Three Dimensional Visualization of Hydrostratigraphic Data Using RockWorks/2002™ - A Hypothetical Case Study

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The stratigraphy present in the Sugob Desert, a hypothetical area located in the Northern Lacitethoppyh portion of the Puedam Plate, is composed of Precambrian basement rocks overlain with near-shore and estuarine carbonates deposited during the Paleozoic and Mesozoic Eras into the early Tertiary. The area was invaded by granitic intrusives and uplifted during the early Tertiary, resulting in fluvial and gravel deposits Miocene to Pliocene in age. Surficial rocks are composed of Pleistocene lake sediments deposited in enormous pre-historic lakes associated with a regional basin and range tectonic system whose normal faulting is still active today.

The case study began with the creation of a borehole and measured-section database in which the XYZ (Easting, Northing, & Elevations) for all observed stratigraphic contacts were recorded (see Figure 1). The next step was to interpolate a series of superface (top) and subface (base) grid models for each stratigraphic unit. These grids were created within the RockWorks/2002™ program using a variety of gridding algorithms including inverse-distance, triangulation, and polynomial-regressions.

Figure 1. Stratigraphic borehole logs and measured sections.
The grid models that represent stratigraphic or hydrostratigraphic contacts may be; (1) interpolated from a list of XYZ control points, (2) interpolated from borehole or measured-section data, or (3) imported from other programs.

These contact models were used as the basis for a stacking operation in which the surfaces are plotted in relative order. At the same time, the program generates stratigraphic profiles along the perimeters of the stack. The final result is a stratigraphic model as depicted in Figure 2.

This type of modeling is referred to as “2½D” stratigraphic modeling. For each surface, there are two independent variables (easting and northing) and one dependent variable (elevation). As a consequence, a surface may not curve underneath itself. For any given easting and northing, there can only be one elevation. Hence the 2½D designation as opposed to true “3D”.

The surfaces that define the tops and bottoms of each stratigraphic unit were truncated in a geochronological order via a series of grid filters. This filtering process insures that upper surfaces are set to the same elevations as the lower surfaces wherever they project below the lower surfaces.

The composite diagram depicted within Figure 2 was displayed within a 3D rendering subroutine (RockPlot/3D) that allows the viewer to manipulate the viewing angles, vertical exaggeration, lighting, etc. The user is also able to determine which stratigraphic units should be visible. This later feature was used to effectively “peel back” formations in order to gain a clear understanding of the paleo-environments.
A completely different approach to stratigraphic modeling involves the creation of a three dimensional matrix of blocks. Each of these blocks (voxels) contains a “G” (grade) value that represents the type of material at that particular point in space. The model depicted within Figure 3 was generated by using the stratigraphic surface grids as bounding filters. For example, if a voxel is bounded by the Permian superface grid and the Permian subface grid, it is assigned a G-value that represents Permian rock.

This type of modeling is considered true “3D” modeling. For any given easting, northing, and elevation, there is one dependent G-value.

Although the net result is not as aesthetically pleasing as the 2½D output, 3D models have some distinct advantages; (1) Volumetric calculations may be made simply by counting the number of voxels with a specified G-value and multiplying the result by the voxel-dimensions, (2) Non-stratigraphic data such as geochemistry, geophysics, or geotechnical observations may be modeled in a similar fashion, (3) Numeric models may be compared with each other to show correlations between material type and other geophysical parameters.

For example, resistivity and gamma models could be combined to create a “saturation” model. This model could then be combined with a lithotype model in order to generate a saturated sand model.

Figure 3. Solid block model.
In order to illustrate the three-dimensional relationships between groundwater flow and the hydrostratigraphy, a series of “flowpaths” were combined with the hydrostratigraphic fence diagrams and surface models (see Figure 4). These flowpaths may either be generated within RockWorks (via a simple downgradient simulator) or imported from more sophisticated particle tracking programs.

Theoretically, there is no limit to the number of “entities” that can be combined into a three dimensional diagram. Other data sets may include aerial or satellite imagery, location maps, geochemical or geophysical models, and model boundaries. In practice, the process may become very slow depending upon the number of “themes” (3-dimensional layers) open in the 3D viewer, the resolution of the models being viewed, and the speed of the processor. Figure 5 is a composite diagram depicting borehole logs, measured sections, fence diagrams, hydrostratigraphic surfaces, and flowlines.