Spring 2007

Final Project Tutorial

Subsurface modeling of a Pleistocene-age shellbed beneath downtown San Diego

Background

1. Topic

   A discrete fossiliferous shell bed (the "Lower Broadway Faunal Horizon") has been encountered in subterranean excavations throughout downtown San Diego. This shell horizon appears to be traceable throughout the downtown area.

   Because of its widespread lateral distribution this stratum may make an effective marker bed useful in deciphering the subsurface geology of downtown area. With this project I hope to develop a hypothetical model of how this horizon is oriented and distributed in the subsurface.

2. Research Question/Problem

   This model can be used in a number of different ways

   First - To predict at what level this layer should be expected to crop out in new excavations in the downtown San Diego area and thus where more fossils can be collected (important for the paleontologists).

   Second – This horizon should represent an effectively planar surface. If interpolation from the known localities yields a hypothetical model that is not planar it would suggest that a structural geologic feature (like a fault) has distorted that surface (potentially important information for everyone).

Data Acquisition

1. In Microsoft Access I cross-referenced the San Diego Natural History Museum's Specimen Catalog with their Locality catalog (using locality number as the linking field). I then queried these data for all localities that have yielded specimens of the Pleistocene-age pectin *Oppenheimopecten vogdesi* (one of the index taxa common in the "Lower Broadway Faunal Horizon"). This yielded a total of 32 localities. I then pared the sample down to just localities that occur within the downtown San Diego area and unquestionably represent the "lower Broadway faunal horizon" shell bed, as opposed to isolated reworked specimens that might have occurred higher in the stratigraphic section. This yielded a total of 16 localities that were usable for this project.

2. I then imported these localities into ArcMap as XY point data (using their UTM coordinates; NAD 27), and created a shapefile (LBFH_DT).

3. I then imported some background data layers. The main one I need for display purposes is the USGS 7.5' Point Loma, CA Quadrangle (obtained from the CASIL website). Because I planned to also display the results of this project in ArcScene I knew that I would also need a DEM of the same area.

4. A DEM of the Point Loma Quad was not available from CASIL, the one that I downloaded from SANGIS would not unzip, and finally the one I downloaded from SANDAG would not convert successfully from an interchange file to a shapefile. So I had to create my own DEM (topogrd1). I did this by downloading the 40' contour polyline topo file from SANDAG ("TOPO" in my GIS) and using the "Topo to Raster" tool in the Spatial Analyst toolset to create a DEM from that polyline file.

Data Manipulation

1. I then used the krigging tool (set to Ordinary, Linear – to approximate a planar surface) to generate a best fit hypothetical surface for the "Lower Broadway Faunal Horizon". At the same time I had the krigging tool generate a variance of prediction raster.

2. Because there is a 95.5 percent probability that the actual z-value at a cell is the predicted raster value, plus or minus two times the square root of the value in the prediction raster I could take the variance raster and use the math tools in the Spatial Analyst toolbox to: generate a raster the depicts the square root of the variance; a raster that multiplied the values of that raster by 2; a raster that added that x2 value to the prediction raster (the upper bound); and a raster that subtracted that x2 value from the prediction raster (the lower bound).

3. I also used the slope tool in the Spatial Analyst toolset to create a raster that depicts the change in slope across the surface of the "lower Broadway Faunal Horizon" best fit raster. This was done to quantify the degree of the perturbations that appeared in the hypothetical surface.

Results: Data Analysis in ArcMap and ArcScene

1. The hypothetical best fit surface, as well as the upper and lower boundary surfaces give a approximation of the orientation and position of the "Lower Broadway Faunal Horizon" relative to the ground surface in downtown San Diego (dipping on average 4 degrees to the southwest). This model can now be used to predict where this horizon will be encountered in the subsurface. As new localities are discovered in new building excavations we can test the model against the real world data and use the new data to further refine the model (hopefully decreasing the "error bars").

2. A dramatic increase in elevation occurs between the western most point (at elevation = -28') and it's closest neighbor (at elevation = 32 feet) 135 meters to the

northwest. Suggesting a slope of 15.5 degrees well above what would be expected for the inclination of this horizon. This is strongly suggestive of a fault or other structural geologic feature separating this western locality from its neighbors. In fact a "earthquake faults" shapefile available from SANDAG shows a fault a little less than 30 to the west of the westernmost locality. It is possible that this fault might be mapped in the wrong place, another related fault strand may lie east of the western most point as suggested by these data, or the position of the fault in the SANDAG file might be a result of a misalignment of the data projections. In any case this will require further testing.

3. The hypothetical surface shows what appears to be a major change in the attitude in the plane approximated from the points in the eastern part of the study area relative to the plane approximated from the points in the western portion of the study area. This is strongly suggestive of the presence of some sort of structural geologic feature (most likely a fault) in roughly the center of the study area. It is interesting to note that the roughly northeast trend of the feature suggested by these data falls roughly in line with the orientation of the mouth of Florida Canyon. Canyon drainages are commonly associated with faults.

Conclusions

While the associated error values produced with the hypothetical surface of the "Lower Broadway Faunal Horizon" are larger than I had hoped for, this project has produced a reasonable model of the subsurface distribution of this stratum. This model has also suggested the presence of two structural geologic features that have perturbed this unit. While at a nascent level, I do believe that this project has accomplished it's goals. The addition of more data points as this fossil horizon is exposed in future excavations will allow for modification and refinement of the model, resulting in future iterations being able to make much more accurate predictions about the real world.