Why Computers Don't Contour Like Geoscientists

by Larry J. Rairden, #2924 – Houston, Texas

Why can't a workstation generate contours that make sense geologically? Why don't computers honor well control? What gridding algorithm should I use? How do I utilize the workstation-generated contour product in my interpretation workflow?

These are just a few of the questions I have been asked when mentoring younger (and sometimes older) geoscientists on effective use of geoscience workstations. Many of these questions can be answered with a basic understanding of gridding and contouring software. This approach is the same for each workstation vendor. The basic procedure is simply:

1) Input a set of x-y-z control points (e.g., well control)
2) Build a regularly-spaced grid with a z-value assigned to each grid node by an interpolation algorithm
3) Thread contours through the grid nodes

Continuing with the theme of prior articles, I will describe workstation gridding and contouring in the context of the Yegua prospect that I am developing. This work is performed on a GeoGraphix Discovery workstation.

I have already correlated logs from a number of wells in my prospect area. Formation tops and fault picks have been entered into the project database. **Figure 1** shows a map of EY-1 subsea depths and Fault A offsets and depths. My interpretation of Fault A is also shown on this map. Well #1 happens to have a good 15-foot sand with an excellent show in the EY-1 formation. This could set up an attractive prospect.

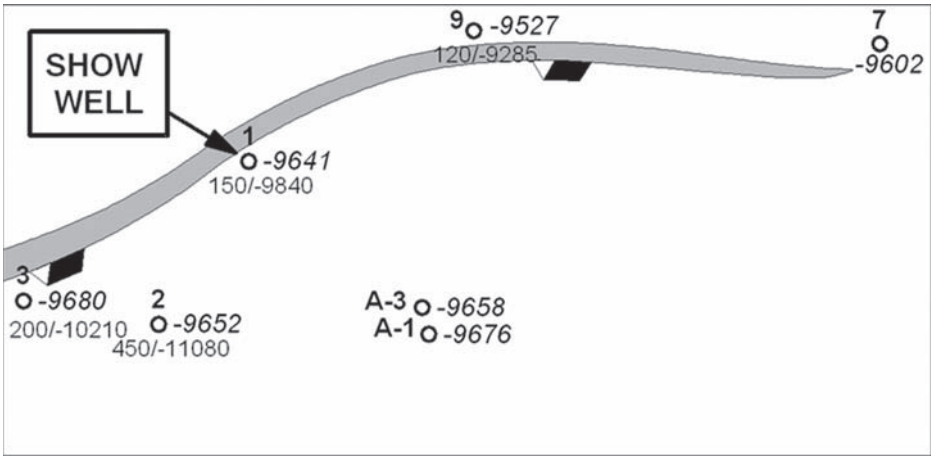

Figure 1. EY-1 depths and fault picks with fault interpretation.

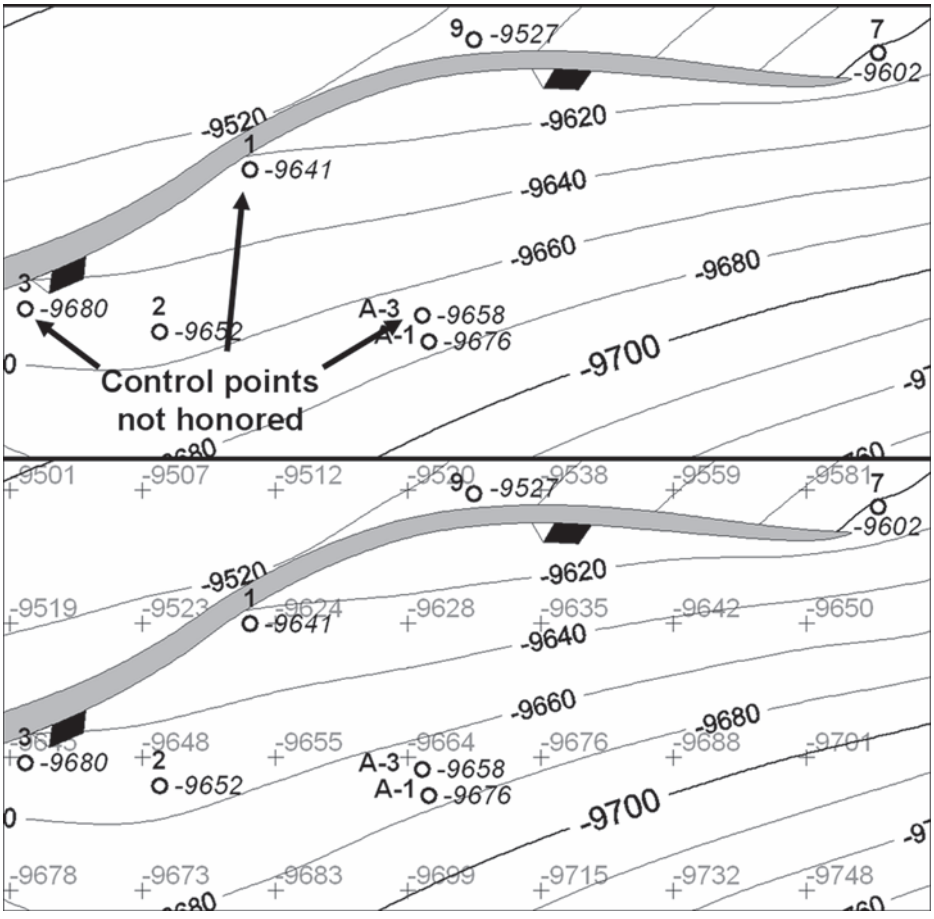

Figure 2. Computer contours on 2000-foot grid. Upper panel shows contours only; lower panel shows grid nodes and grid values.

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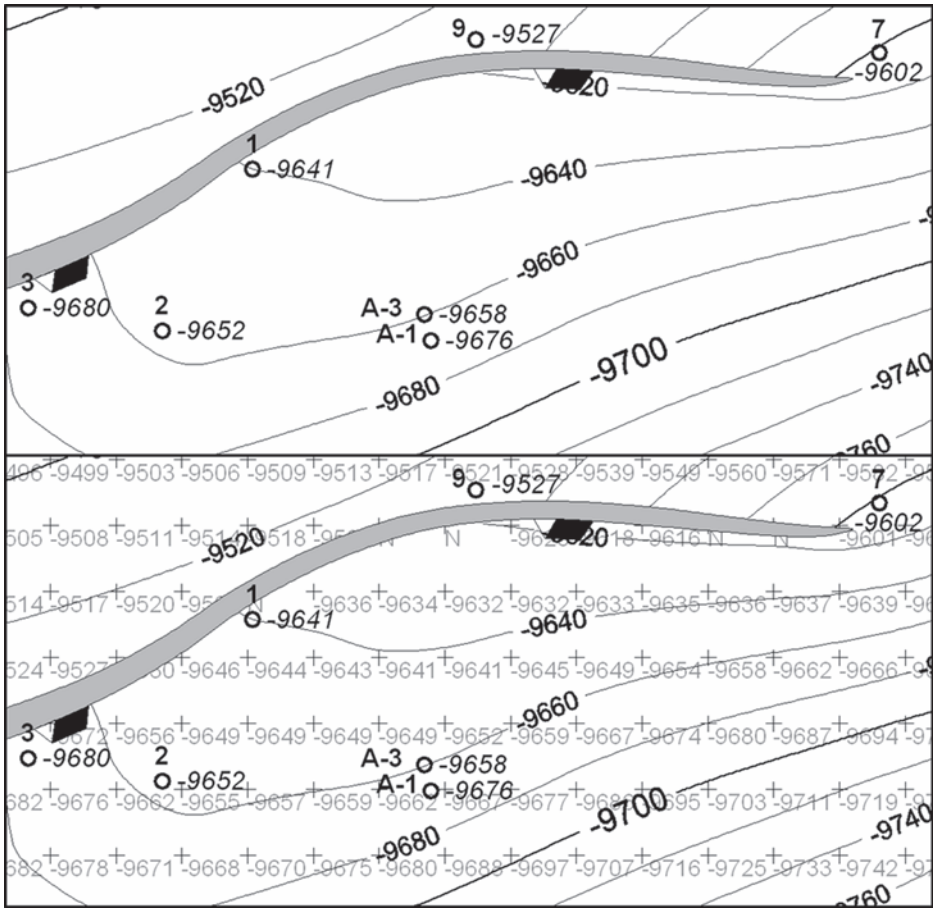

Figure 3. Computer contours on 1000-foot grid. Upper panel shows contours only; lower panel shows grid nodes and grid values.

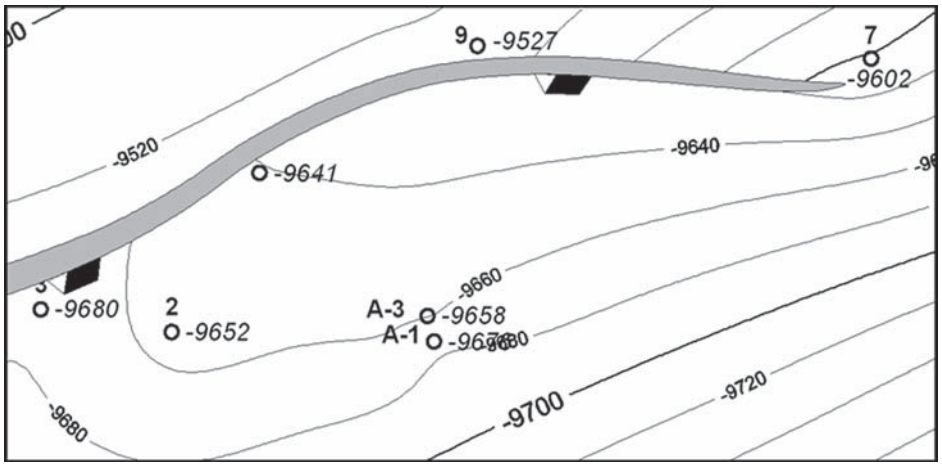

Figure 4. Computer contours on 200-foot grid.

In my first pass, EY-1 control points are contoured on a 2000-foot grid, that is, a regularly-spaced grid with 2000 feet between each node in both the x- and y-dimensions. A minimum-curvature gridding algorithm is applied. A 20-foot contour interval is selected. The output, overlain on the control points, is shown in **Figure 2**. The software has treated Fault A as a discontinuity, as appropriate.

The computed grid is usually hidden, as in the upper panel of Figure 2. In this panel, it can be seen that depth control points at wells #1 and #A-3 have not been honored by the contours. To gain a better understanding of why this occurred, the grid has been toggled on in the lower panel. Grid nodes are represented by "+" signs. Nodes are each 2000 feet apart. Calculated z-values are posted next to each node.

The contours honor the grid nodes. Are the grid nodes wrong? Did I use the wrong gridding algorithm?

Consider the #A-3 mistie. The nearest grid node, about 200 feet NW of #A-3, has a z-value of -9664 feet. Apparently, too much weight was placed on #A-1 (600 feet away, z-value of -9676 feet) and not enough weight on #A-3 (z-value of -9658 feet) and #1 (3200 feet away, z-value of -9641 feet) for contours to tie #A-3 at this grid interval.

I now take a second pass at contouring the EY-1, this time with a 1000-foot grid. The same minimum-curvature gridding algorithm and 20-foot contour interval are used. **Figure 3** shows the result, overlain again on the well control. The upper panel shows that the contours now tie wells #1 and #A-3. Grid nodes are toggled on in the lower panel for inspection.

Obviously, there is more detail in the contours of Figure 3 using the 1000-foot grid than in the contours of Figure 2 with the 2000-foot grid. Why don't we just use a finer grid? The

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answer to this question is in the trade-off between grid-spacing and compute time. Compute time increases with increasing grid-node count. If control points are sparsely spaced relative to grid nodes, a finer grid provides diminishing returns in terms of final contours but can drive up compute effort to the point of being unmanageable on the workstation. Grid-node count can also increase if greater extents are included. It is often desirable to crop the extents of the area to be gridded to the immediate area of interest so that a finer grid can be applied.

Figure 4 shows contours based on a 200-foot grid for comparison. It can be seen that these contours are not much different from the contours based on the 1000-foot grid.

Other questions concern how the contours are threaded through the grid nodes and editing of such contours. Each contour line contains its own control points that are calculated from grid nodes. These contour control points lie on the defined grid between each two adjacent grid nodes that bound the contour value. **Figure 5** shows a close-up of the -9700-foot contour with contour control points toggled on. It can be seen that these points line up on the rows and columns containing the grid nodes, their distance from adjacent grid nodes being interpolated from grid node values, and that the -9700 contour intersects each of them.

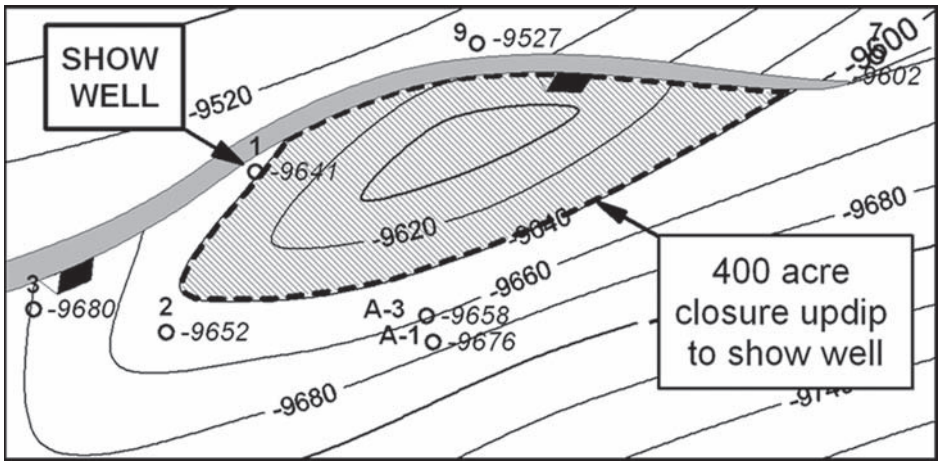

Figure 6. Hand-drawn contours showing closure and potential reservoir area.

Contours can be revised by manipulating these contour control points. Such efforts can be tedious and time consuming, especially if a fine grid was used to generate the contours. Furthermore, if well control or fault interpretation is updated and the contour layer has to be recreated, prior edits will be lost.

There are a vast number of finer points to computer gridding and contouring that are not addressed in this article, such as:

1) Contouring around faults and pinchouts
2) Annotation (contour labels, etc.)
3) Extrapolation in areas with no control
4) Alternative gridding algorithms (e.g., kriging)
5) Grid math (grid-to-grid) calculations
6) Color fill and shaded relief maps

What about the prospect? Perhaps you see the potential trap downthrown to Fault A from well #9, but none of the workstation generated contour maps described above show any structural closure.

Good old-fashioned hand contouring can resolve this. **Figure 6** shows my hand-contours overlain on well control. Note that, not only do these contours tie well control, but they make sense geologically! The rollover structure updip of the show well planimeters at 400 acres closure. Assuming the EY-1 to be 15 feet thick, and at 1200 mcf/ac-ft and 200 Bbl/MMcf recoverable reserves, this prospect could hold over 7 BCF gas and 1.4 million barrels condensate.

If you have a Technology Corner article you would like to submit for publication in the SIPES Quarterly, *please email it to Larry Rairden at rairden@novageoscience.com.*

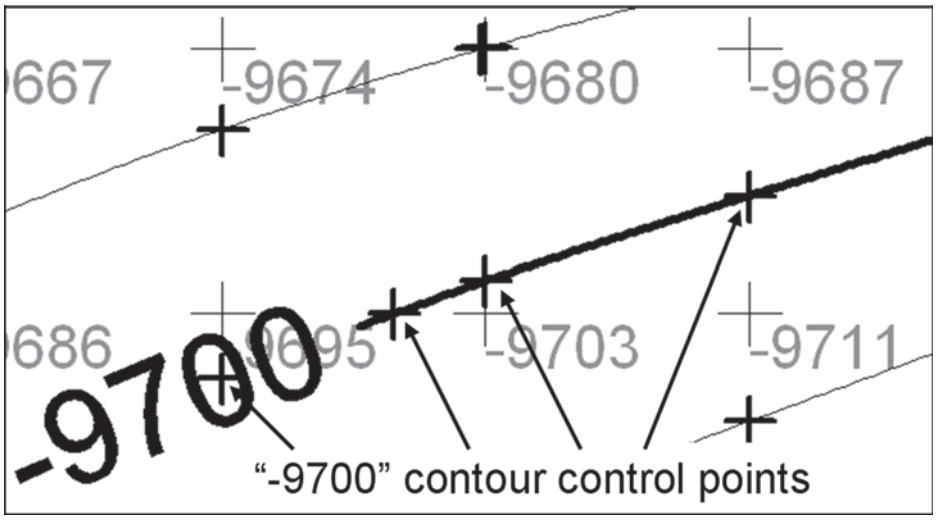

Figure 5. Contours threaded through contour control points. Contour control points (bold "+") are located on rows and columns of the 1000-foot grid and interpolated between grid nodes.