Digitizing and Gridding Contours in Petrel

SCM trainers and consultants use Petrel’s contour digitizing and contour gridding tools on most projects. Thickness, structural trends, and petrophysical trends are the most common 2D Grids built from contour data. These grids are used extensively when building structural frameworks and when building facies and petrophysical property models. Often these grids are built and then tied to sparse point data. A second use of digitized contours is to fine tune 2D Grids built from point data in areas where the point data are sparse. In this instance, the points and digitized contours are merged and the combination gridded. A workflow is often used to automate this process.

**Figure:** Digitized Contours (left) and the 2D thickness Grid built from them (right).

When presenting methods for digitizing and gridding contours in Petrel, we have noticed that many mappers try to apply techniques they used in programs such as Z-MAP Plus (a mark of Halliburton) or CPS-3 (a mark of Schlumberger). Both of these programs have editing and gridding tools that treat contours as continuous lines of data. Users of these programs had to learn the line editing techniques and how to use the contour gridding algorithms to yield the best results. In Petrel the user must also learn to edit contours and build 2D Grids from those contours. However, in Petrel both the editing and gridding techniques are very different from the two programs mentioned above. Petrel treats contours as a series of points and not a continuous line. Once this is understood and the techniques learned, most users find Petrel’s contour gridding methods are efficient, versatile, and yield high quality results. This paper describes methods used in Petrel to digitize contours, build 2D Grids from contour data, and to merge points with contour data and build 2D Grids.

**Figure:** Thickness contours from the original point data (left), zero contours showing where thickness is desired (center), and digitized contours merged with point data and used to create the final thickness contours (right).
Digitizing Contours

Contours are digitized and stored as polygons in Petrel. The Make/edit Polygons process is used to do this. Most important is to digitize as few points as possible for two reasons: 1) it requires an interactive click for each point and 2) to edit the contours you move either an entire line or individual points. Your goal is to be efficient when doing the initial contour digitizing and when editing those contours. After sparse point contours have been created, Petrel has an algorithm that will smoothly resample the lines while continuing to honor the original digitized points.

**Figure:** Contours digitized as a sparse set of points (left). An algorithm used to resample points to represent smooth contours (right).

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**Steps**

The steps used to digitized contours in Petrel are:

1. Prepare the display
   a. Open a 2D Window
   b. Display a reference object or objects to guide digitizing

   **Figure:** 2D window with reference object (points) displayed.

2. Click on the *Make/edit polygon* process (make it bold)

3. Click on the *Pops up Z-value selector* icon on right side of display
   (note the bar in lower left corner)
4. Digitized the first contour
   a. Click on the Start new set of polygons (deactivate old) icon
   b. Start clicking on the points, keeping them widely spaced
   c. Close the polygon by:
      i. Stopping digitizing near but without clicking on the first point of the line
      ii. Clicking on the Close selected polygon(s) icon

   Figure: Digitized first contour before closing (left) and after closing (right)

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   Figure: Digitized first contour before closing (left) and after closing (right)
a. Check to see that the polygon file you want to add another contour to is bold in the Petrel Explorer Input tab

b. Click on the **Start new polygon on the active set of polygons** icon

c. Start clicking on the points, keeping them widely spaced

d. Close or end the polygon

e. Assign a Z-value to the contour

6. Repeat step 5 for as many contours as you desire (Note: If your contours wind up in two different polygon files then open one and use Operation → Polygons operations → Append polygons to merge the two files and delete the unmerged file.)

**Figure:** Final contours ready for gridding. Note that green (-20) and yellow (-40) contours are added to keep the gridding algorithm from projecting positive away from the zero line (purple contour), a standard technique used with all mapping packages.

You will note that contours are left in their coarse or sparse point form. That is, additional points are NOT added to make the contours smooth. Adding points will only increase the number of points that must be moved when edits are required. Additional points will be added on the fly (automatically to a temporary file) during the gridding step and is discussed below.

**Gridding Contours**

Building a 2D Grid of digitized contours is similar to building a grid of point data with the addition of a few more parameters. The **Make/edit surface** process is used to build the 2D Grid. The steps used are:

1. Double click on the **Make/edit surface** process
2. Clear all parameters
   a. Click on the Result surface name
b. Click on the delete key

c. Answer Yes to the question that pops up.

**Figure:** Dialogs used to clear all parameter settings for the Make/edit surface process

3. Insert the contours as the *Main input* data
4. Set the *Geometry* parameters as desired (X-Y limits and Grid increments)
5. Set the *Algorithm* parameters
   - Usually the *Convergent interpolation* is used
   - Occasionally *Functional with Fit points to a Planar Surface* is used for tilted planes
6. Set *Pre processing* parameters
   a. Check the Box in front of *Refine the polygons by*
   b. Make sure that the *Smooth (Cubic spline)* radio button is pushed
7. Set *Post processing* parameters
   - Smoothing before or after is not normally done
   - Clipping the grid is often done when working thickness as the contours often extend negative
     i. Change the Max or Min Z-value choice to *Truncated*
     ii. Enter the value to truncate at
     iii. Un-check the *in % of input data* box
8. Adjust the other parameters as desired (Name, etc.)
9. Click the *Apply* button to build the grid

**Figure:** Parameters used to build a thickness grid from digitized contours.
Edit Contours and Re-build Grid

Once a grid has been built from contours it is a simple process to edit the contours and re-build the grid. Editing involves moving contour lines or individual points. Re-building the grid involves right clicking on the grid name and selecting Regenerate. The steps used to do this are:
1. Make a copy of the contour (polygon) file to be edited for backup (there is no undo for *Make/edit polygon* process)

2. Set up the display
   a. Open a 2D Window
   b. Display the 2D Grid (set transparency to about 40%)
   c. Display the contours with points large enough to easily see and edit

3. Make the contour (polygon) file to be edited **bold**

4. Click on the *Make/edit polygon* process

5. Click on the *Select and edit add points* icon (Note: If this icon is grayed out then click on the *Make/Edit polygons* icon to un-gray it.)

6. Edit the contours
   - Click on the point to move and drag it to the desired position.
   - Click on a line to add a point and then move the point
   - Hit the delete key while a point is highlighted to delete it
   - If the point is below the grid’s surface then turn the grid off temporarily and move the point then turn the grid back on (the graphic editor cannot “see” through a grid to get to a point)

**Figure:** Contours before (blue) and after (red) edits.
7. Rebuild the grid by right clicking on the grid’s name and selecting *Regenerate*

**Figure:** *Regenerate* switch used to rebuild the grid using all the original parameters.

**Figure:** Contour and grid before editing (left) and after editing (right). Both sets of digitized contours are on each display.

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**Gridding Contours and Tying to Point Data**

Petrel offers a simple way to add point data to the contour gridding process. The points are added in the *Well adjustment* step. Care, however, must be taken to make sure that the data being tied to matches the grid that is being built. The *Well adjustment* step is implemented after the *Post processing* step, therefore, any clipping planes that are built will be shifted vertically by the error correction surface, moving the plane to an incorrect position. The solution is to eliminate the *Post processing* step and then clip the grid with an *Operation* after building the grid. This solves the warping of the clipping plane. However, another problem exists. The zeros in this example do not
match the negative digitized contours and will cause the error correction to be extreme in those areas. The solution is to blank the data (get rid of the zeros) prior to the gridding step. The operation clip-to-zero will then make the grid honor the zero data again. These steps are easy to do interactively (there are only two steps, gridding and an operation) but could be placed in a workflow to automate. We will do them interactively here.

**Figure:** 2D Grid built without the **Well adjustment** step (left) and with the **Well adjustment** step (right) added and the **Post processing** step still executed. Note how the clipped surface is warped up and down by the error grid and that zero points are used in the tie process.

The steps needed to combine the contour and point data for this example are:

1. **Blank out data that violate the digitized contours when the data are in error.** Usually these are zero data when the contours are going negative to ensure a clean zero line.
   a. Make a copy of the data (you will want to post the original un-blanked data on the final maps)
   b. Go to the settings dialog for the data and use the `Operations → Eliminate where → Z<= constant` (for this specific situation)
   c. Set constant to zero
   d. Click Run

2. **Alter the Make/edit surface parameters** (those used in previous section to grid contours)
   a. **Add Well adjustment** tab parameters
      i. Use the blue arrow to insert the blanked data
      ii. Check the **Global adjustment** radio button
      iii. Alter the influence radius if needed
   b. Turn off the **Post processing** clipping by setting the **Max and Min Z-value** parameters to **Unchanged**.

3. **Click Apply** to build the grid

4. **Use the Operation → Replace where → Z<= constant** (for this example) with constant set to zero.
Figure: 2D Grid allowed to go negative and tied to the positive data points (left) and the tied grid clipped to a minimum value of zero (right) with all data posted.

Merging Point Data with Digitized Contours

This section sounds much like the previous section but is very different. In this scenario, point data are used to build an initial 2D Grid. In some locations that 2D Grid is not acceptable and needs to be altered. The adjustment could be made interactively and then the 2D Grid retied to the point data. This works fine unless new data are being added on a regular basis. In that case, the interactive surface edits, required with each update, will not be done the same way each time (a problem) and those edits require considerable amount of repeated effort. The solution is to create a set of digitized contours to control the surface form in areas where points are sparse. These digitized contours are then re-sampled to have a dense set of points along the lines, merged with the original point data and then the Make/edit surface process used to build a 2D Grid of the merged data. Again this process could be done interactively, but the steps are starting to become more complex. Add to this the mixing of zero point data with negative digitized contours and you have the perfect candidate for a Petrel workflow. We have included a workflow here that was used to build a thickness grid primarily from point data with a few zero and negative contours added to control extrapolations. We do not discuss the workflow but include it here for those who are more experienced and would like to try the technique.
**Figure:** Workflow used to merge point data with a few contours. The point data are blanked at zero to avoid conflicts with the negative contours which requires that a zero contour line be used to ensure that zero data are not violated.

<table>
<thead>
<tr>
<th>1</th>
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<tbody>
<tr>
<td><strong>Build Sand Thickness Grid</strong></td>
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<tr>
<td>2</td>
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<tr>
<td>***** inputs</td>
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<td>3</td>
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<tr>
<td>Variable F - Reference Work Folder -&gt; Cleared each execution</td>
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<td>4</td>
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<tr>
<td>Set reference - Variable F = F Work folder</td>
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<tr>
<td>5</td>
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<tr>
<td>Variable G - Reference Contour data (coarse polygons)</td>
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<td>6</td>
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<tr>
<td>Set reference - Variable G = G Zero Contours</td>
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<tr>
<td>7</td>
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<tr>
<td>Variable H - The reference point data</td>
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<td>8</td>
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<tr>
<td>Set reference - Variable H = H Structure Points</td>
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<td>9</td>
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<td>Remove content - The folder: - Variable F</td>
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<td>***** Processing</td>
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<td>12</td>
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<tr>
<td>Prepare the Thickness Data</td>
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<td>13</td>
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<tr>
<td>Copy Contours -&gt; Set the Name -&gt; Spline Interpolate</td>
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<td>14</td>
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<tr>
<td>Copy A reference subject: - Variable M = - Variable G Folder to copy it into: - Variable F</td>
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<td>15</td>
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<tr>
<td>Set name - Variable M Name: Dense Zero Line Polygon</td>
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<td>16</td>
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<tr>
<td>Define by spline approximation - Variable M Approximate tolerance: 1</td>
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<td>18</td>
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<tr>
<td>Prepare the Point Data</td>
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<td>19</td>
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<tr>
<td>Copy Points -&gt; Set the Name -&gt; Eliminate zero points -&gt; Merge with Contours</td>
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<tr>
<td>20</td>
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<tr>
<td>Copy A reference subject: - Variable N = - Variable H Folder to copy it into: - Variable F</td>
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<tr>
<td>21</td>
</tr>
<tr>
<td>Set name - Variable N Name: Merged Thickness Data</td>
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<tr>
<td>22</td>
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<tr>
<td>Eliminate where Z &lt;= Constant - Variable N Constant: 0 Exact intersection</td>
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<tr>
<td>23</td>
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<tr>
<td>Append points - Variable N Points to append: - Variable M Selected only</td>
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<td>24</td>
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<td>25</td>
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<tr>
<td>Build the Thickness grid -&gt; Set the Name -&gt; Move to Work Folder</td>
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<td>26</td>
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<td>Make/edit surface - F</td>
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<tr>
<td>Set reference - Variable P = P Output</td>
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<td>28</td>
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<tr>
<td>Set name - Variable P Name: Sand Thickness Grid</td>
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<td>29</td>
</tr>
<tr>
<td>More Object to be moved - Variable P Folder to move it into: - Variable F</td>
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<tr>
<td>30</td>
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</tbody>
</table>
Figure: Final thickness grid built using the above workflow. The display shows the zero and negative valued digitized contours used to control extrapolation.