

Integrating a Geologic Map and Cross-Sections into an Interactive 3-D Block Diagram with Google SketchUp

Paul Karabinos

Department of Geosciences

Williams College

Williamstown, MA 01267

June, 2011

This is a description of my method for creating interactive 3D block diagrams with Google SketchUp, which I developed from March 2010 through June 2011.

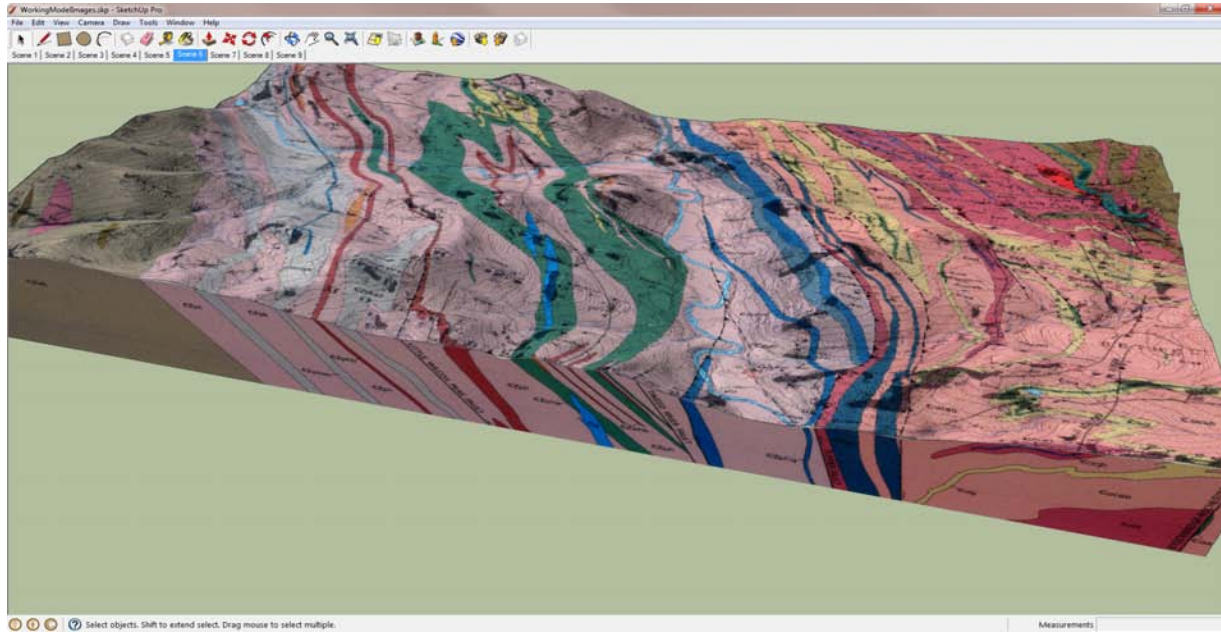
To illustrate the details of the method, I used the Bedrock Geologic map and cross-sections of the Rochester, Vermont, Quadrangle published by Greg Walsh and Christine Falta in 2001. I chose this map because Greg Walsh used it as one of two examples in his excellent paper:

Walsh, G.J., 2009, A method for creating a three dimensional model from published geologic maps and cross sections: U.S. Geological Survey Open-File Report 2009-1229, 16 p. available at <http://pubs.usgs.gov/of/2009/1229/>

Greg's paper describes how to drape a geologic map on the topographic surface in Google Earth and use Google SketchUp to position cross-sections in their correct position within the geologic map. This allows the user to view that part of a cross-section which is above the topographic surface together with the geologic map in a 3-D context. Steve Whitmeyer from James Madison University has created a wonderful tool that makes positioning a cross-section in Google Earth straightforward.

<http://csmres.jmu.edu/Geollab/Whitmeyer/web/visuals/GoogleEarth/tools/XS.html>

This guide shows how to make a 3-D block diagram with Google SketchUp that integrates a geologic map with cross-sections below the topographic surface. This approach requires the ability to make segments of the map invisible in order to see the cross-section. The image below shows what the finished model looks like:



If you discover ways to improve the method described here please email me (pkarabin@williams.edu) and I will update this document and acknowledge your contribution.

Programs Required-

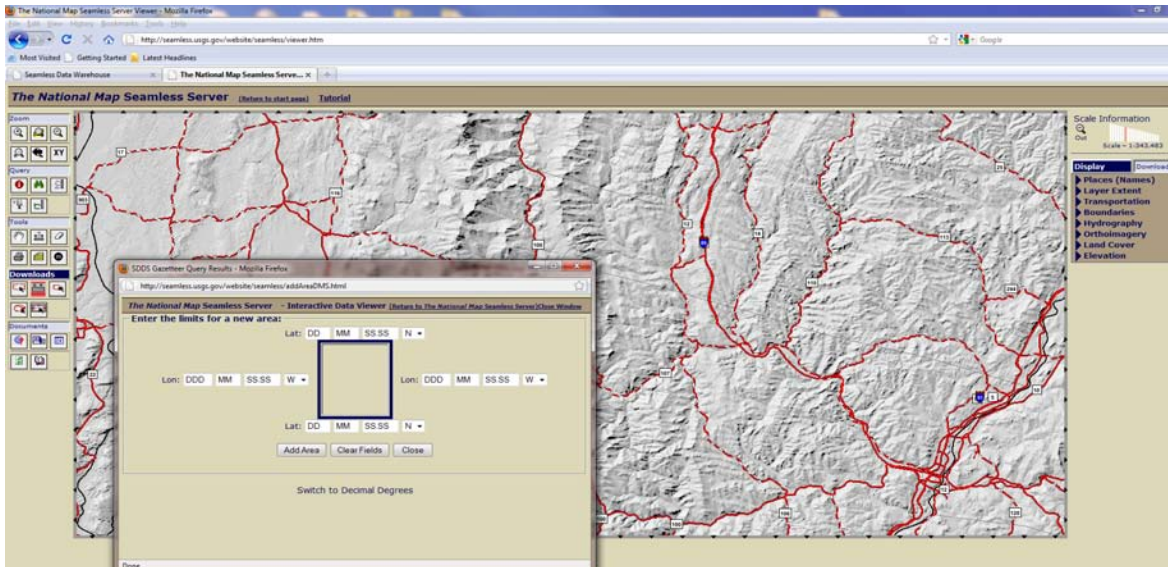
1. Global Mapper 12 or ArcMap 10 for digital elevation model (DEM) creation.
2. ArcMap 10 for cropping map and cross section images.
3. Photoshop (CS5) for additional image processing.
4. SketchUp 8 or SketchUp Pro 8 for combining maps and cross sections into a 3D model.

Materials Required-

1. A **DEM** of the area downloaded from <http://seamless.usgs.gov/>.
2. A **geologic map and cross sections**. These can be scanned from paper copies or downloaded in digital format. I downloaded a sid file of the Rochester Quadrangle, Vermont from this site: http://ngmdb.usgs.gov/ngmdb/ngm_catalog.ora.html.

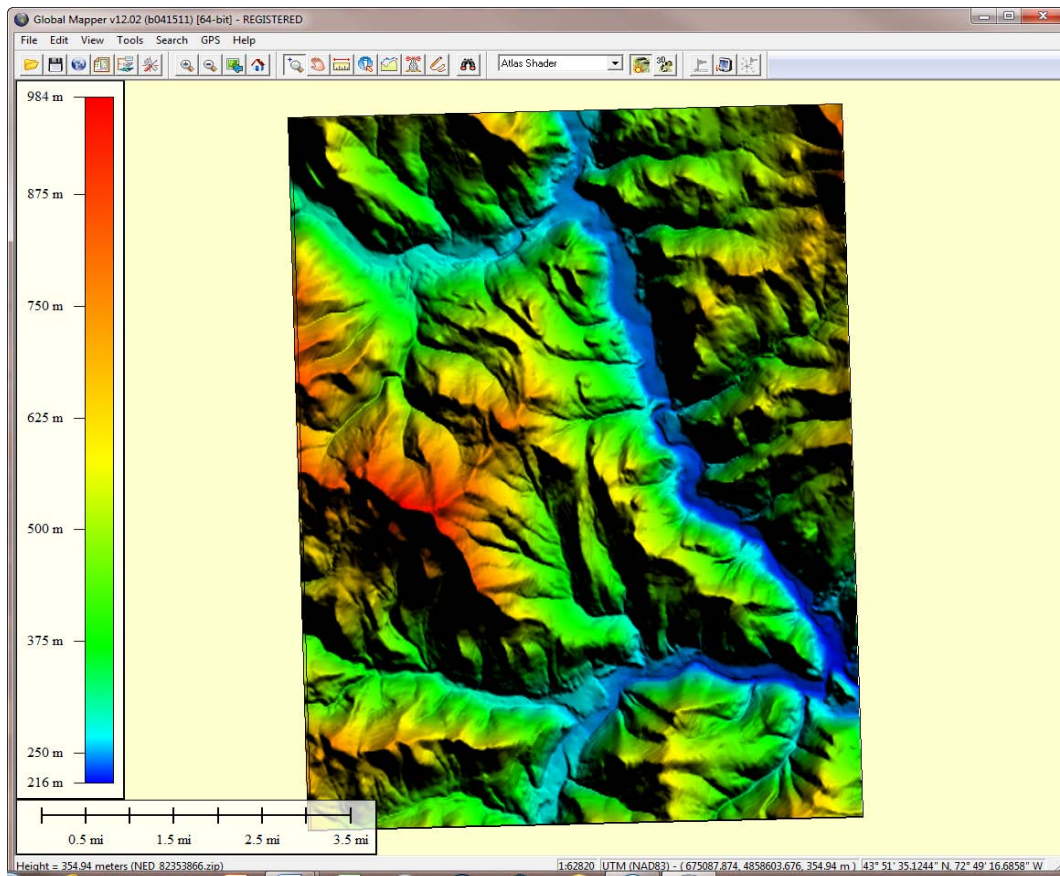
Creating the Model-

1. **Download a DEM** of the area of interest from <http://seamless.usgs.gov/>. Note that you must turn off Pop-Up Blocker to navigate the Seamless server.

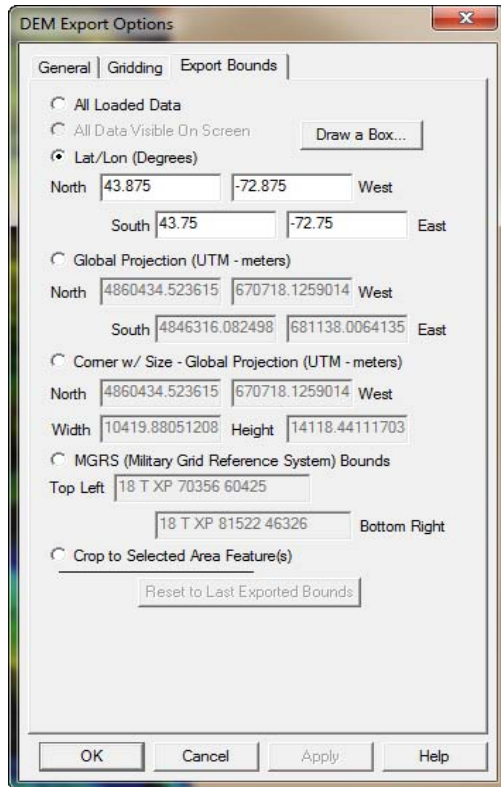


- a. Exact coordinates can be specified in the Seamless Viewer Downloads area using the Define Download by Coordinates tool.
- b. Alternatively, Global Mapper or ArcMap can be used to clip a DEM of larger extent using the coordinates or a polygon feature that corresponds exactly to the area of interest. The easiest workflow is to open the downloaded zip file of the DEM in Global Mapper, define the coordinate system, and export the file in an Elevation Grid Format as a DEM or an USGS DEM. I like to import a bit larger area and trim it with Global Mapper to the exact coordinates when I export the DEM. This extra step helps prevent funny edge effects that distort the topography along the borders of the DEM.

2. Prepare the DEM for your model.

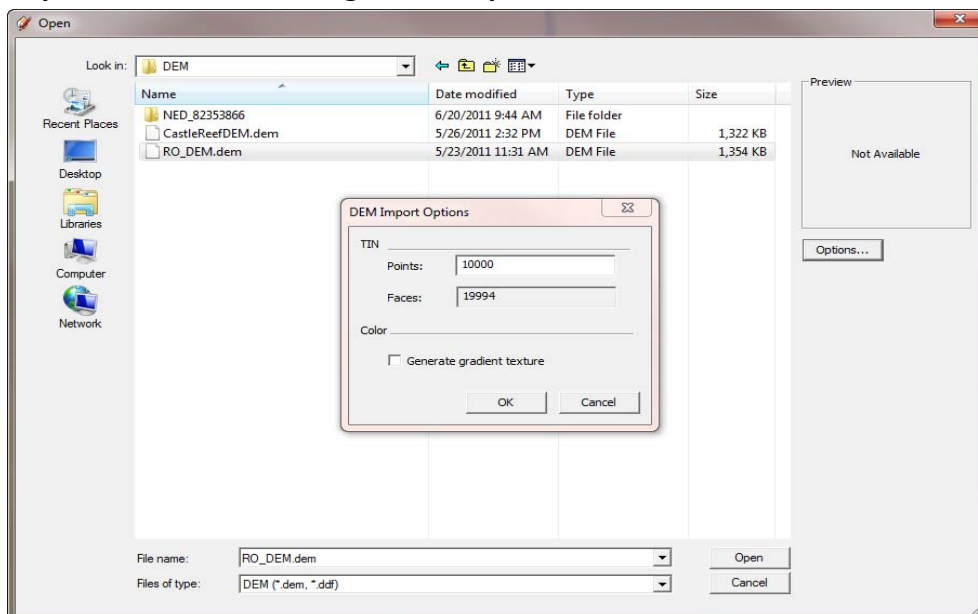


- Once downloaded, open the zip file directly in Global Mapper or unzip it and open it in ArcMap.
- Define the projections you wish to use. For Global Mapper: Tools menu/Configuration/Projection. Unprojected Geographic Coordinate System (GCS) DEMs will be square for a 7.5' quadrangle, whereas projected UTM DEMs will be rectangular and have the same shape as the published map.



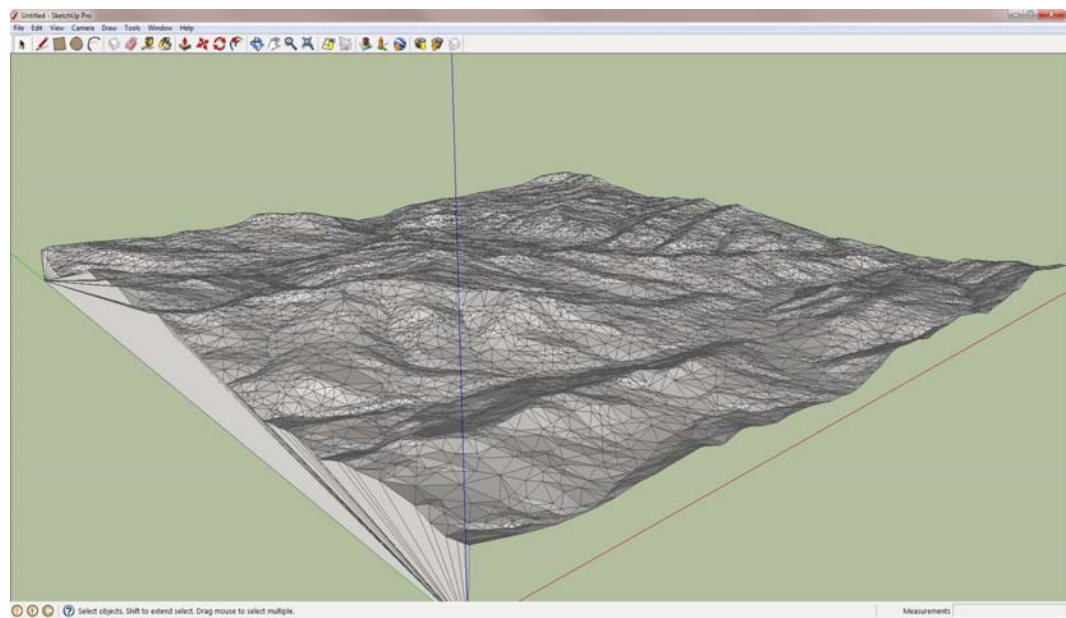
- c. I prefer to use Global Mapper to prepare the DEM for Google SketchUp. I export it in an Elevation Grid Format as a DEM or USGS DEM: File menu/Export Raster/Image Format.

3. Import the DEM into Google SkechUp.

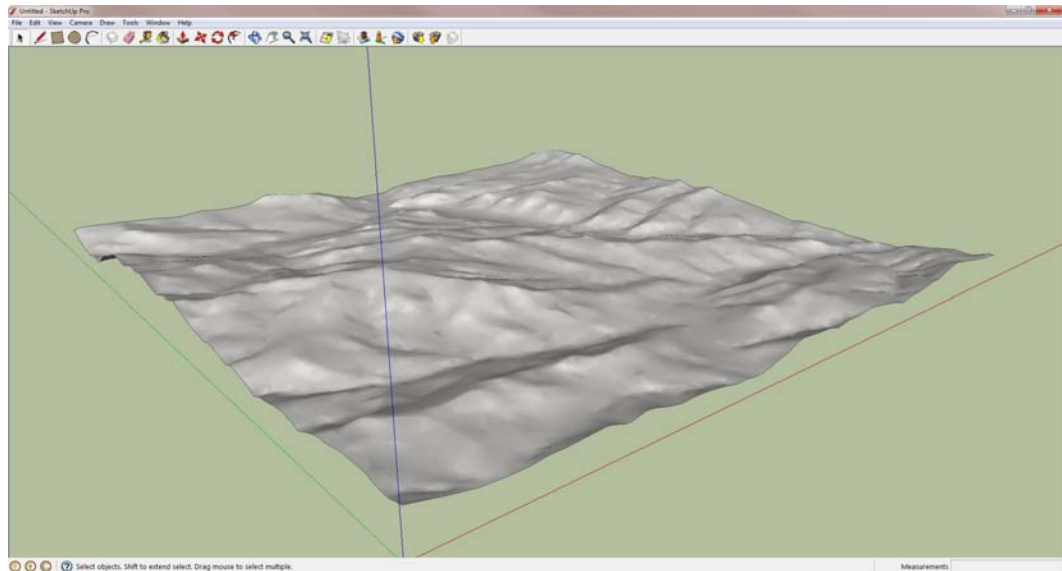


- a. In the File menu select Import. You have to use the drop down menu to let SketchUp know you are importing a DEM, and you can use the Options button to control the level of detail you want to preserve in the DEM. More points (and

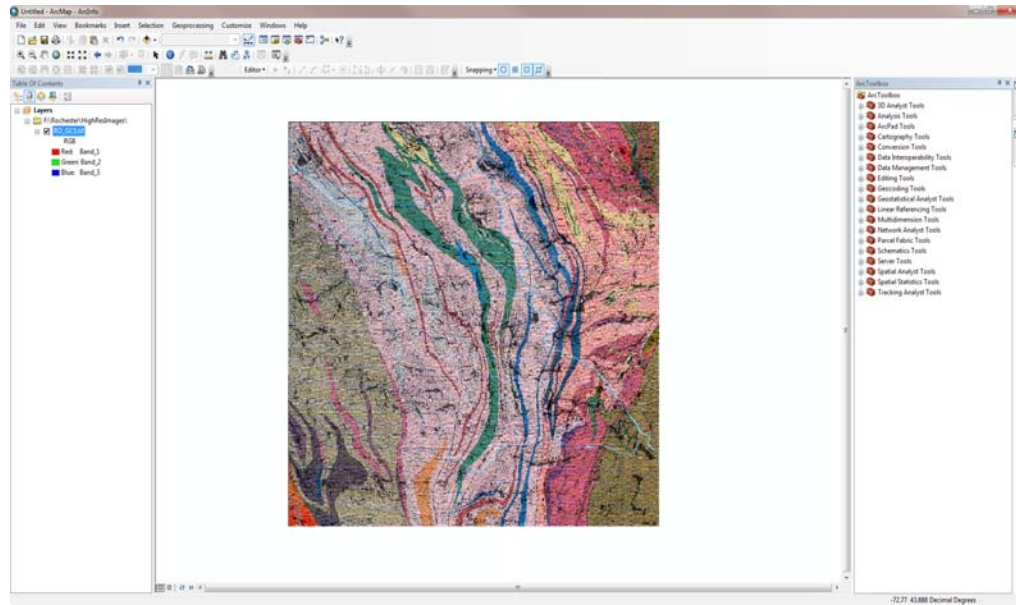
more faces) preserve more topographic information from the DEM, but more points also create a larger file that can bog down SketchUp during subsequent steps. I used 10,000 points for the model of the Rochester Quadrangle, which is a reasonable compromise between topographic detail and file size. The imported DEM becomes a TIN, or Triangulated Irregular Network. The TIN is a **component**, or self-contained entity in SketchUp; when you click on any part of it, the entire feature is selected. To edit a component, it is necessary to right-click on it and select Edit Component from the context menu. Typically, the DEM does not look very promising when it is first imported. There may be a vertical wall along one edge of the DEM, and the borders of the triangular faces that define the surface are visible.



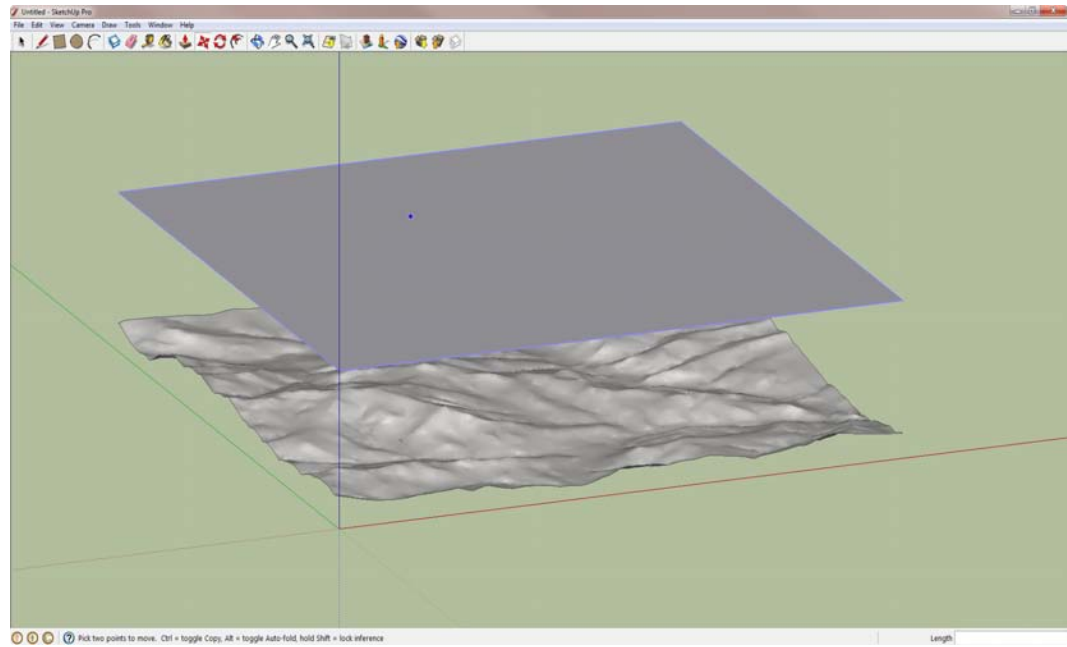
- b. Right-click on the DEM component, select Edit Component in the context menu, select the triangular faces on vertical walls that may exist on the DEM edges with the Select Tool, and delete them.



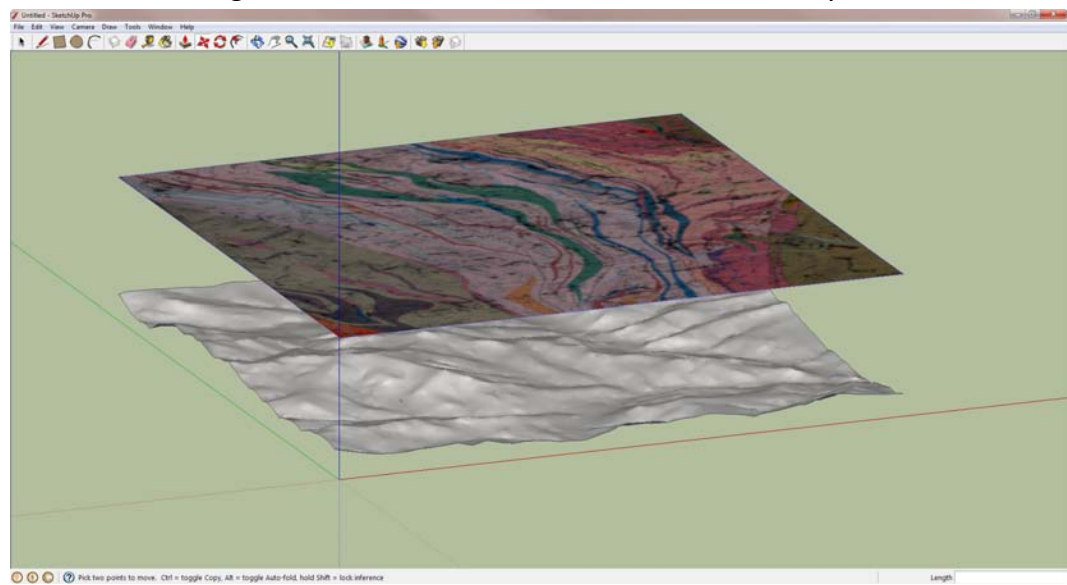
- c. Right-click on the DEM again, select Soften/Smooth Edges, set the Angle Between Normals to 120 degrees, check both the Smooth Normals and Soften Coplanar boxes. The DEM should look pretty good now.
4. **Prepare the Geologic Map and Cross-sections for your model.** Geologic maps and cross-sections can be scanned from paper copies or downloaded in digital format. The following site is an excellent place to start looking for material: http://ngmdb.usgs.gov/ngmdb/ngm_catalog.ora.html. There are numerous ways to prepare the map and cross-sections; the following are the steps I used to create the map and cross-sections for the Rochester, Vermont Quadrangle.
 - a. I downloaded the map and sections as one file in sid format and opened it in ArcMap.
 - b. I set the data frame to Geographic Coordinate System with the same datum as the map. I georeferenced the map and accompanying sections using the latitude and longitude values on the corners of the map. Then I changed the data frame to the same coordinate system I used for the DEM exported from Global Mapper. It is worthwhile making sure that the map and cross-sections go through the exact same processes when preparing the images so that no vertical distortion of sections is unintentionally introduced.
 - c. I used the ArcToolsbox/Data Management/Clip Tool to create separate raster images of the map and each cross section; I eliminated as much 'collar' as possible. In order to use the Clip Tool, you must create a polygon shapefile, digitize polygons in the precise shape of the map and cross-sections, and use these polygons to clip the larger image.



- d. I opened the map and each cross-section file individually in ArcMap and exported them as png files at 600 dpi resolution.
 - e. I opened each file in Photoshop to crop the images and make sure that any area I wanted to be invisible was transparent. Not all image formats support transparent edges. Unless you use a format which does, there will be white boundaries around the edges of the map and cross-sections- not a look you want because the white edges will obscure the map behind the cross-sections. I also used Photoshop to make sure the base of each cross-section was as close to horizontal, i.e. as level, as possible. I used the Rotate Image Tool to adjust sections as needed.
- 5. Drape the geologic map onto the DEM surface.**
- a. Use the Camera menu/Standard Views/Top to look straight down at the DEM. Then use the Camera/Zoom Extents to make the DEM fill your screen. Finally, Camera/Parallel Projection will make the DEM look like a rectangle with smooth edges to simplify some of the following steps.
 - b. Use the Rectangle Tool to make a rectangle the same shape and size as the DEM, you may have to make it a bit larger so that the rectangle doesn't interact with the DEM component.

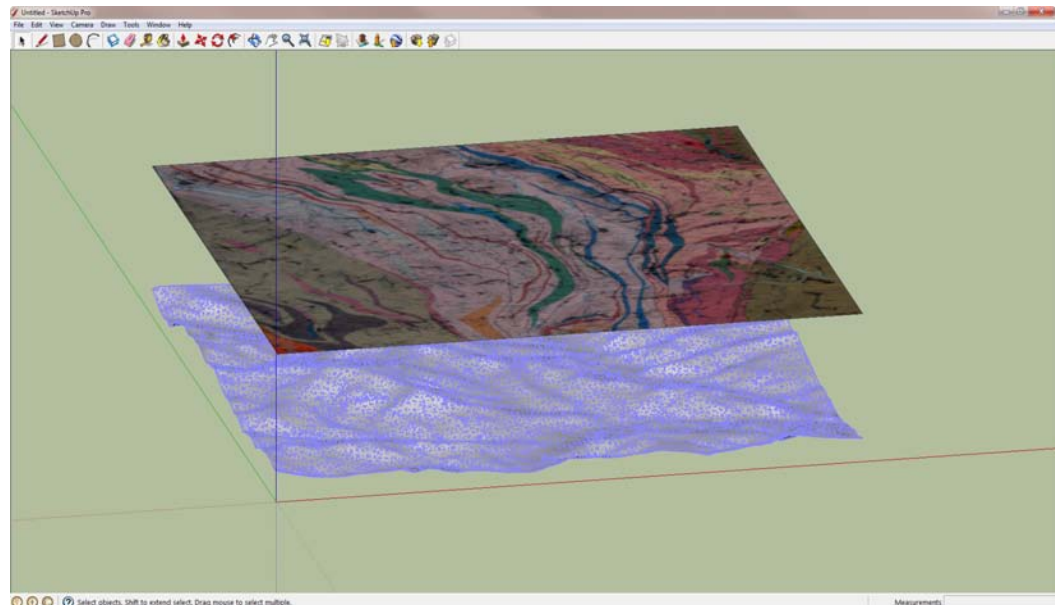


- c. Select the rectangle and use the Move Tool to elevate it directly above the DEM.

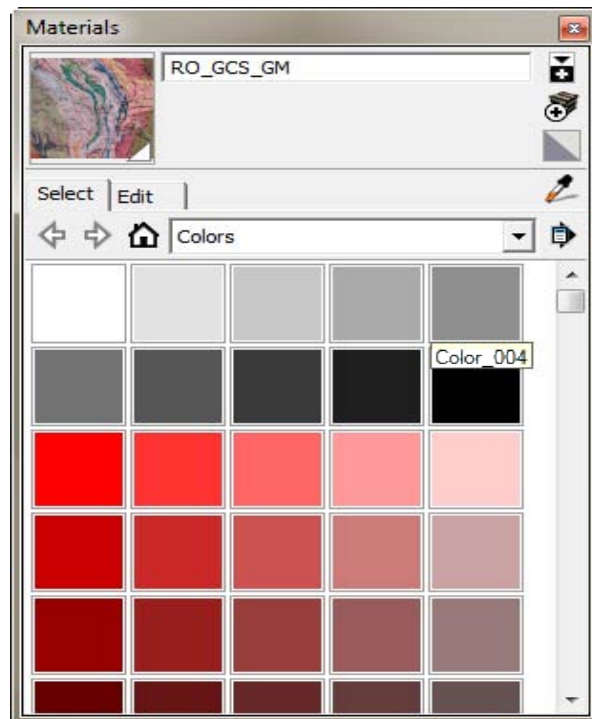


- d. Use File/Import to import the image of the geologic map and place it on the rectangle. You have to use the drop-down menu to let SketchUp know that you now want to import an image. Use the cursor to pin the lower left corner of the image on the lower left corner of the rectangle, and drag the cursor to expand the image to the edges of the rectangle. If the image is not the same shape as your rectangle, there is a mismatch in coordinate systems between the DEM and map. You can use the scale tool to compensate for small discrepancies, but correcting a large mismatch this way will produce different length scales in the x and y directions.

- e. Orbit the model to select the rectangle below the geologic map image and erase it- just the rectangle, not the map.
- f. Right-click on the map and select Explode.

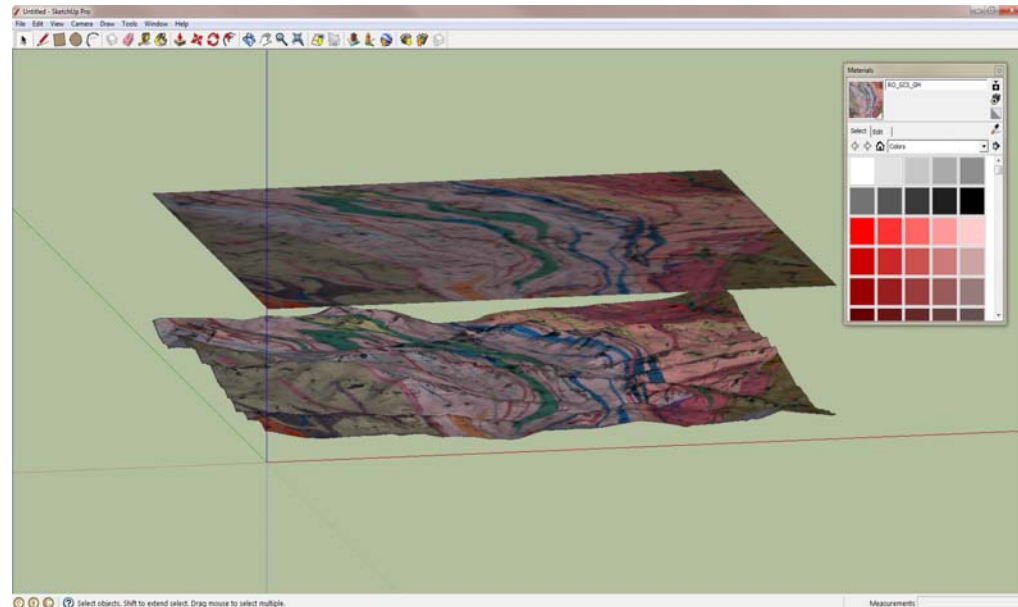


- g. Right-click on the DEM and select Explode; this may take a while if you used many points when you imported the DEM.

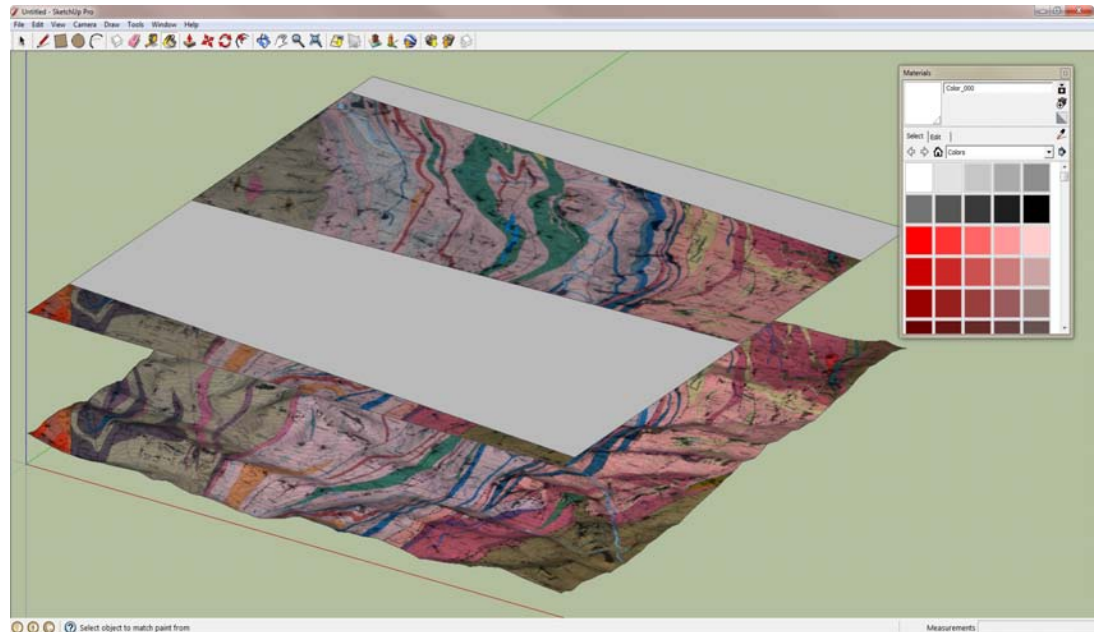


- h. Use the Window menu to open the Materials window. Select the Eyedropper tool in the Materials window and click on the geologic map. You should see a

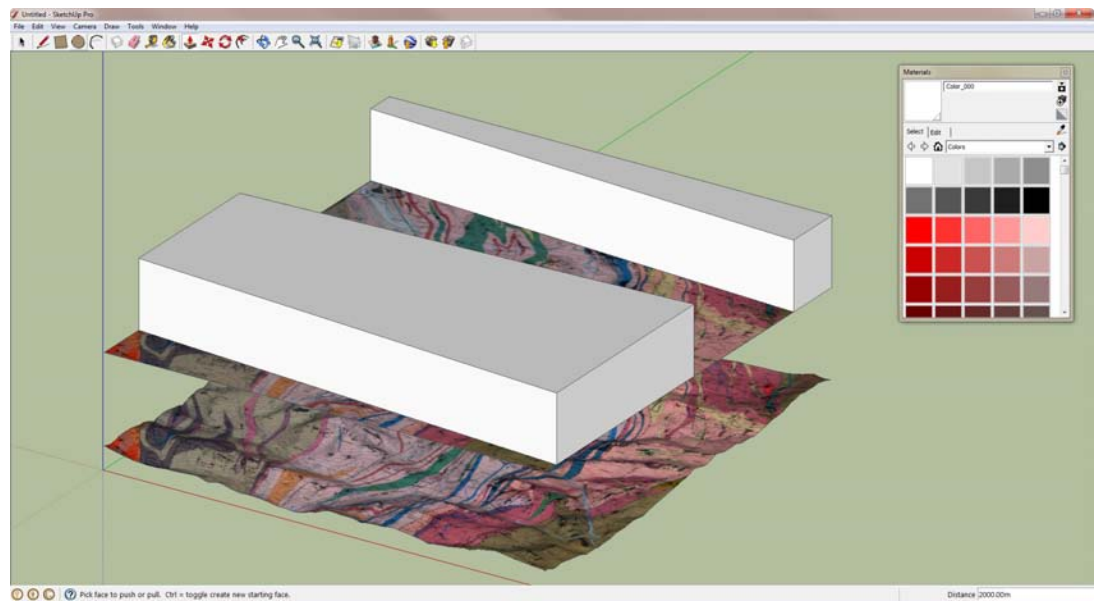
thumbnail of the map in the upper left corner of the Materials window, indicating that you can use it as a material.



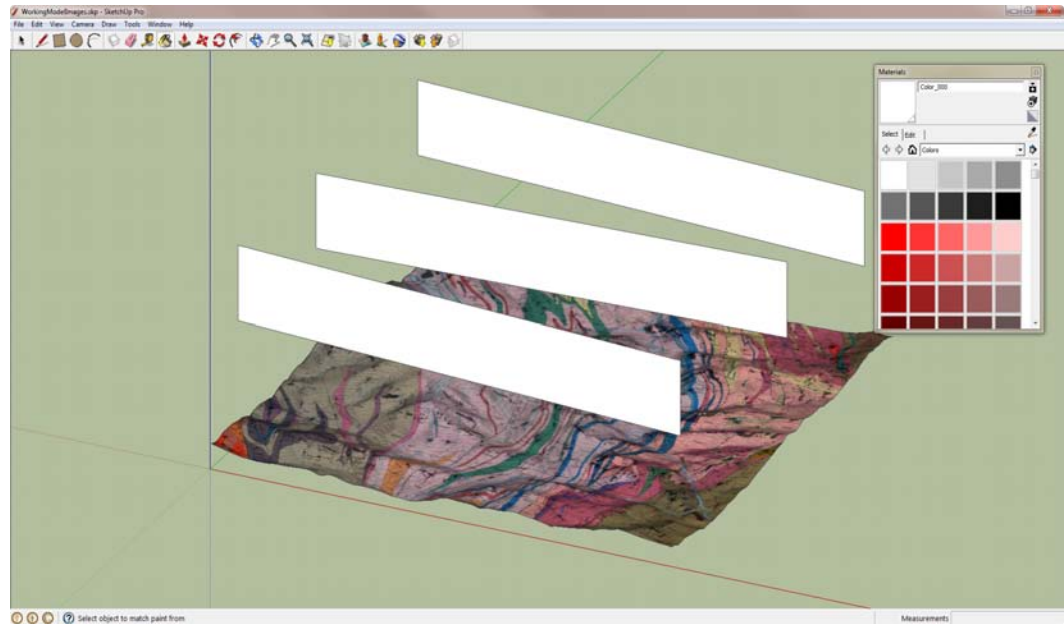
- i. When you move the cursor over the DEM, it will change appearance and indicate that the Paint Bucket Tool is active. When you click on the DEM with the Paint Bucket tool you will drape the map over it. This may take a while, so be patient. You can right-click on the rectangle and select Hide it to hide the upper layer and admire your DEM with the geologic map draped on it. Don't erase the rectangle yet, because we are going to use it in the next step.
6. **Create the cross-section planes.** There is no one correct way to integrate geologic cross-sections with the map, although some methods are far easier and more precise than others. What follows is a detailed description of a method I developed to accommodate the free version of SketchUp, which eliminates a great deal of potential frustration that goes along with a strictly manual approach to positioning the sections. Advanced users of SketchUp Pro have other options available if they make the cross-sections dynamic components and take advantage of the Component Attributes window.
 - a. Unhide the rectangle above the DEM if necessary. To be on the safe side, select it, make a copy using the Move Tool in conjunction with the Control key, move the copy up or down from the original, and hide the copy in case things go badly.



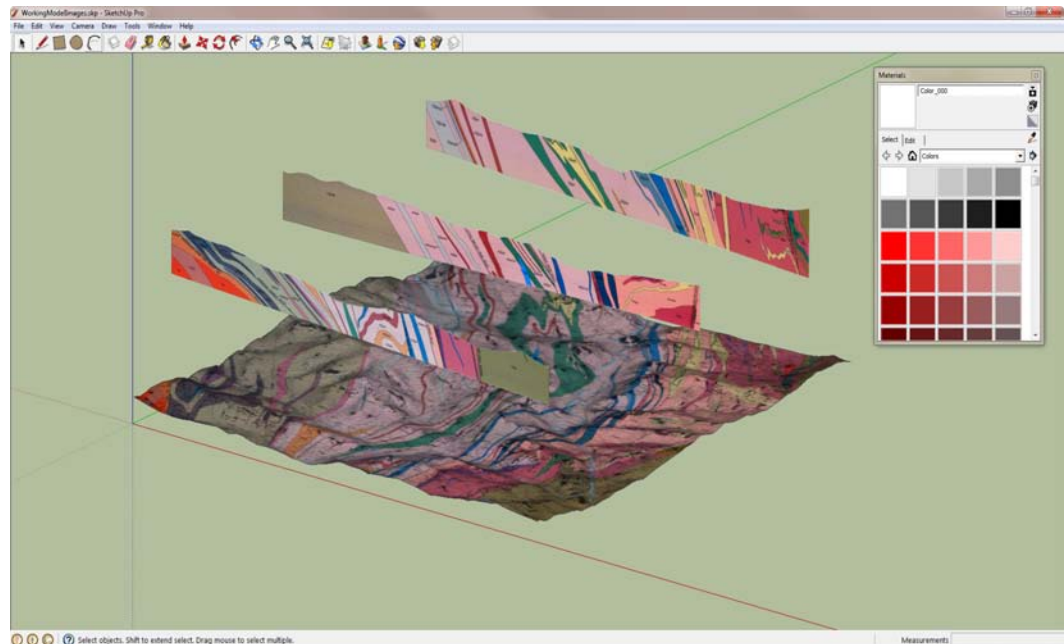
- b. Use the Line Tool to trace the cross-sections lines on the flat map above the DEM. Make four-sided polygons and connect adjacent cross-section lines along the edges of the map. Each section line should only connect with one other line; if there are an odd number of lines, create a polygon containing the odd section line and three edges of the map.



- c. Use the Push/Pull Tool to elevate the polygons just created at least as high as the vertical relief of the cross-sections. There is no need to be precise here; the vertical planes will exist only long enough to help import the cross-section images.

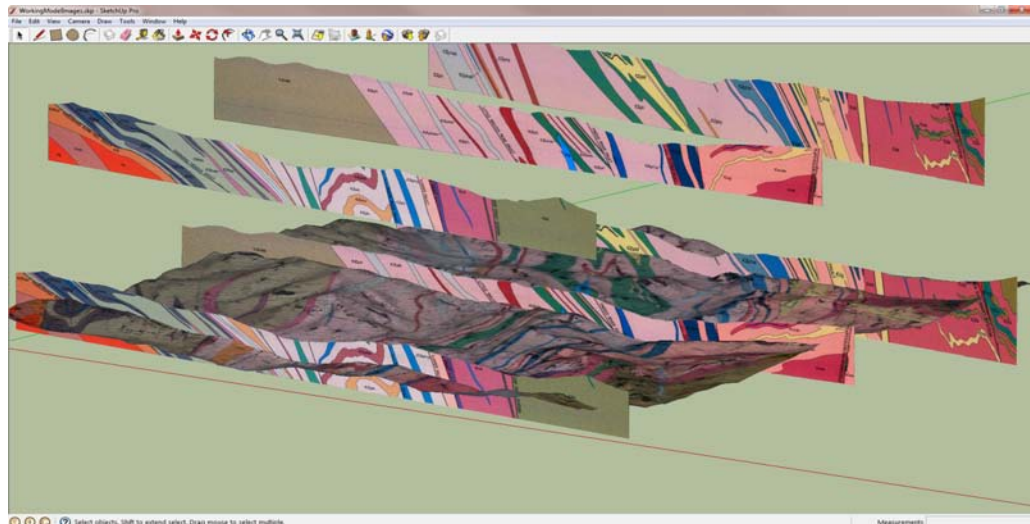


- d. Select ALL planes and lines that are not the vertical planes corresponding to the cross-section lines, and delete them. (The hidden copy of the map serves as backup.)
- e. Import the cross-section images one by one, pin them to the lower left corners of the corresponding vertical section planes, and expand them to fill the horizontal extent of the section planes.



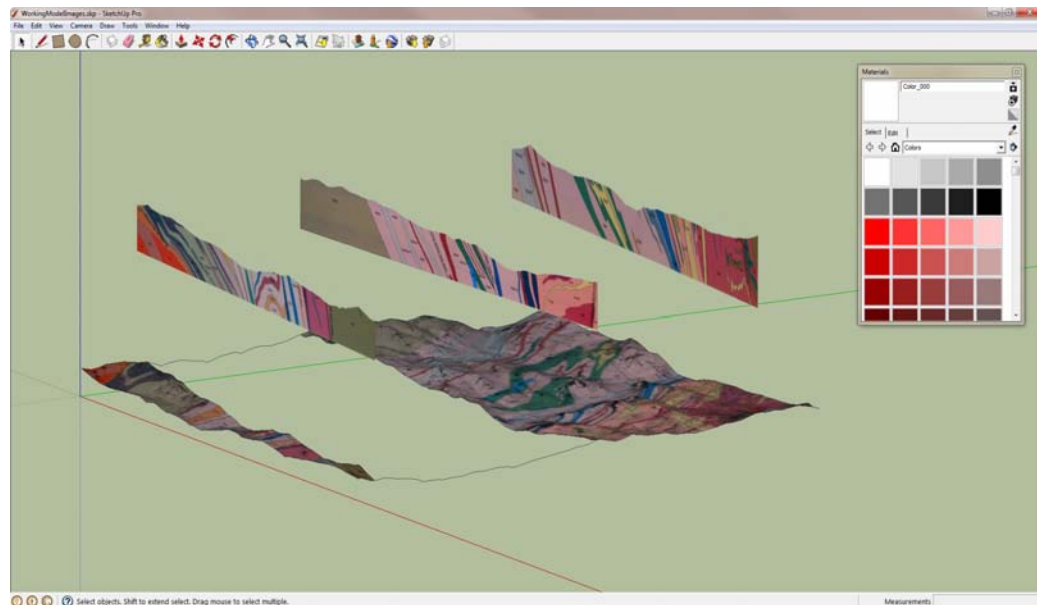
- f. When the cross-section images are all imported, select the vertical planes used as guides, and delete them. The cross-section planes should now be hovering over the DEM directly above the section lines.

7. **Divide the DEM into segments defined by the cross-section lines.** At this point, the DEM is a single entity. If we want to be able to see where the cross-sections and map meet at the topographic surface, we need to be able to ‘turn off’ portions of the DEM.
- Select one of the hovering cross-section planes, and use the Move Tool in conjunction with the Control button to move a COPY of the cross-section plane. Move the plane parallel to the Z direction, or Blue Axis until the plane intersects the DEM. When SketchUp recognizes that you are moving vertically, a floating box appears with the message “On Blue Axis”. Once this box appears you can hold down the shift key and restrict movement parallel to the blue axis, or you can type in a specific value for displacement of the plane. The values you type appear in the Measurements Box in the lower right-hand corner of the SketchUp window- you don’t have to click in the box, just start typing and press Enter to move the plane by the specified amount. Also, you can type in another value to move the plane a different amount if necessary. I highly recommend this approach to get used to fine-tuning the placement of planes. At this point, however, we are not trying to make fine adjustments, just intersect the cross-section plane with the DEM.

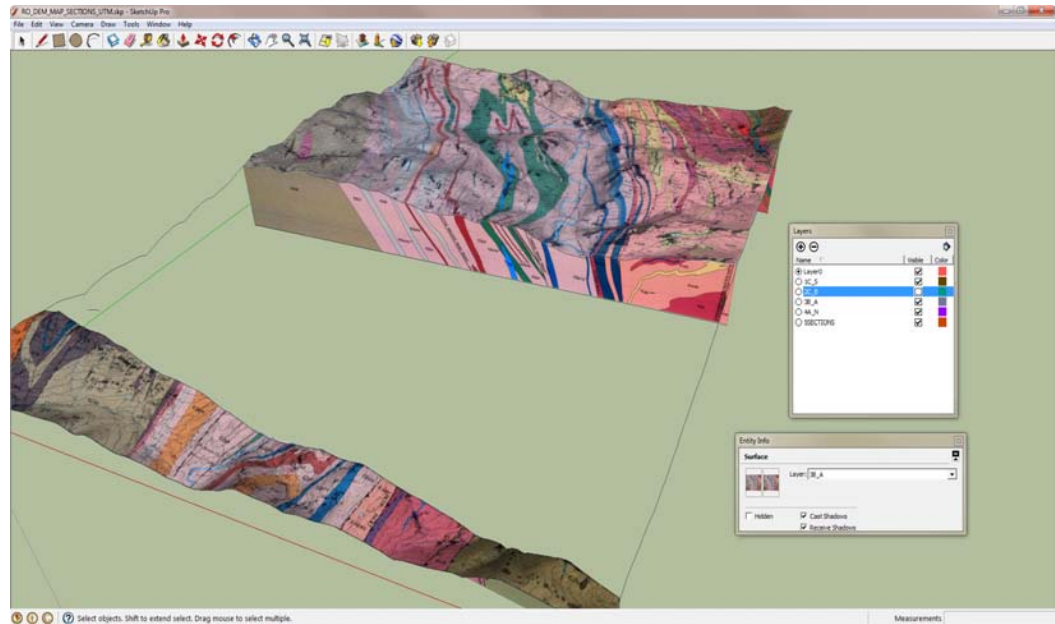


- Use the Scale Tool to make the cross-section plane a bit wider than the DEM. With the cross-section plane selected, click on the Scale Tool, and grab the handle on the east side, hold down the control key, and stretch the plane about

the center point to make it longer than the DEM.

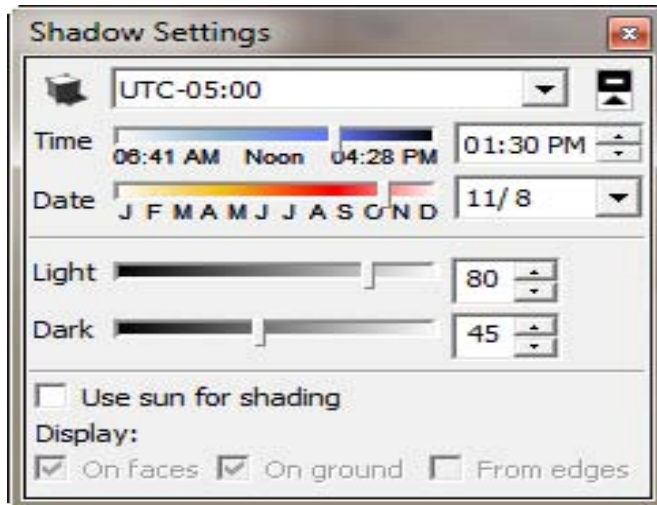


- c. With the section plane copy still selected, go to Edit/Intersect Faces/With Model. This will divide the DEM into two segments on opposite sides of the cross-section plane. An easy way to tell if you have succeeded is to click on one segment with the Select Tool; it should be the only part of the map selected if you correctly intersected the plane with the DEM, and it should be possible to hide this segment. Delete the cross-section plane copy.
 - d. Repeat this process for all cross-section planes. If you have n cross-sections, you should have $n + 1$ DEM segments.
8. **Integrate the cross-section planes with the DEM and geologic map.**
- a. Select one of the cross-section planes and use the Move Tool to lower it until the topographic surface of the section matches the topographic surface of the DEM. It is easier if you Hide one of the DEM segments adjacent to the section plane. I prefer to use the Measurements Box to move the section-plane by precise increments to achieve the best fit. If all went well in previous steps, the *location* of the section planes should coincide exactly with the cross-section lines on the geologic map; the topographic surface will almost certainly *not* match exactly. If the location of the section planes and lines do not coincide something went wrong in an earlier step.



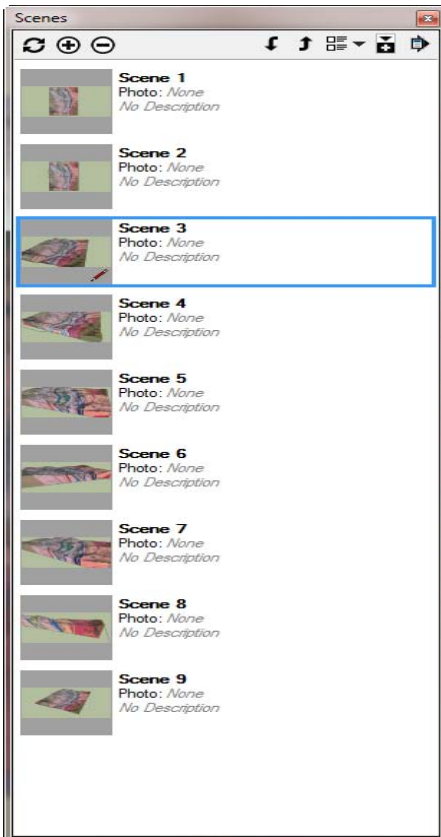
- b. Assign each segment of the DEM to its own layer. Cross-sections can each have their own layers, or be grouped into one layer, depending on how you want your model to look.

11. Use Shadows to illuminate your model.

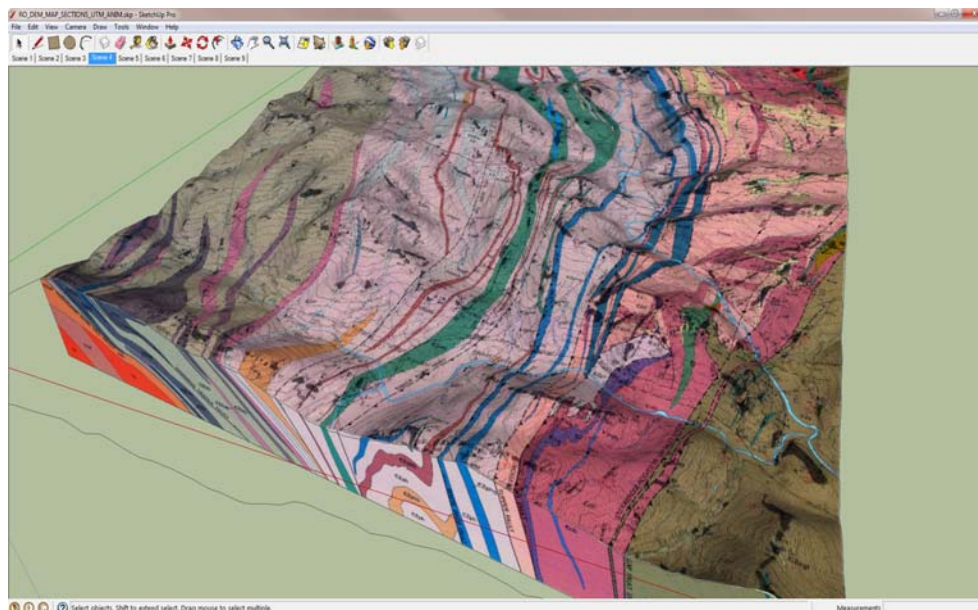


In the Window menu select Shadows. The controls allow you to simulate shadows cast by the sun for any time of any day of the year! Experiment with the settings to find the best light to highlight the topography without making the cross-sections too dark to see.

12. **Use Scenes to create animations of your model.** Among the many cool features in SketchUp, Scenes is very cool. It allows you to record an exact perspective of your model with specific layers visible or invisible. Multiple scenes can be created to organize a sequential presentation of your model. The family of scenes can also be combined to produce an animation, and the animation can be exported in a variety of formats.



- a. In the Window menu, select Scenes. No scenes will be listed until you create them. Set up your model with the layers you want to be visible and the desired perspective. Click the + button to create the first scene. You can label the scenes and describe them to help you keep track of them.

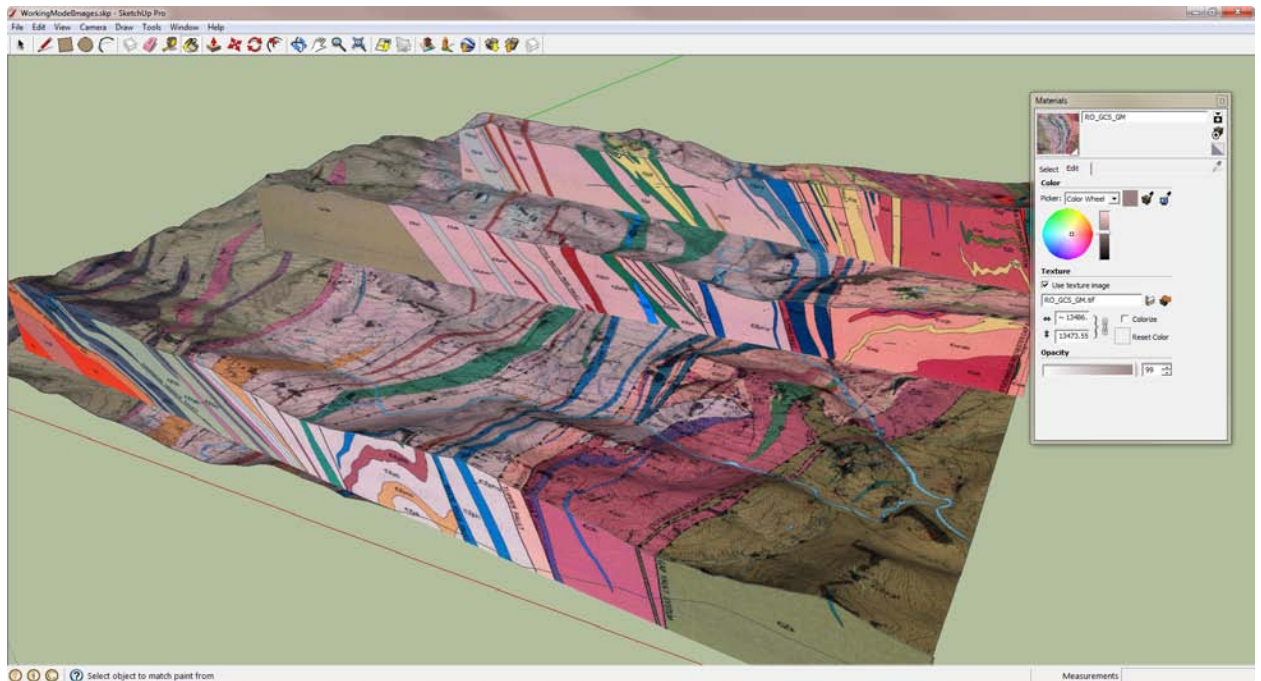


- b. Create a new scene each time you change perspective or the visibility of a feature. Each time you create a new scene, a small box with its name appears

just above the SketchUp model window. If you click on one of these boxes your SketchUp model rotates and pans smoothly to that scene. So, by clicking on the scenes in order, you can run a guided tour of your model, in this case your DEM with a draped geologic map and integrated cross-sections.

- c. Go to the View menu/Animation/Play to run an animation of your model using the scenes you created. You can control how the speed at which the animation runs and the delay between scenes by going to the View menu/Animations/Settings/Animation.
- d. You can export your animations by going to File menu/Export/Animation. There are several export File Types available on the drop-down menu, and a host of possible options to control the quality of the exported file with the Options button.
- e.

13. One more trick for viewing your model.



Here is one trick I discovered recently. If you change the opacity of the map from 100% to a lower value, even 99% will do, the cross-sections will take precedence over the map. This means that you can 'see through' the map to the cross sections below, eliminating the need to 'turn off' segments of the map. It works fine, but some viewers may have more trouble processing the map and sections this way than they would if the an entire segment of the map were invisible. I suspect part of the problem has to do with missing visual cues to help interpret the image. Still, it makes for an amusing perspective on the block diagram.