIS capabilities you should first export the entire map to another file with the WBLOCK command. When this is done the new file will have its WCS in the same orientation as the cross section. You can then operate the GIS commands in the same way as other map projects. Erase the old file and then rename the new file to the original file name.

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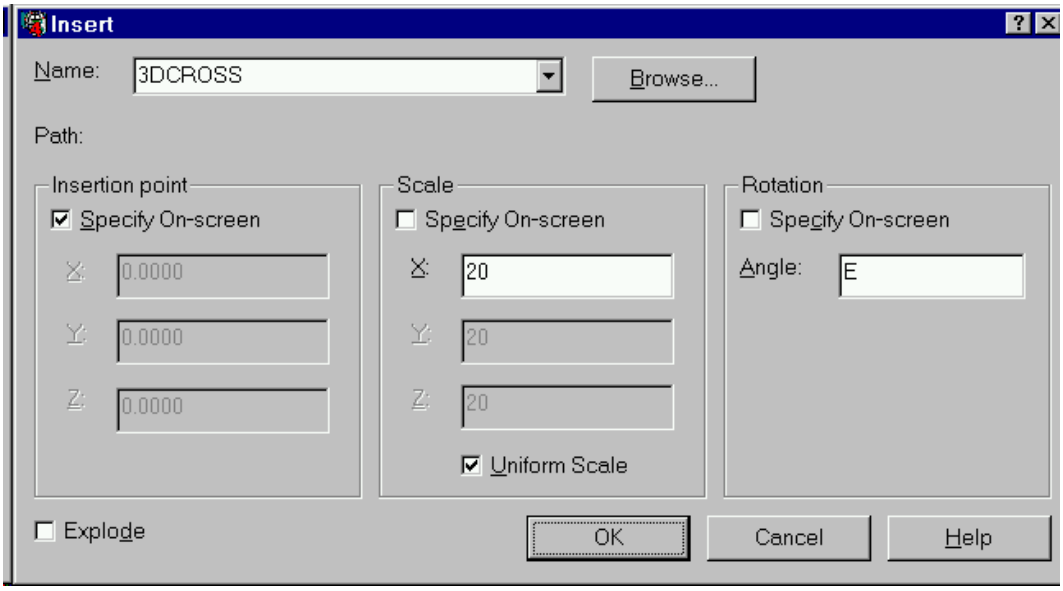

Figure 1: Insert block dialog box setup for placing 3DCROSS block.

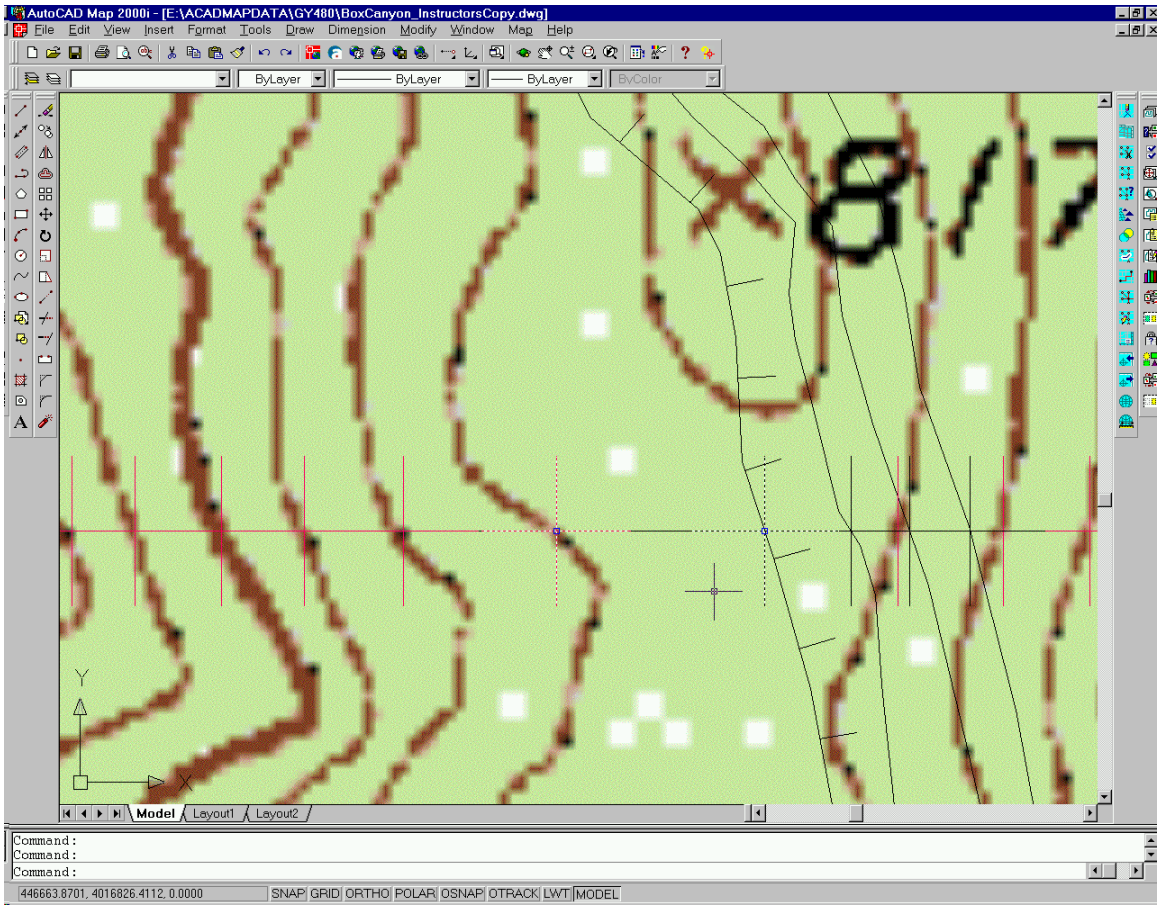

Figure 2: Inserted topographic block markers for contour and contact intersections.

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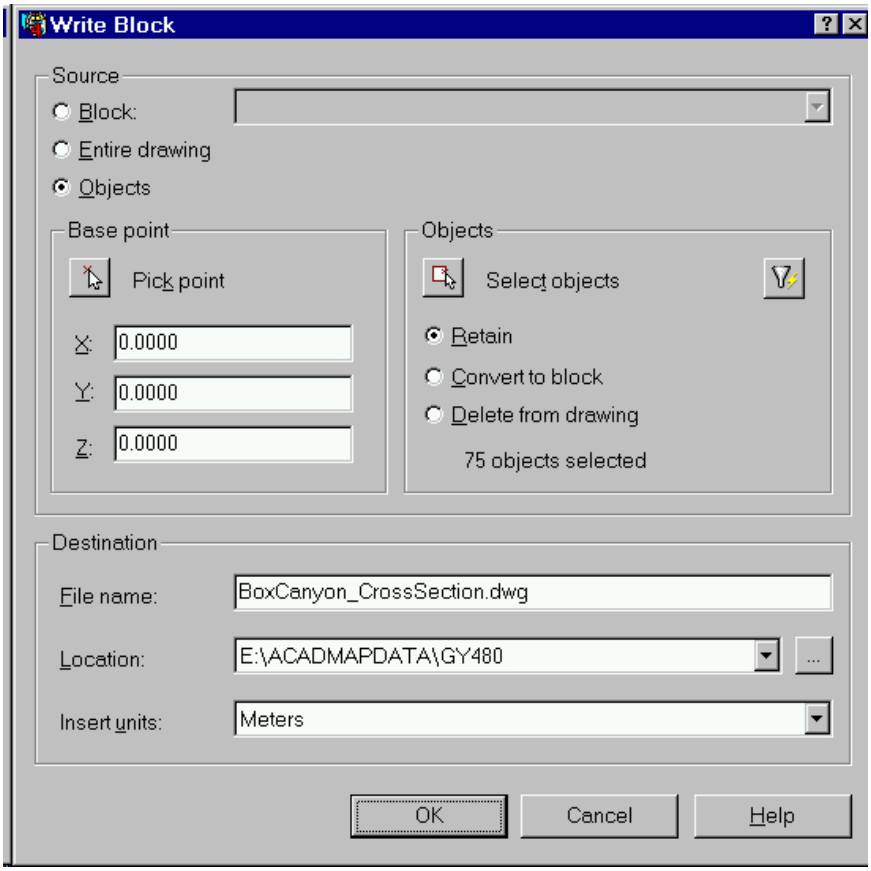

Figure 3: Dialog generated by the WBLOCK command, which is used to export topographic profile blocks.

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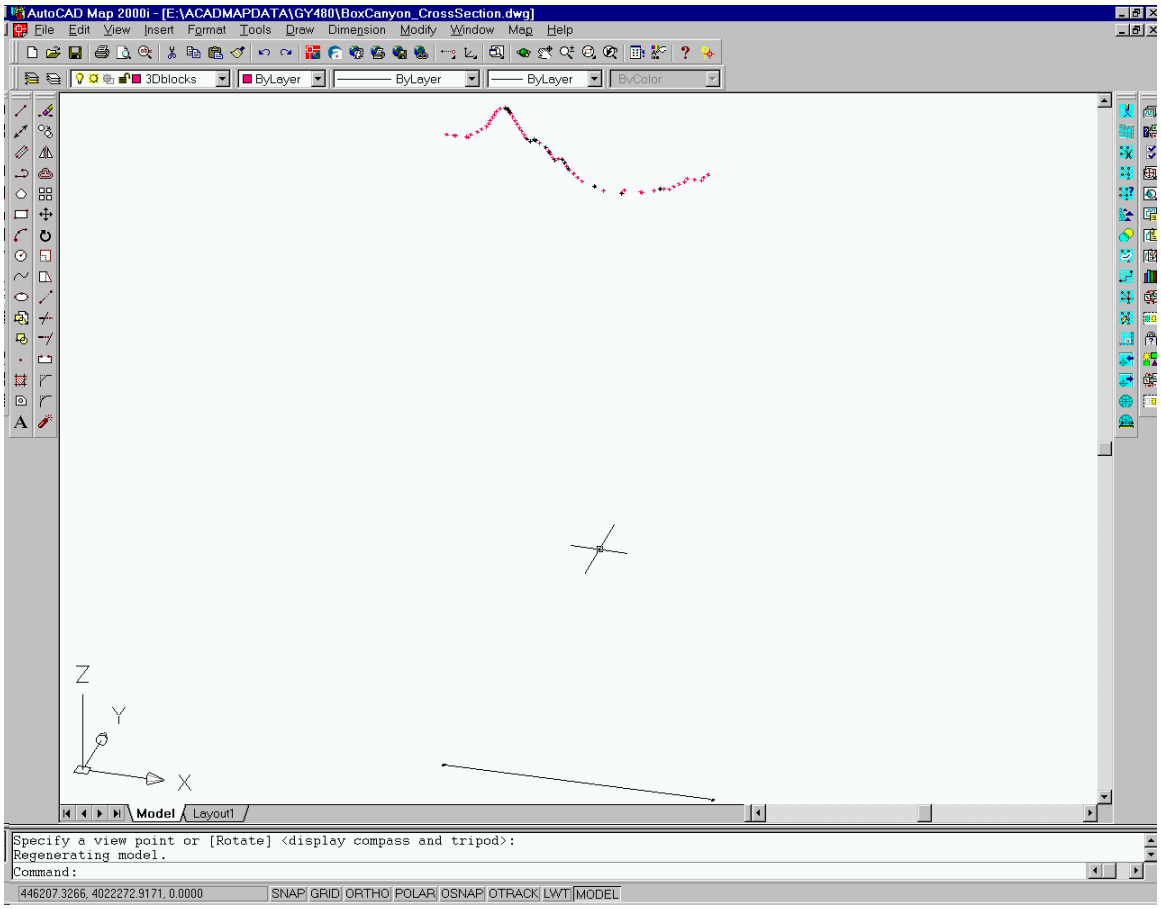

Figure 4: 3D perspective view of marker blocks exported to an external file (VPOINT).

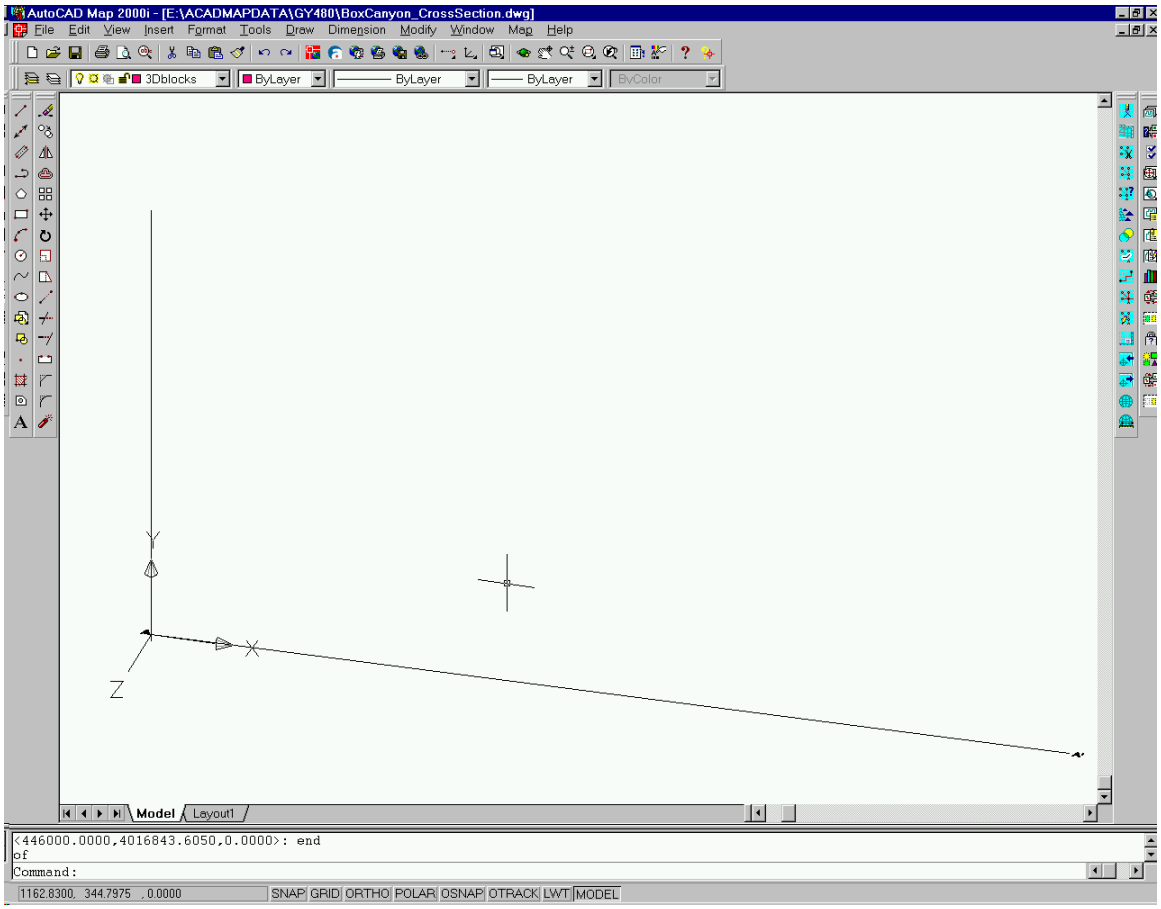

Figure 5: New UCS defined from the X and Z axes of the orginal WCS.

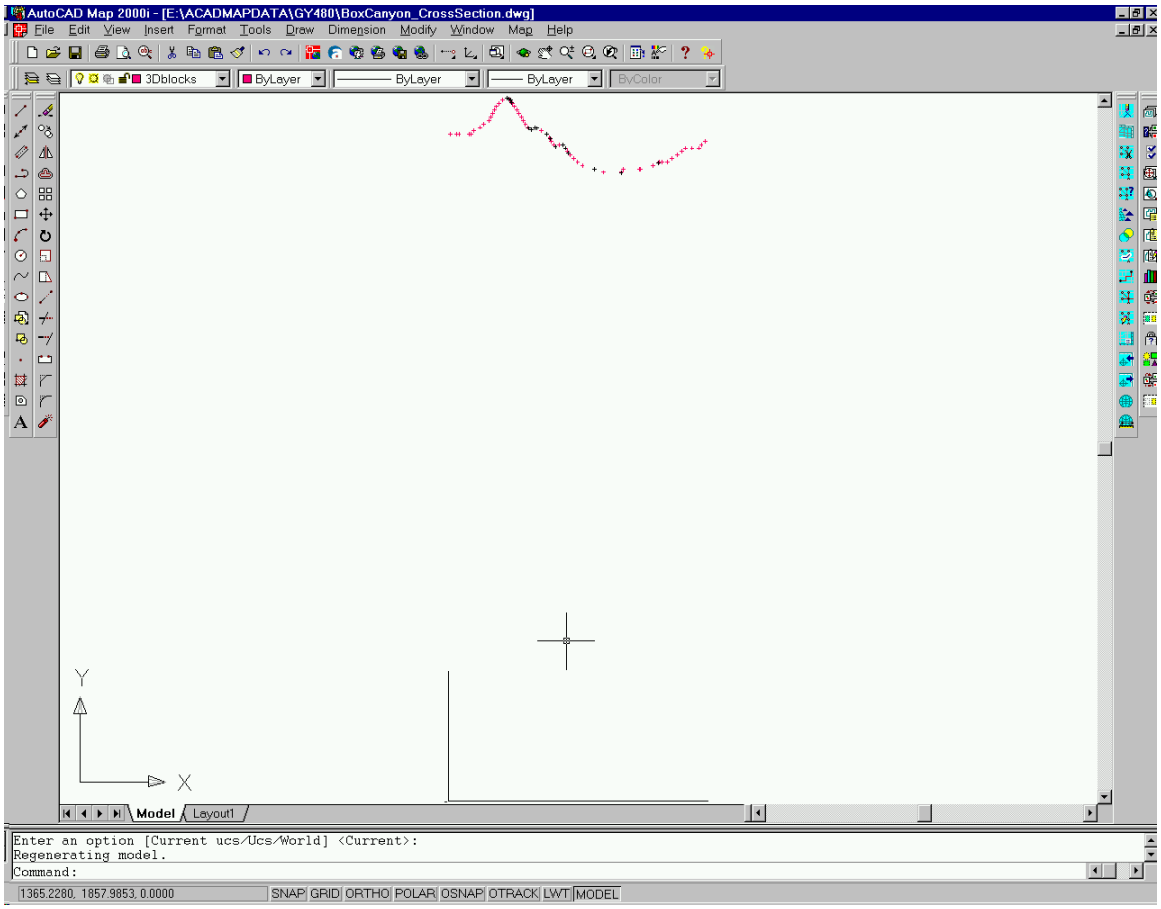

Figure 6: New UCS defined in "plan" view.

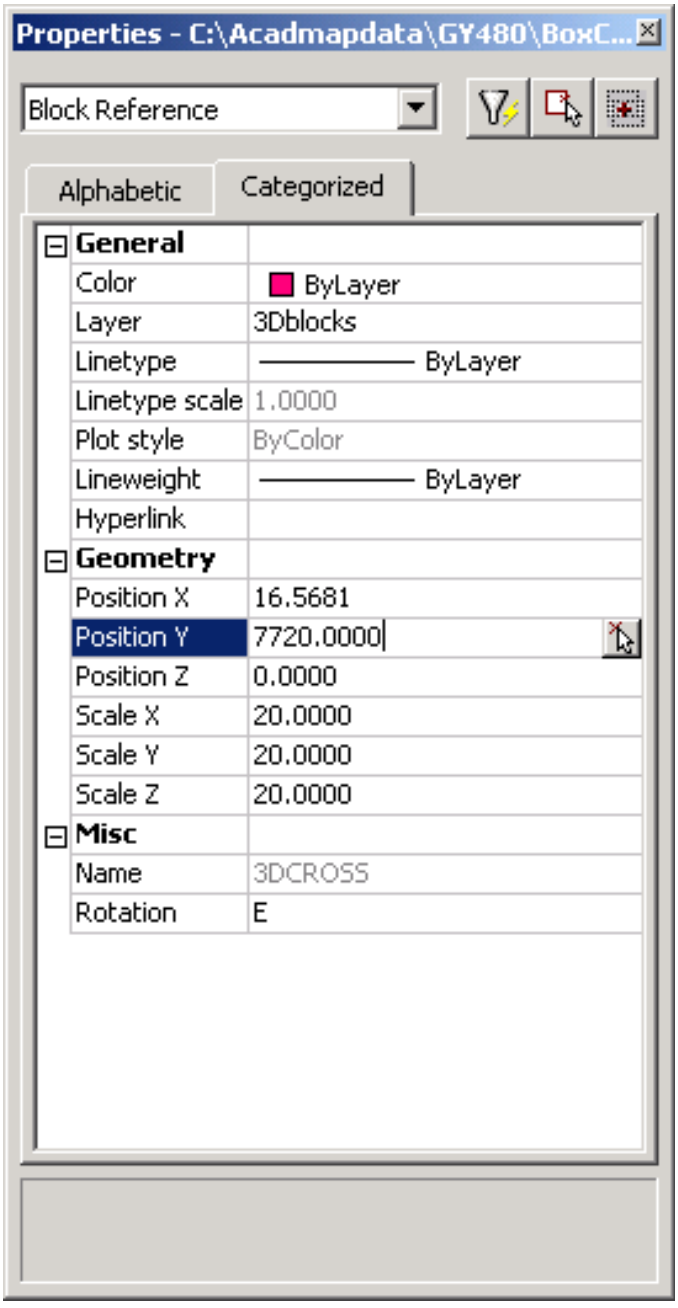

Figure 7: Modify properties dialog window for a marker block.

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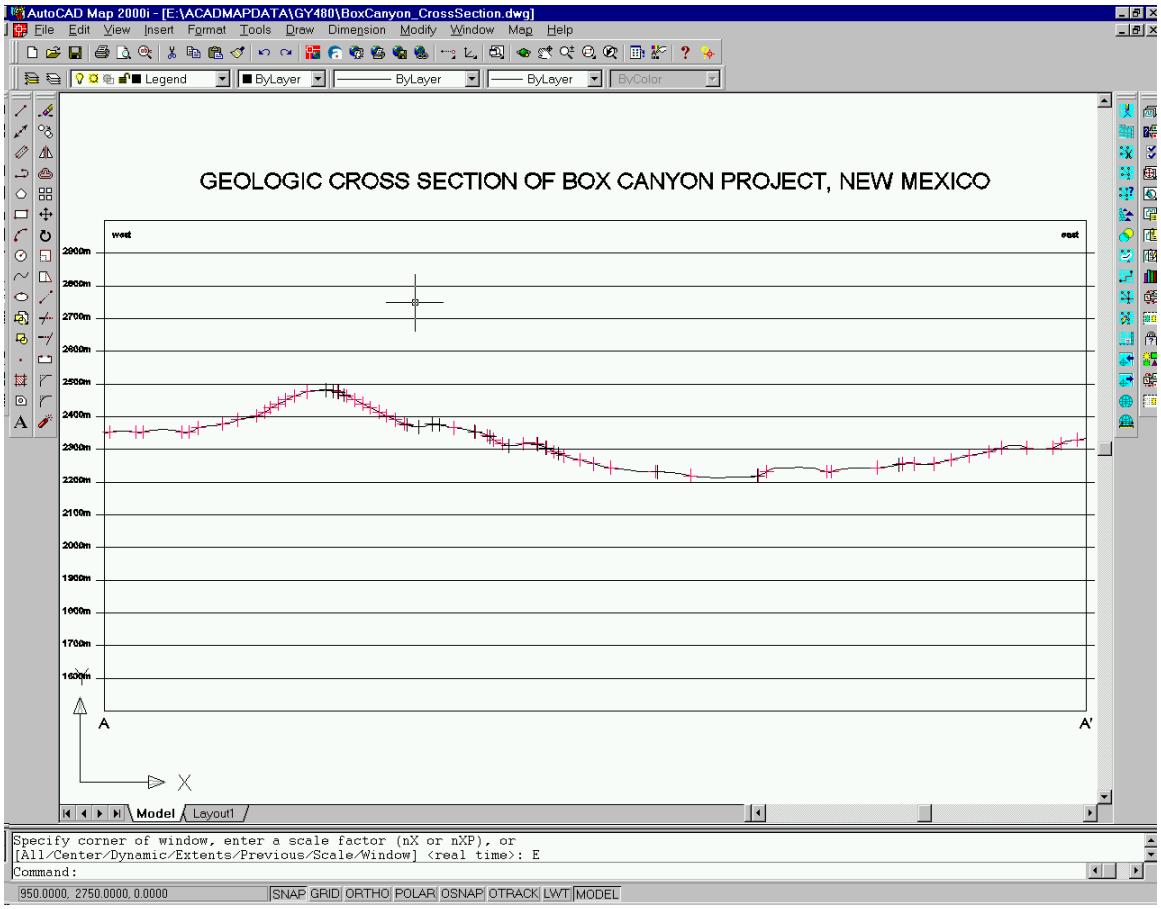

Figure 8: Topographic grid and profile constructed from exported marker blocks.

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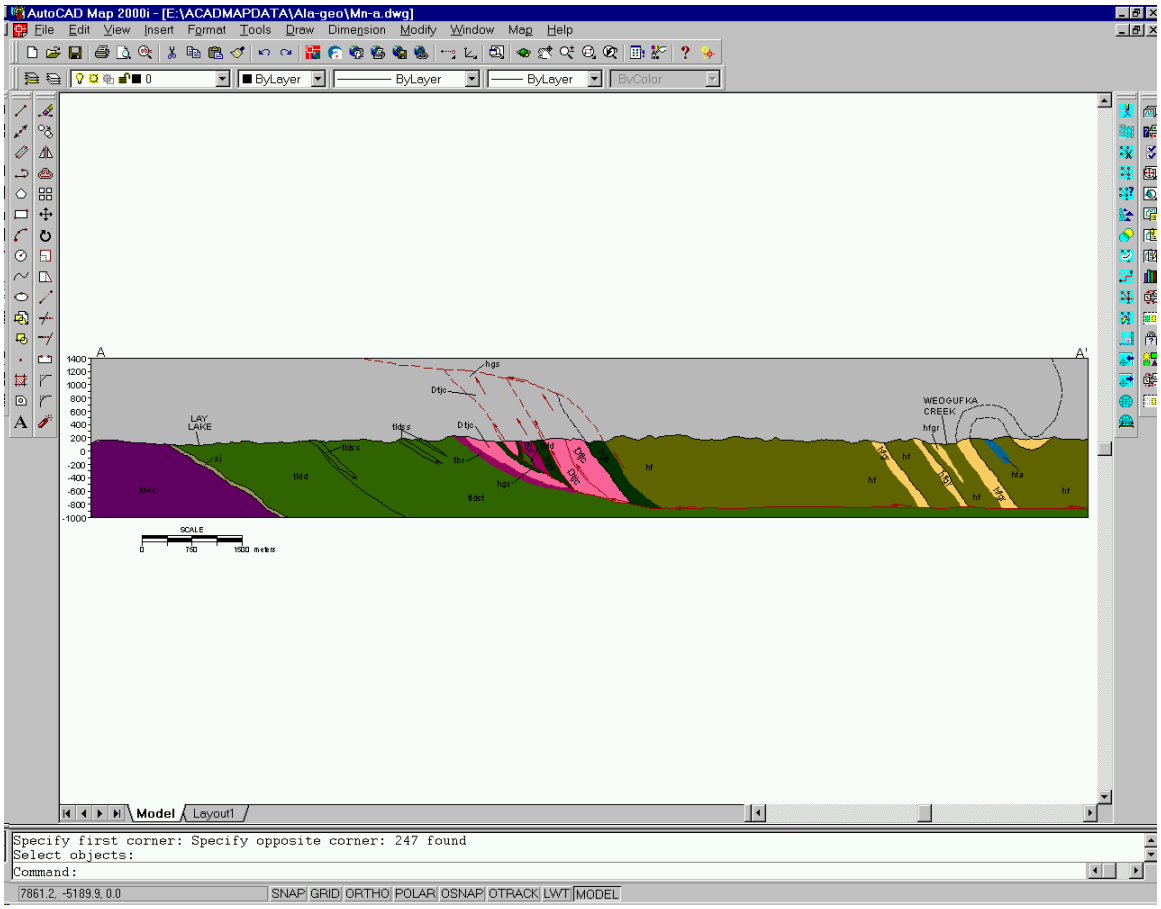

Figure 9: Example of a completed cross section including the lithologic polygon topology.