Developing the Magic Eye for folds

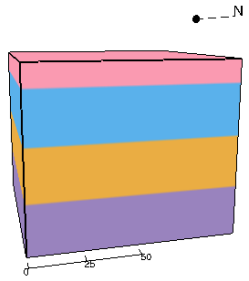
This lab exercise is designed to get you thinking about the chronology of structural processes and and the resultant map patterns in areas with flat topography. You may want to use this tool later *with* topography to help you visualize complex map patterns. This tool will allow you to recreate scenarios within a 3-D model.

For the first part of this lab, we will walk through an example with instructions on how to operate the software to create a block diagram. This is the introduction phase and will serve as a familiarization of the software.

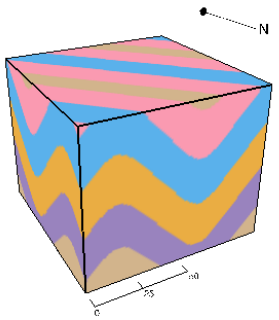
The next phase includes being given a picture of a block diagram from which you have to work backward to recreate the map pattern and cross sections using what you have learned in Structural Geology thus far. It is important to realize that map patterns are non-unique and that there may be several ways to deform the rocks to get them to produce a given map pattern. In geology we tend to not worry overly much about this and use the simplest explanation as a primary working hypothesis.

Part 1: Introduction to Visible Geology

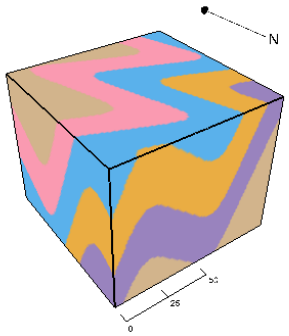
1. Click on Visualize
2. Click on the "add new" bed tool.
3. A window should show up and you can add beds, edit beds, etc. For this assignment I have made four equally thick beds and gave them arbitrary colors and petrologic nomenclature. Be creative, but try and have them make some sort of sense geologically (i.e.: slate bounded on top and bottom by sedimentary rocks is not exactly feasible). This figure shows what it should look like up to this point. →



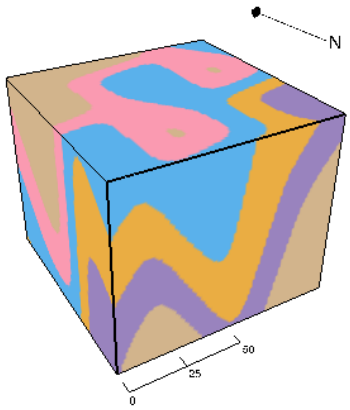
4. Once you have created your beds, it is now time to liven up these boring old laterally continuous units.
    a. Click on the folds button.
    b. Set the strike of the axial plane to 136, the dip to 90, and the rake to 0.
    c. Now press the button that says "Add new folding event"
    d. You should get a nice 3-D look at what has happed to these units; like this →



5. Go ahead and spin this block around a bit and think through what has happened. Compare the map view to the cross-section views and comment on the different patterns you observe with each perspective.
6. Now click on the "tilting tab"
    a. Set the strike and dip of the tilting plane to 226/45 NW.
    b. Click "add new tilting event"
    c. You have now created a plunging fold train. As you can see, it's getting tougher to identify what has happened here, see? →
7. Alright, now click folds again.
    a. Set the Strike and dip of the axial plane to 046/74 with a 20 degree rake (notice that this rake tilts the fold axis to



an angle of 20° from the strike of the axial plane along the plane) and click on "add new folding event" once again. This figure shows the abstract artwork you should be looking at now →



Take note of the map patterns and cross section views. The key to reconstructing viable geologic histories from these is going to be understanding the different functions. We have only used two functions (folding and tilting). In an effort to ease you into this we are going to leave it at this for now. So, when working on the next part, keep that in mind. It is either folding or tilting. Just pay attention to the orientation of the folding and tilting and do your best to make your picture look like mine.

Part 2: Following the leader, the leader, the leader….

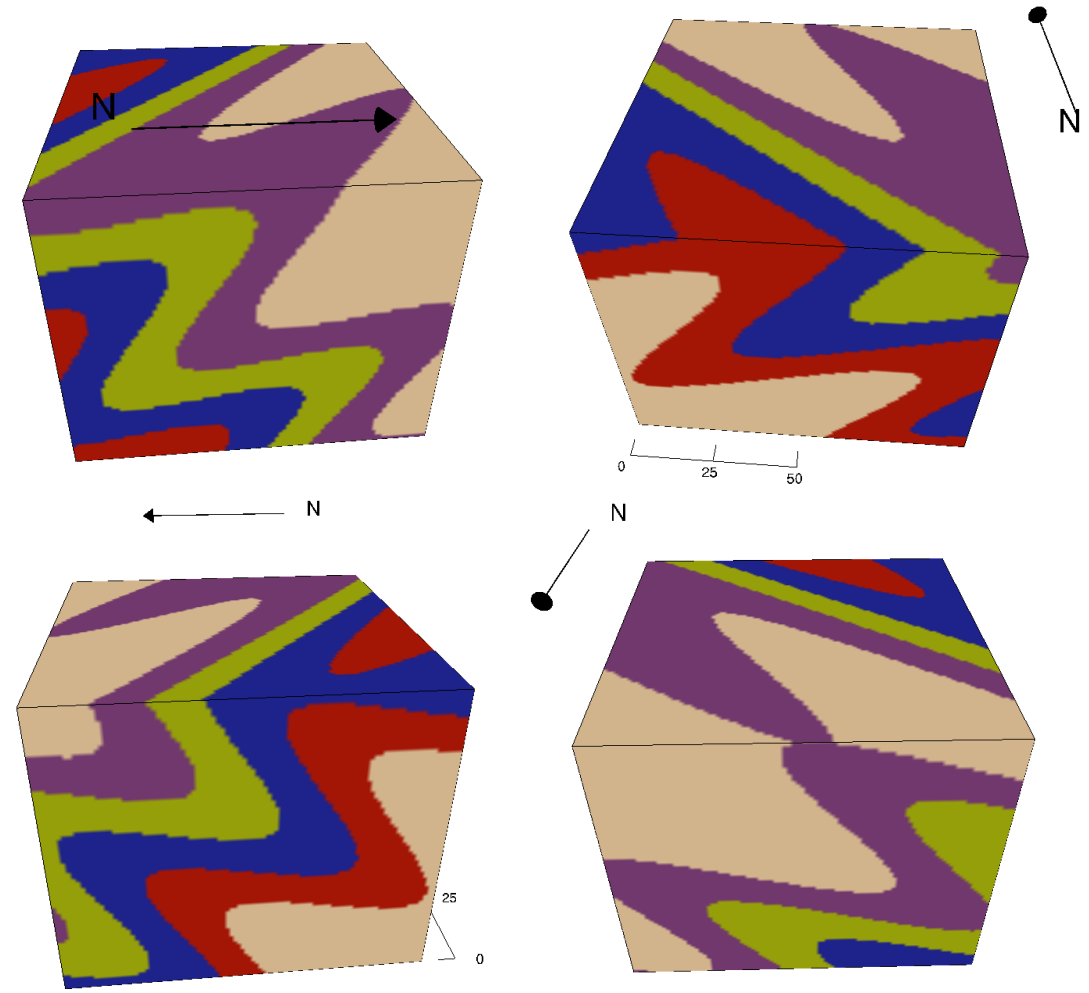
Use the instructions below to create a new block diagram. In the interest of saving time you can just undo all the changes you made to your current model and get it back to flat lying units.

Follow these steps:

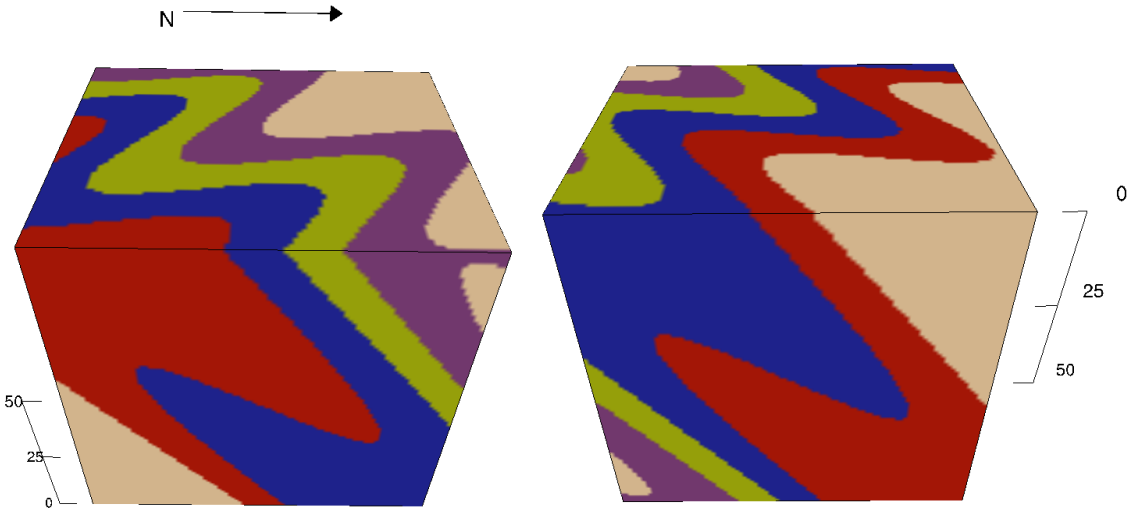
1. Fold at 254/84 w/10° rake
2. Tilt at 187/60
3. Tilt at 097/20
4. Fold at 332/75 w/02° rake
5. Take a screen shot of what you have produced and print it to hand in with your lab.

Part 3: I know why the caged bird sings…it's crazy!

This is going to be the hard part. I have jumbled up the model. On the following page are screen shots of the results. Your mission, should you chose to accept it, is to figure out what happened by recreating the geologic events using the model. This will be an iterative process and you may not all go about it the same way. You will probably have to play with this part at home some. HINT: *Pay attention to the north arrow so you can determine orientation of the fold axis and other features*. Once you are done print your image hand in with your lab. Ensure there are view-direction labels on these images.



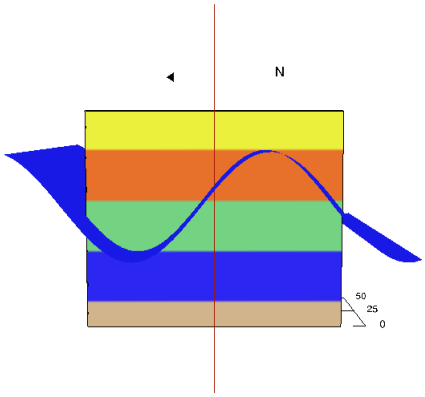
Bottom View

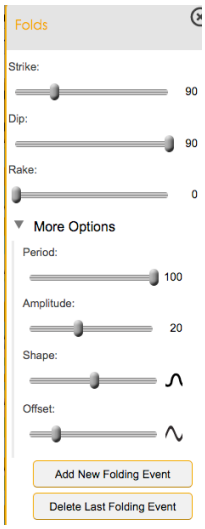


Part 4: Non-unique cases of non-uniquity

The next exercise is intended to lead you through the process of visualizing *non-unique* map patterns of folds to prepare you for exploring folds on bedrock geologic maps. This exercise uses the following webpage: http://app.visiblegeology.com/

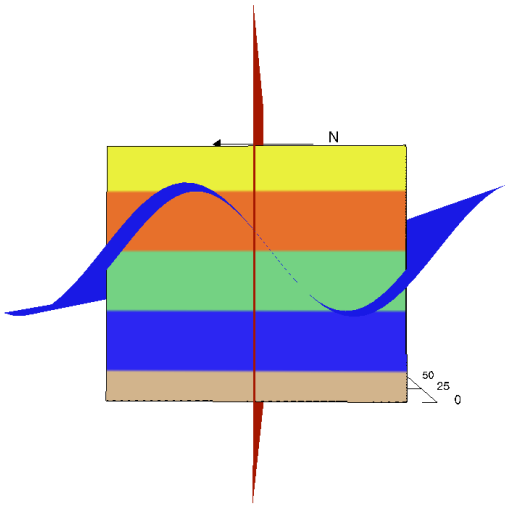
1. Enter the site and click on "Geologic Beds" to enter layers.
    a. Make 5 or 6 differently colored beds, each with a width of 25. (The names don't matter.)
    b. If there is a tan layer at the top of the block diagram, then click on "settings" and change the starting depth to -40.
2. Next we need to make some folds.
    a. Click on the "Folds" button.
    b. Modify the information in the options to match the values shown here →
    c. This should make the display look like this:
    d. Click "Add New Folding Event" to see the results.
3. Now we need to tilt the folds.
    a. Click on the "Tilting" button
    b. Add a tilting event along a plane oriented 000°, 35°E
4. Now sketch (or print) the result with these specifications:
    a. A block diagram viewing slightly down to the NE so that you can see three faces (the top, the S-facing side and the W-facing side).
    b. Label the map view with fold symbols and strike and dip symbols.





Let's try another one:

1. Delete the last tilting event and the last folding event. You should now have flat-lying units again.
2. Click on "Folds" and modify the "offset" option so that the trough and crest of the folds are reversed from the first module (shown to right) and create the fold.
3. Then add a new tilting event on a plane oriented 180°, 35°W.
4. Sketch (or print) the box diagram, oriented as above, and mark the map symbols on this image.
5. Lastly, comment on similarities and differences in the three block diagram views (paying special attention to the map view patterns).
6. *For 10 pts extra credit (on your own at home) develop a Visible Geology model to solve problem 6.5 in your lab book.*



Part 5: Now you're ready for some real outcrops!

1. Open foldA.kmz and print foldA.jpg

a. Draw strike and dip symbols and fold symbols on the printout, aided by what you can see in Google Earth.
b. Sketch a structural cross section along line X-X'
c. Determine from the outcrop pattern whether this fold is cylindrical (has a straight hinge line) or non-cylindrical (has a curved hinge line). Explain your evidence with words and a sketch.

Stereographic analysis of folded rocks

The two following datasets contain attitude measurements taken from the limbs of outcrop-scale folds. For each dataset complete the following:

1) Plot a ß-diagram on a sheet of tracing paper
2) Plot a π-diagram on a different sheet of tracing paper
3) Report the orientation of the ß-axis, π-axis, and π-circle girdle for each dataset.
4) Label each sheet of tracing paper with a descriptive title and your name.

Dataset 1: M&M folds

106	36.0	sw
150	45.0	sw
079	40.0	se
040	60.0	se
177	65.0	sw
053	50.0	se

Dataset 2: Palm Canyon Folds

130	53.0	sw
128	66.0	sw
240	22.0	nw
240	50.0	nw
247	49.0	nw
241	22.0	nw
258	38.0	nw
221	17.0	nw
205	20.0	nw
161	34.0	sw
156	37.0	sw
152	42.0	sw
164	47.0	sw

Now you are ready for Part 2 of your term project. Start collecting your strike and dip data from the map and plotting it in stereonets. Please continue to do these by hand for now. I will give you an opportunity after your first exam to take a stereonet quiz, which, if you pass, will allow you to turn in computer-generated stereonets to me for future homeworks. There are many stereonet programs out there that have the same basic functionality but different manuals. I would recommend Rick Allmendinger's programs, some of which I posted for you on Angel.