**Creation of a 3-dimensional model from stacked structural contour maps**

Much effort has been expended in trying to find ways of making cross sections of subsurface data. These efforts have included various purely geometric techniques (busking, dip-domain modeling based on kink geometries, various area-balanced techniques, attempts at volume balancing, etc.), but the fact remains that natural processes are not constrained by our notions of geometric simplicity but rather are constrained by material properties, environmental conditions, and the physics (mechanics) of deformation.

The other fact we have to contend with is that we are always trying to understand the subsurface geology based on a (generally insufficient) finite amount of data that might include various forms of well data (cores, strat logs, geophysical logs), geophysical surveys (seismic reflection/refraction, conductivity, resistivity, potential fields like gravity and magnetism), and ground-surface geologic mapping. Considering multiple independent finite datasets (e.g., well data plus seismic reflection data) can be very helpful in constraining subsurface models.

Here, we build a 3-dimensional model of two structural surfaces from all available well data. These surfaces are in an area that is known to have normal faults, so the surfaces are potentially discontinuous. The surfaces are sedimentary contacts, and the strata are generally tabular and approximately horizontal over a broad area, but might be locally wavy or slightly folded due to the effects of faulting and the movement of salt. All of the wells depicted on the maps are vertical wells.

We start at the surface that is closest to the ground surface, because it will be pierced by the greatest number of wells and so we will have the most data to work with.

All elevations are relative to sea level, so "-9061" is 9061 feet below sea level.

Top Map: Base of the Massive Anhydrite, East Texas Basin (CindyTopMap.jpg)

Step 1. Create a structural contour map based on the preliminary assumption that this is a continuous surface. In this exercise, we will use a contour interval of 100 feet.

Step 2. Visualize the shape of the surface. One way of doing this is to use colored pencils to highlight the highs and lows of the surface. Another is to write code that computes the gradient between adjacent data points, and then you can add color to the tie lines that represent the highest gradients.

Step 3. Based on the interpretation that areas of high gradient might be caused by fault discontinuities (rather than by folding), we infer the location of any faults in the map area and re-draw the map as a structure map of a discontinuous surface.

A structure contour map of a faulted surface involves edges where the fault intersects the faulted surface.

Bottom Map: Base of the Rodessa Member, Lower Glen Rose Formation (CindyBottomMap.jpg)

Step 4. Identify the areas on the bottom map where there is enough data to create local contour maps, then sketch-in some contours.

Step 5. Establish a line of cross section that is approximately perpendicular to any major fault trend that you have inferred, and draw a profile of the base of the Massive Anhydrite on one of the cross-section boxes (CindyXsec.jpg). Notice that this cross-section box has a vertical exaggeration of 2x, so a normal fault with a dip angle of 60° will have a vertically exaggerated angle of 73.9°.

Step 6. Add the available data from the bottom map to the cross section, and fill-in the missing data based on the shape of the upper-map surface and the inferred fault(s). Sketch the profile of the bottom surface on the cross section.

Step 7. Transfer the elevation data for the bottom surface along the cross section onto the contour map of the bottom surface, and use those points to (tentatively) constrain redrawn contours on that map.

Steps 8 through infinity. Repeat steps 5 through 7 for vertical cross sections at other strike orientations throughout the map area.

The result will be an internally consistent 3-dimensional model of the subsurface (between those two surfaces) that honors all of the available data. The model can be revised as new data become available.