Chapter

4

Interpret Horizons

In this section, the C38 formation top from well data will be tied to the first peak below the formation top on a seismic line, and a horizon will be picked along the peak throughout the 3D seismic survey.

1. Display in-line 136. Make sure that the **All Wells** subset is active. You should see the Stratton #8 well within the down thrown fault block and the Stratton #2 and Stratton #16 wells in an upthrown fault block.

2. If the tops are not displayed, select from the menu bar **Tops > Formation Top Management > Display**, select the **C38** and **B46** tops, and put a check in the **Display Working Set** box. Check Abbreviation and Time for the Right of Borehole. Make the background transparent. Click on **OK**.

3. Interpret the Major and Minor faults on this line.

   Check to see if the Major and Minor Faults are checked in the **Project Tree** under the Faults data folder.

   Open the Faults Picking toolbar (**View > Toolbar > Faults Picking**).

   Make the Major fault active by highlighting it and then digitize the fault segment on in-line 136.

   Repeat for the Minor fault.

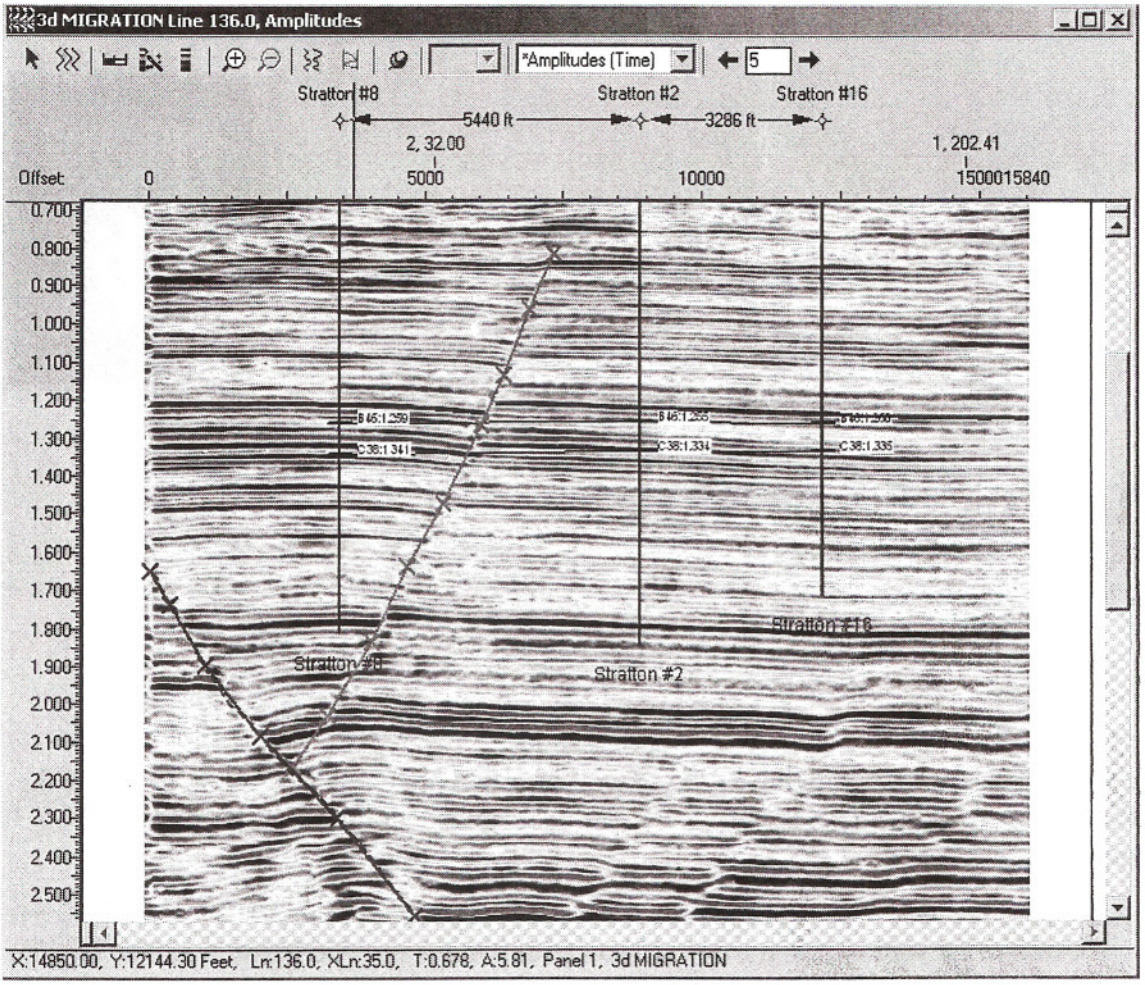

Figure 4.1 — Line 136 with Faults and Formation Tops

4. Scroll until the C38 top is displayed in the down thrown fault block around 1.3 seconds.

   Horizons are created in much the same way as faults. Right click in a vertical seismic display and select **Horizon Management**. Select the **Create** tab and then enter **C38** and your initials (C38 XXX) for the horizon name and select a color.

5. Click on **OK**. Your C38 horizon is now active.

6. **Display the horizon** in the **Base Map** by double clicking on the icon next to your C38 Horizon in the **Project Tree**. This opens a new **Base Map**. No picks have been made, therefore the map is blank.

Note: You can also display the horizon by the "drop and drag" method from the **Project Tree** to the **Base Map** View.

7. Right click on a seismic line and select **Picking Parameters**. Make sure that **Stop at Displayed Fault Surface Intersections** is enabled in the Picking Parameters tab. This feature, when enabled, works with the Autopick-2D Hunt mode. Be sure the fault surface display mode is turned on in the Fault Surface Management > Display dialog box.

8. Select a **Peak** or a **Trough**.

9. **Select Largest Amplitude** and **Search Both Directions**. Your picking parameters dialog should look similar to the one shown below (Figure 4.2).

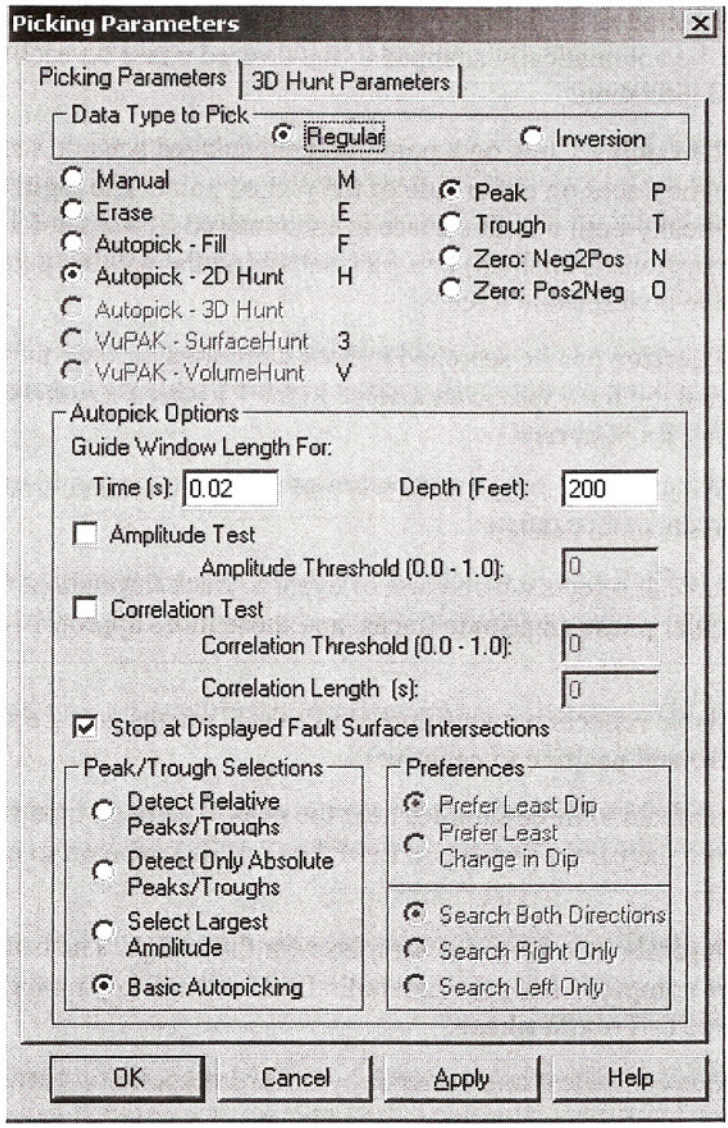

Figure 4.2 — Picking Parameters dialog box

10. Again, ensure the display boxes to the left of your Major and Minor faults are turned ON in the **Project Tree**.

Pick Mode Options

Following is a list of Pick options and an explanation of each:

- **Manual** – Click on a series of points, double-click to end digitization. The digitized horizon will consist of a series of straight line segments between the picked points. *The phase of the seismic data will be ignored.*
- **Autopick - Fill** – Click on the first point, then on a second point. A straight line segment will be drawn between the two points and the selected phase nearest the straight line will be selected as the horizon pick on each trace. Continue picking and the horizon pick will be automatically snapped to the desired phase on each trace. Double click to end digitization.
- **Autopick - 2D Hunt** – Click on a point on the displayed seismic section to automatically digitize the traces on either side of the picked point. The digitization will continue automatically until a fault surface is encountered (if Stop at Displayed Fault Surface Intersections is enabled) or a pick satisfying the picking parameters can no longer be made on a seismic trace
- Note that the horizon can be searched in both directions, or only to the left or only to the right by making the appropriate choice in the **Picking Parameters** dialog **Horizons > Picking Parameters**.
- **Erase** – Hold down the left mouse button and swipe the seismic traces where the picked horizon is to be deleted.
- **Data Type to Pick** selects which class of event to track throughout the data set: those related to regular phase amplitude traces, and those more appropriate to inverted data sets.
- Regular available reflection events include Peaks, Troughs, and Zero Crossings (negative to positive and positive to negative).
- **Peak** fits a parabola to three samples near the peak. The peak time and amplitude are computed from the parabolic fit. Use the **P** key on the keyboard to quickly change to **Peak phase**.
- **Trough** fits a parabola to the three samples near the trough. The trough time and amplitude are computed from the parabolic fit. Use the **T** key on the keyboard to quickly change to **Trough phase**.
- **Zero: Neg2Pos** computes time or depth by linear interpolation between negative amplitude and positive amplitude one sample later. Use the **N** key on the keyboard to quickly change to **Zero: Neg2Pos phase**.
- **Zero: Pos2Neg** computes time or depth by linear interpolation between positive amplitude and negative amplitude one sample later. Use the **O** key on the keyboard to quickly change to **Zero: Pos2Neg phase**.

- Inversion available events include Maximum and Minimum Velocity, and Maximum Rate (positive and negative).
- **Min** finds the minimum inversion value in the time window and fits a parabola to three samples near the minimum. The minimum time and inversion amplitudes are computed from the parabolic fit. This pick estimates the minimum inversion value in a guide window.
- **Max** finds the maximum inversion value in the time window and fits a parabola to the three samples near the maximum. The maximum time and inversion amplitudes are computed from the parabolic fit. This pick estimates the maximum inversion value in a time window.
- **Max Rate +** finds the maximum rate of change of increase in inversion value in the time window and fits a parabola to the three samples near the maximum rate of positive change. The Max Rate + time is computed by parabolic interpolation. This pick estimates the time of the top of a layer where impedance is increasing at the boundary. It also picks the bottom of a layer of lower acoustic impedance.
- **Max Rate –** finds the maximum rate of change of decrease in inversion value in the time window and fits a parabola to the three samples near the maximum rate of negative change. The Max Rate – time is computed by parabolic interpolation. This pick estimates the time of the top of a layer where impedance is decreasing at the boundary. It also picks the bottom of a layer of higher acoustic impedance.

Note: Only one reflection event can be designated at a time; however, a horizon may contain picks of varying types.

Hot Keys

Table 1: Hot Keys for Horizon Picking

Hot Key	Action
M	Manual picking
F	Fill Mode
H	2d Hunt
E	Erase
P	Peak
T	Trough
N	Negative to Positive Zero Crossing
O	Positive to Negative Zero Crossing

Note: The Hot keys are also listed in Appendix A at the back of this manual. The shape of the cursor and the status bar. The cursor is now represented by a '+' with an E, M, F, or H next to it. The status bar will list the horizon name, pick mode and pick type.

Horizons Toolbar

1. Select the Horizons Toolbar from **View > Toolbars** and toggle on **Horizons**.
2. Click on the different icons in the top row and read the pick modes selected in the seismic view status bar. Do the same for the peak, trough, negative to positive zero crossing and positive to negative zero crossing icons.

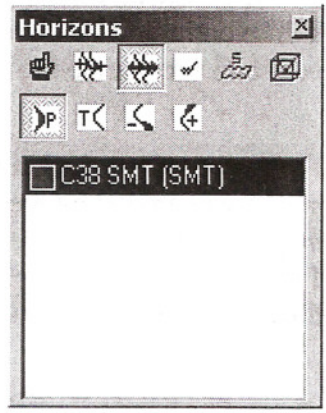

Figure 4.3 — Horizons window with Hunt and Peak icon selected

3. Pick the C38 horizon in both in-line and crossline directions. Begin on in-line 136 or another line of your choosing.

4. Set the picking mode to **Fill,** and the phase to either **Peak** or **Trough,** depending on your picking parameters. Note that your active horizon, C38 is highlighted in the toolbar. Click on the **F** key on the keyboard to digitize the horizon in the Vertical Seismic window.

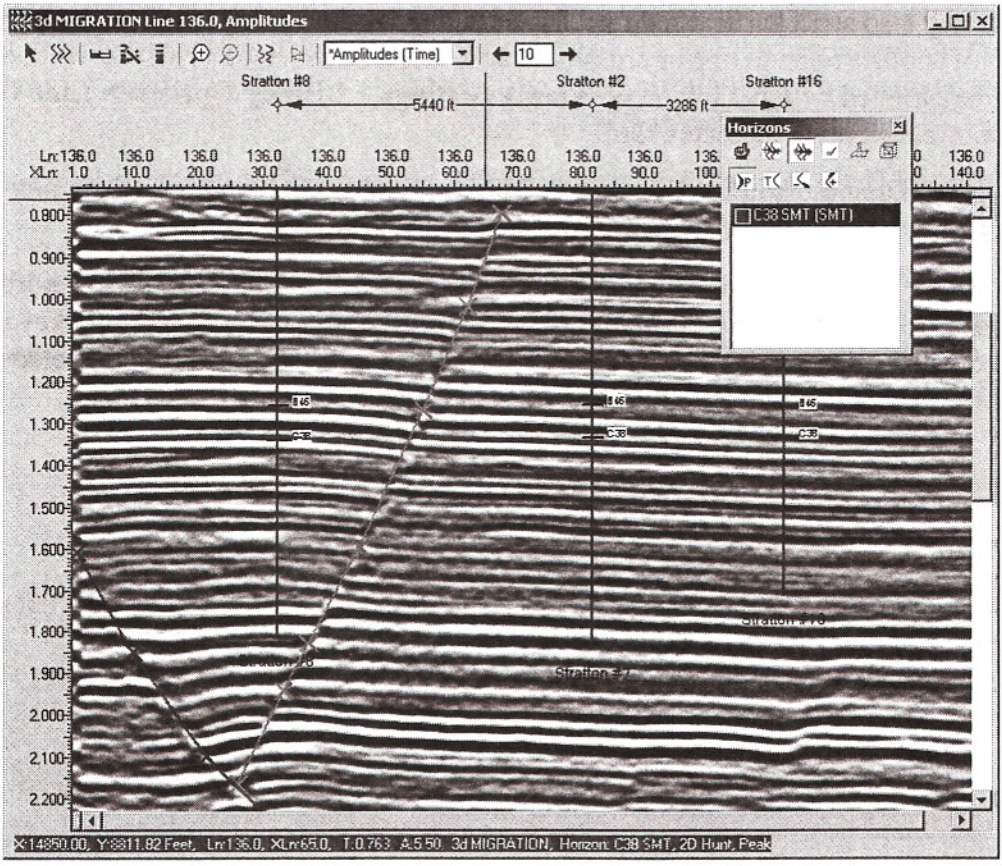

Figure 4.4 — C38 - SMT Horizon

5. Try the **2D Hunt** mode. Press the **H** key on the keyboard and then click on the peak (or trough) on a seismic line. The entire horizon between fault surfaces will be automatically picked. This is a very efficient method to pick data if the signal to noise ratio is very high.

6. Use the **Correlation Polygon** (**Tools > Correlation Polygon > Digitize**) to correlate across both faults. Digitize a polygon around an area on your seismic section with good C38 picks (double click to close the polygon), then drag and drop the polygon on the upthrown side of the fault to make your correlation on your C38 horizon. Pick your C38 horizon on the upthrown side of the fault and continue digitizing the horizon.

7. Use the "seed points" along several in-lines to help identify the horizon picks on the crosslines. Place the cursor on a crossline location within any inline seismic display, then right click and display the crossline at that point. A small tick mark is visible where the two lines intersect. The tick mark color will be the same as that of the horizon you are picking.

Tip: Use **Project > User Preferences >Line Thickness** and increase the Horizons thickness to make it easier to see the horizon seeds on intersecting seismic lines.

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8. You may also see a vertical red line. This red line is a line overlay indicating the location of another seismic line or crossline that is displayed in another window. The line can be disabled by left clicking on **View > Settings > Display Options > Line Overlays**. A check mark indicates 'On'.

9. Drop and Drag the horizon to the **Base Map**, or double click on the horizon name in the **Project Tree** to see the horizon displayed on a new **Base Map**.

10. Increment through your data using the arrow keys and continue picking this horizon. Remember that the skip increment that occurs with each touch of the arrow key can be adjusted using the **View > Settings > Seismic > Line Skip Increment** selection. Alternatively click on the Settings icon.

Create Fault Polygons

Fault polygons are created to indicate the fault cutout zone or fault heave on the map and also to create boundaries for contouring and gridding.

1. In the **Base Map**, display the 2d and 3d surveys, the C38 horizon and the Major and Minor faults (Figure 4.5).

   The shotpoint annotation is turned off for the 2d surveys. (**Survey > Survey Annotation > Text Options** tab. Uncheck Display In-line, Crossline/Line, Shotpoint Annotation.>

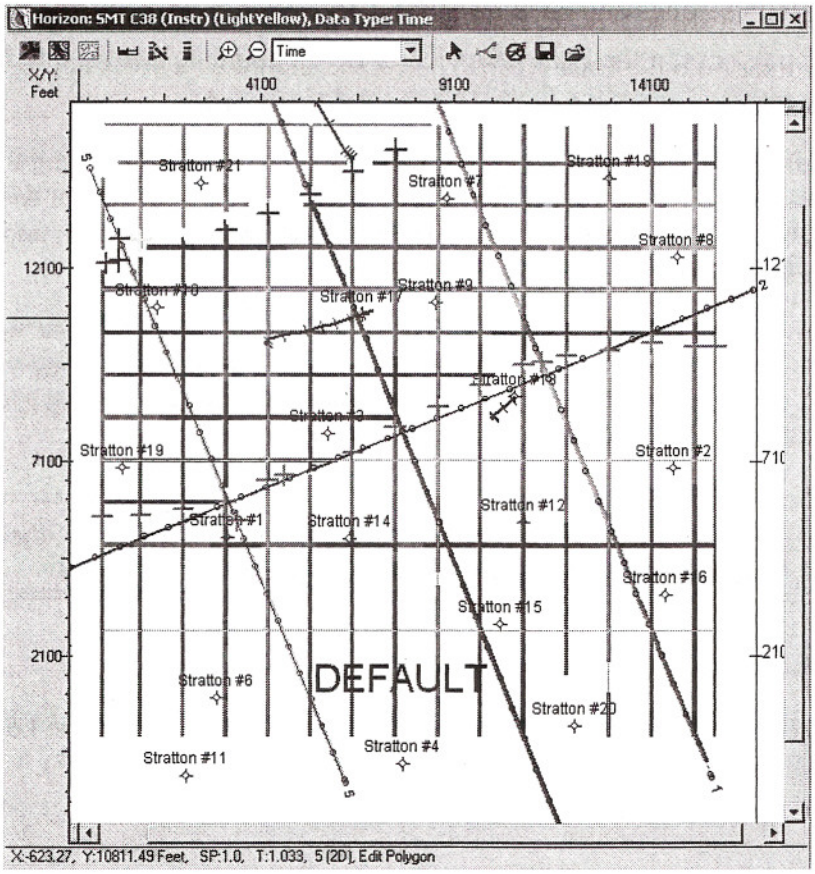

Figure 4.5 — Base Map with C38 horizon and Major and Minor faults displayed

2. Right click on the **Base Map** and select **Edit Fault Polygons > Enable Editing**.

3. Hit the **<D>** key on the keyboard. The **Select Fault Polygon Set** window will open (Figure 4.6).

   The purpose of the Fault Polygon Set is to store fault polygons in the data base. It is recommended that a single Fault Polygon Set be created for a single horizon.

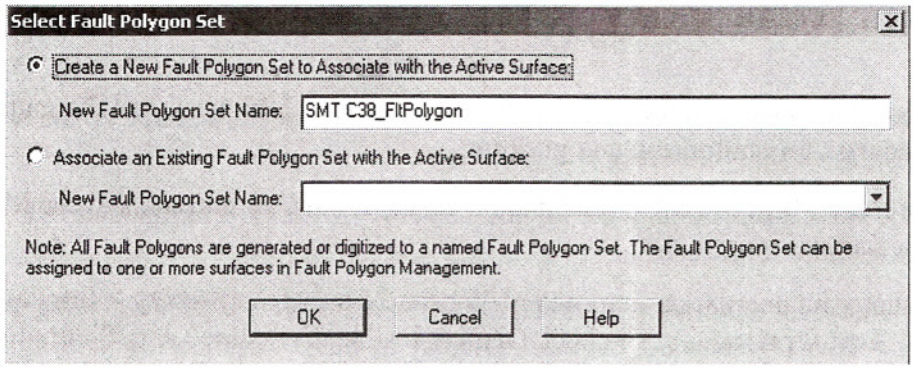

Figure 4.6 — Select Fault Polygon Set dialog box

4. Take the default settings and click on **OK**.

5. Move the cursor onto the **Base Map**. The cursor should be a cross and **D** indicating digitizing mode. If not click the **<D>** key on the keyboard.

6. Begin digitizing a Fault Polygon for the Major fault. Begin left clicking a series of points surrounding the fault gaps. The fault polygon string will appear as a closed triangle, which forms the polygon as it is drawn. It may help to zoom in and digitize polygon picks in visible segments on a close-up view.

   Use the auto scroll option to continue picking, and double click to close the polygon. *You should not end on the same point as you began*, rather let the program connect the first point you digitized to the last point digitized. Double click to stop at the last data point. The closed polygon should appear yellow.

Note: Black is the default color for unassigned faults and fault polygons if the color is not changed in **Faults > Fault Surface Management > Properties** tab.

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7. Digitize a fault polygon for the Minor fault.

   Since Digitize Fault Polygons remains enabled, click the **D** key on the keyboard to change the cursor from selection mode to digitizing mode (Figure 4.7).

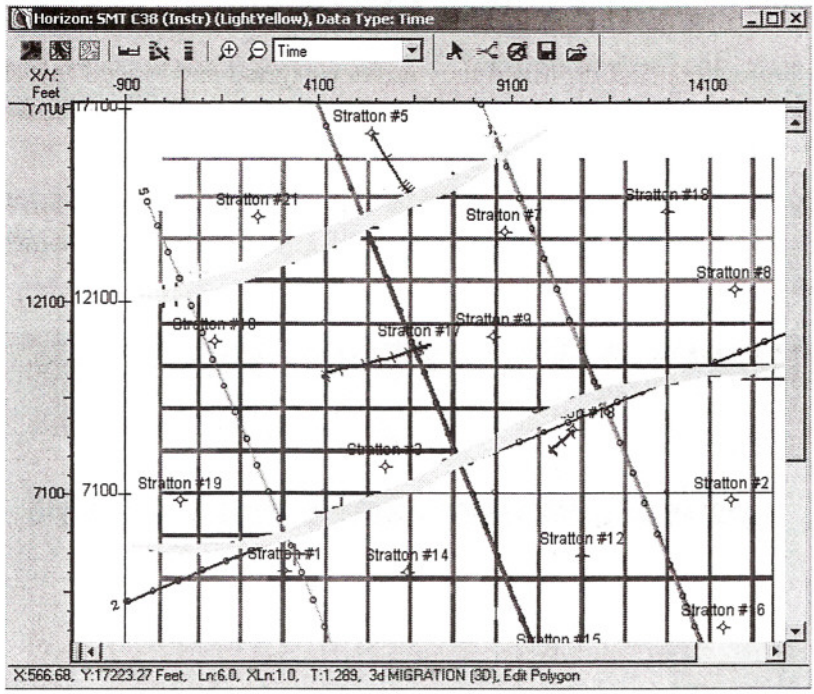

Figure 4.7 — Zoomed View of digitized fault polygon (yellow) for the Major fault

Assign Unassigned Fault Polygons

When the fault polygons are first digitized they are unassigned and placed into the Fault Polygon Set. The following methodology demonstrates how to assign the unassigned fault polygons to a specific named fault.

1. In the **Base Map** double-click on the fault polygon to open the Assign fault Polygon to Fault dialog (Figure 4.8) which will allow you to assign a fault name to the unassigned polygon.

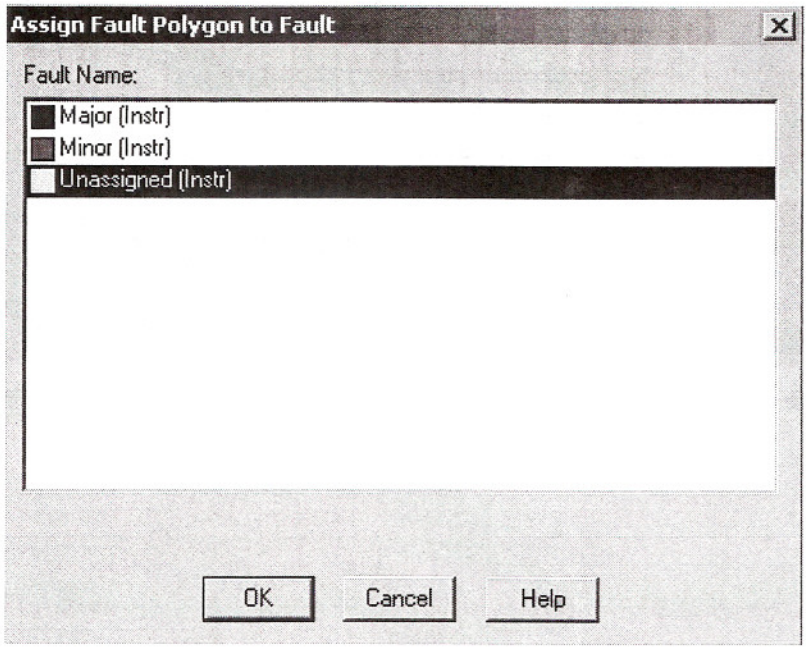

Figure 4.8 — Assign Fault Polygon dialog box

2. In the **Assign Fault Polygon to Fault** dialog box, select the appropriate fault by clicking the left mouse button on the fault name you want to assign to.

Tip: If you forget which fault to assign to, simply point the cursor at one of the fault cross intersection symbols and read the fault name from the Tool Tip that will open. You can move the unassigned fault polygon out of the way if it covers the fault crosses by first making the unassigned polygon active, left click on it, and second by holding **Ctrl + left mouse button** and dragging the polygon aside. Then point at the fault cross symbol for the Tool Tip.

Generate Automatic Fault Polygons

1. First, enable fault polygon editing.

   In an active **Base Map**, select **Faults > Edit Fault Polygons**. If a check appears next to Enable Editing they you are in the correct mode. If not, enable by clicking on **Enable Editing**.

   When fault polygon editing has been enabled, clicking on the fault polygon will activate it. Editing fault polygons allows you to add points (also called nodes), delete points, and move points.

   You can also delete the entire polygon by activating it and pressing the **Delete** key.

   Holding down **Ctrl + left mouse button** will allow moving a fault polygon on the **Base Map**.

   Fault polygons will only be displayed if the faults associated with the polygons are active in the **Project Tree**.

2. To demonstrate how to generate automatic fault polygons, delete the fault polygons that were digitized.

3. Make the fault polygons active and click the **Delete** key on the keyboard.

4. Select **Faults > Create Automatic Fault Polygons** from the menu bar or from the pop up menu after clicking the right mouse button on the **Base Map** (Figure 4.9).

5. Highlight the Major and Minor faults and click **OK**.

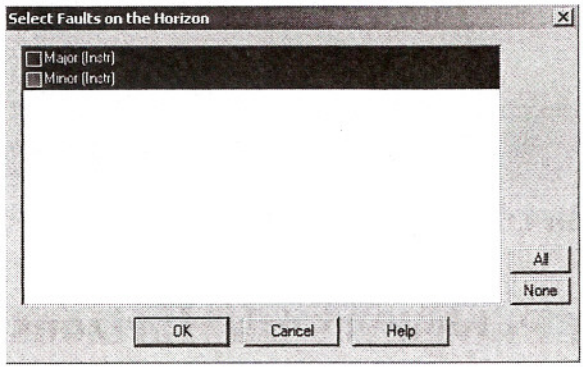

Figure 4.9 — Select Faults on the Horizon dialog box to create automatic fault polygons

Display Options for Fault Polygons

Fault polygons can be displayed in several ways: outline only, solid fill or solid fill with an outline and with downthrown symbols.

1. To change the display, right click on the map, select **Faults > Fault Polygon Management** then select the **Display** tab **(Figure 4.10).**
2. Check Display Downthrown Fault Symbols and click **OK**.

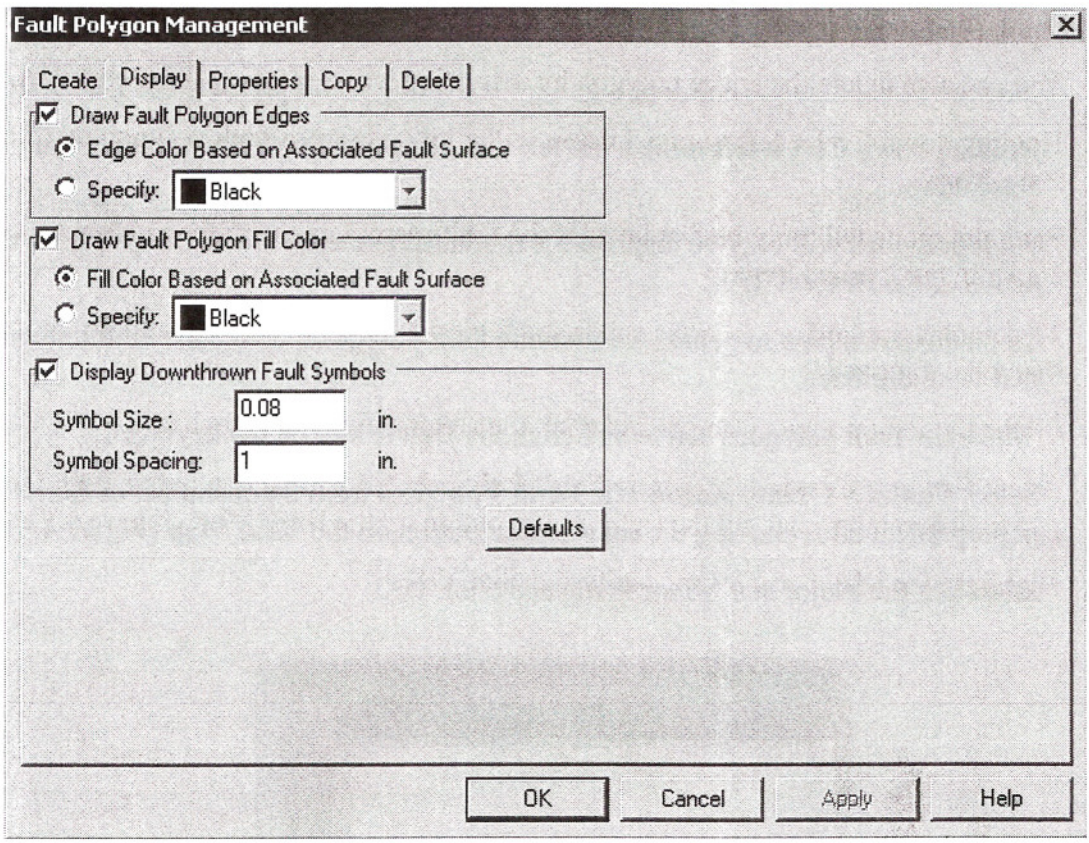

Figure 4.10 — Fault Polygon Management dialog box

Associate Fault Polygons with Horizons and Grids

The purpose of associating a fault polygon set to a horizon or grid of the horizon is to be able to display a horizon or grid on the **Base Map** with the fault polygons displayed.

We will now assign the C38 fault polygon set to the C38 horizon.

1. From the **Project Tree**, drop and drag the C38 horizon to the **Base Map**.
2. Open the **Fault Polygon Management** dialog by clicking on **Faults > Fault Polygon Management** and go to the **Properties** tab **(Figure 4.11).**

3. Click the down arrow for the Fault Polygon Set Name and select the Fault Polygon Set.
4. Select the C38 horizon from the **Associated Horizons** list. The dialog should look similar to the one shown below.
5. Click on **OK** to close the dialog box and associate the C38 Fault Polygon Set with the SMT C38 horizon.

Note: A fault polygon set can have more than one horizon or grid associated with it, but a horizon or grid can be associated with *only one fault polygon set* at a time. Remember: if you associate a fault polygon set with a surface, the fault polygon set will not be visible unless the polygon set faults are active in the **Project Tree**.

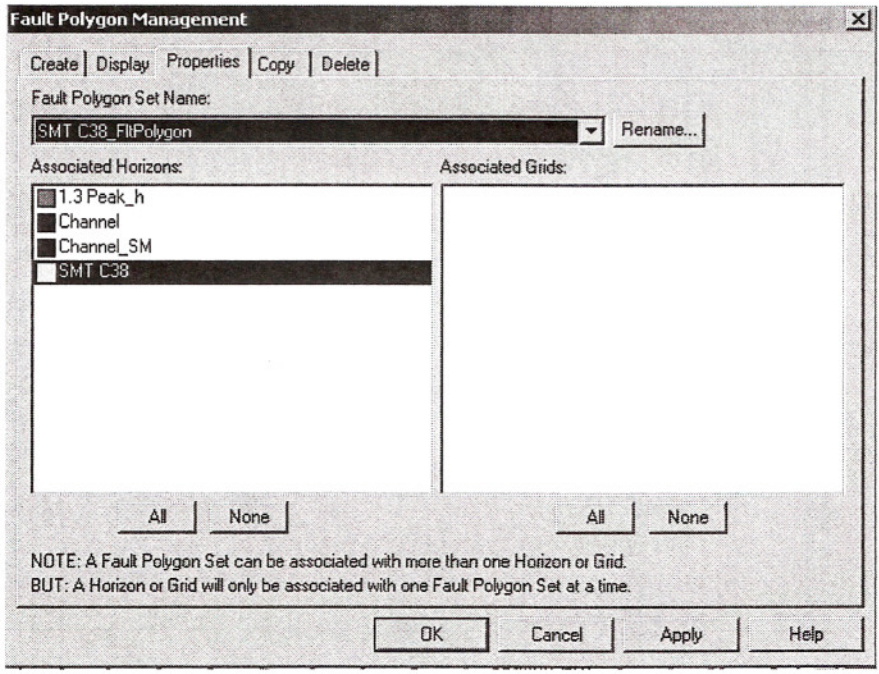

Figure 4.11 — Fault Polygon Management dialog box with Properties tab active

Auto Picking Horizons

The **KINGDOM** auto pickers include Fill, 2D Hunt and 3D Hunt. The Fill and 2D Hunt auto pickers are used when auto picking on vertical seismic views. The 3D Hunt auto picker is used to pick traces through the 3D seismic volume on lines that were not interpreted. 3D Hunt uses seed picks on lines that were interpreted using the Manual, Fill and 2D Hunt picking methods. Two versions of **Autopick - 3D Hunt** are available; the current **3D Hunt** and **Basic Autopicking**. **Basic Autopicking** is selected in the **Picking Parameters** dialog box on the **Picking Parameters** tab, toggle ON Basic Autopicking. Set the **Basic Autopicking** parameters on the **3D Hunt Parameters** tab as shown in Figure 4.12.

3D Hunt and **Basic Autopicking** can be launched on the base map by using **Polygon Hunt**.

To launch **3D Hunt** or **Basic Autopicking** from a vertical seismic window a horizon surface must be made active then **3D Hunt** or **Basic Autopicking** can be launched from the **Picking Parameters** dialog box.

Basic Autopicking

We will use a copy of the manually picked **C38** horizon as seed picks and automatically pick the rest of the traces in the survey using the Basic Autopicking 3D Hunt picker.

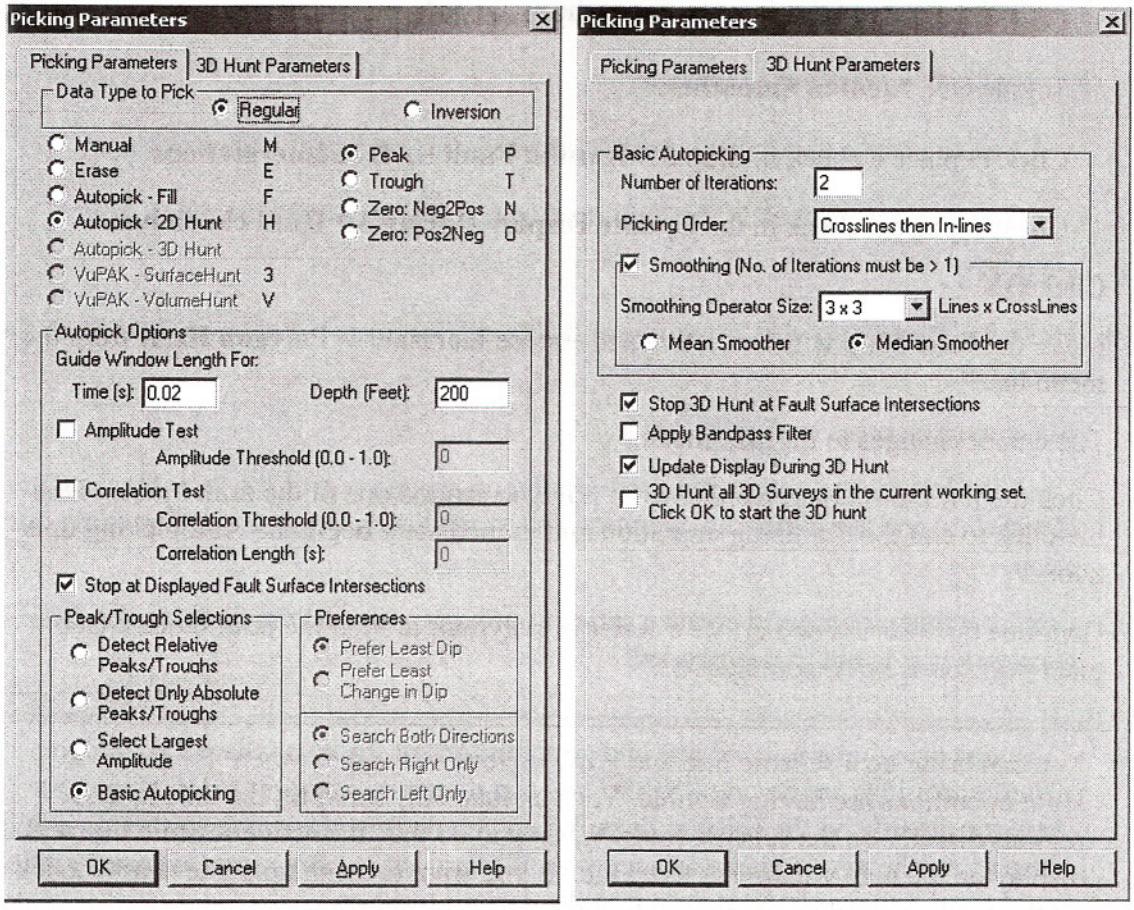

Figure 4.12 — Picking Parameters dialog box showing Basic Picking Parameters and 3D Hunt Parameter tab

1. Make a copy of the C38 horizon by selecting Horizons > Horizon Management > Copy tab.
2. On the Copy tab select C38 and enter the name **C38 Basic Autopick**. Click OK.
3. In the base map click on the Select icon.
4. In the **Select Data to Display Map** dialog box on the **Horizons** tab select the **C38 Basic Autopick** horizon and **Time** as the Data Type. Click **OK**.
5. From the main menu select **Horizons > Picking Parameters.**
6. In the **Picking Parameters** dialog box, toggle ON **Basic Autopicking** under the **Peak/Trough Selections** area.
7. Click the **3D Hunt Parameters** tab as shown in the right panel of **Figure 4.12**.

8. In the **3D Hunt Parameters** tab, proceed as follows:
   - Specify a value of **2** for **Number of Iterations**.
   - Set the **Picking Order** to pick **In-lines** first, then **Crosslines**.
   - Click to place a check in the **Smoothing** check box.
   - Toggle ON, **Median Smoother**.
   - Click to place a check in **Stop 3D Hunt at Fault surface Intersections**.
   - Click to place a check in the **Update Display During 3D Hunt check box**.
9. Click **OK**.
10. Make the **Base Map** window active and choose **Horizons > Polygon Hunt** from the menu bar.

    The cursor changes to digitize mode.
11. Click the left mouse button and draw a polygon around one of the fault blocks. Double-click to end the digitizing operation and immediately begin the Autopicking operation.
12. Continue this process and create a series of polygons around the fault blocks. One giant polygon is not recommended.

Note: You can bring up a seismic line and go to regions of the data where the Polygon Hunt operations are having trouble. You can manually interpret the data in these regions directly on the seismic lines. When you do this, the active seismic line will display on the map window as a red line. If you want to bring up a line nearby, click on the red line overlay and drag it to the desired location.

Your completed horizon interpretation should look similar to the one shown in Figure 4.13 below. The display was color filled and the fault polygons were outlined in black using **Faults > Fault Polygon Management > Display**.

Autopick - 3D Hunt

We will use the original C38 horizon and autopick with **3D Hunt**.

1. Open a vertical seismic window by selecting **Project > New Vertical Display**.
2. In this dialog box, toggle ON Survey and select 3d MIGRATION. Toggle ON In-line and enter **50**. Use Amplitudes (Time) for the Data Type. Click **OK**.
3. On the in-line 50 vertical display, right click and from the pop-up window select **Set Active Surface for Picking**.
4. Toggle ON Horizon and select the **C38** horizon. Click **OK**.
5. In the in-line 50 vertical display, right click and from the pop-up window select **Picking Parameters**.
6. In the **Picking Parameters** dialog box and on the **Picking Parameters** tab toggle ON **Autopick - 3D Hunt**, **Select Largest Amplitude** and **Peak**.
7. Click **OK**.

Polygon Smooth

Polygon Smooth applies a matrix type smoother to time or depth values within a defined polygon and fills in missing traces on the horizon.This is very useful if there are small holes appearing on your Auto Picked horizon.

1. Make the **Base Map** active and launch Polygon Smooth from the main bar under **Horizons > Polygon Smooth**.

2. Digitize the polygon on the **Base Map** over the areas to be filled. Double-click the last node to finish.

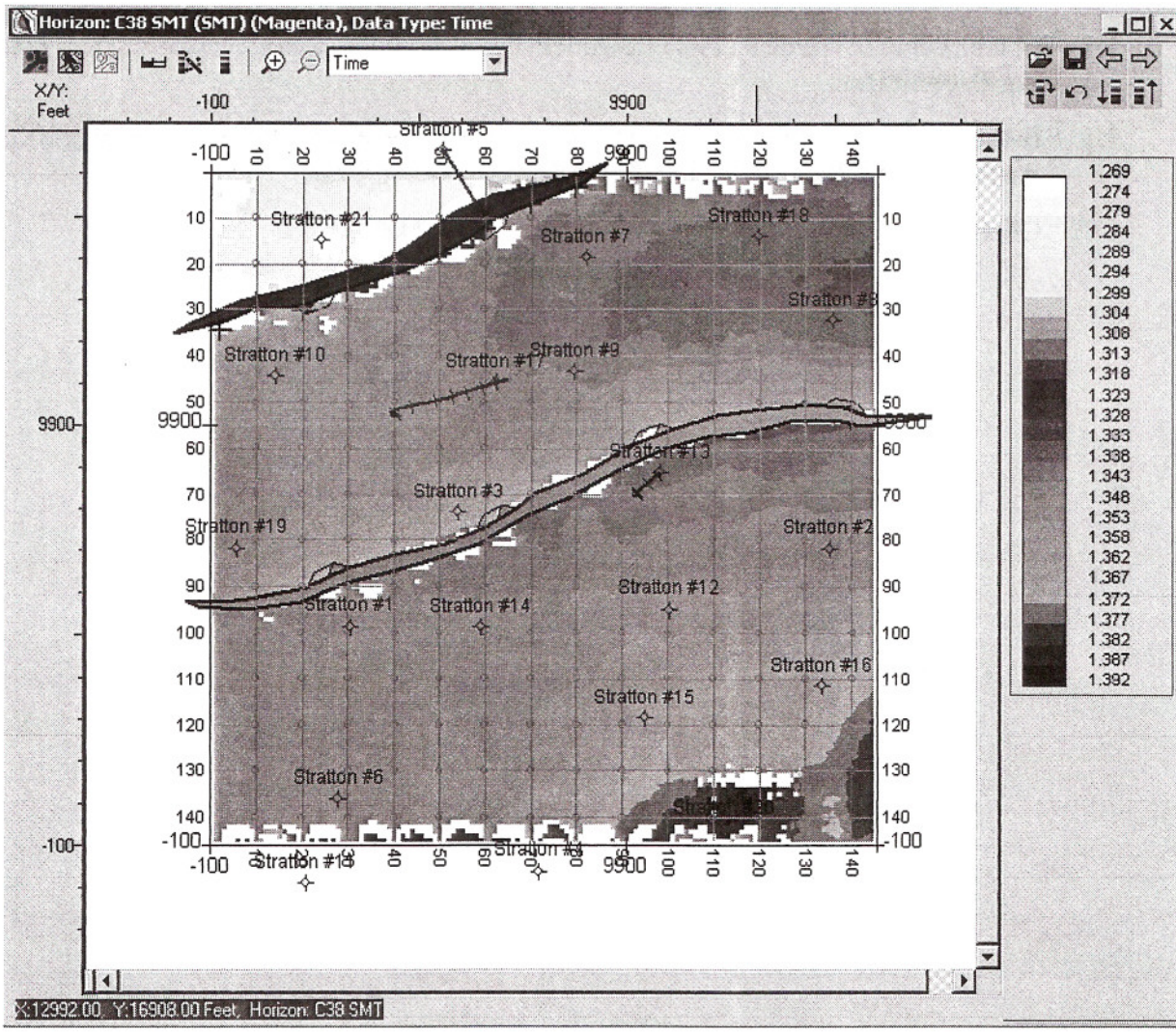

Figure 4.13 — Autopicked Horizon

Polygon Erase

If you want to correct a horizon pick from the base map use the Polygon Erase feature.

1. Select **Horizons > Polygon Erase**.
2. Digitize a polygon around the problem area.
3. You will be given the following options:
   - Erase non-manual picks only
   - Erase manual picks only
   - Erase both non-manual and manual picks.
4. Select **Erase both non-manual and manual picks**. Click on **Yes** and all the picks within the polygon will be erased.
5. Re-pick a tighter grid if necessary and re-run Polygon Hunt.

Displaying Horizon Amplitudes on the Base Map

1. After the map is completed go to the **Horizons** list in the **Project Tree**
2. Left click on the '+' sign adjacent to the **C38** horizon to open the **Horizons** folder and reveal the additional surfaces available.

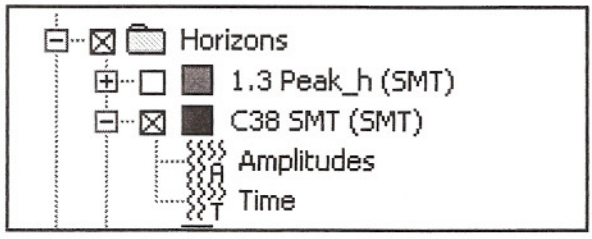

Figure 4.14 — Project Tree Amplitude

The **SMT C38** horizon is saved as **Amplitudes** and **Time** displays.

3. Drag your **C38 Amplitudes** horizon from the **Project Tree** list to a **Base Map** window to view the location and strength of the amplitudes.

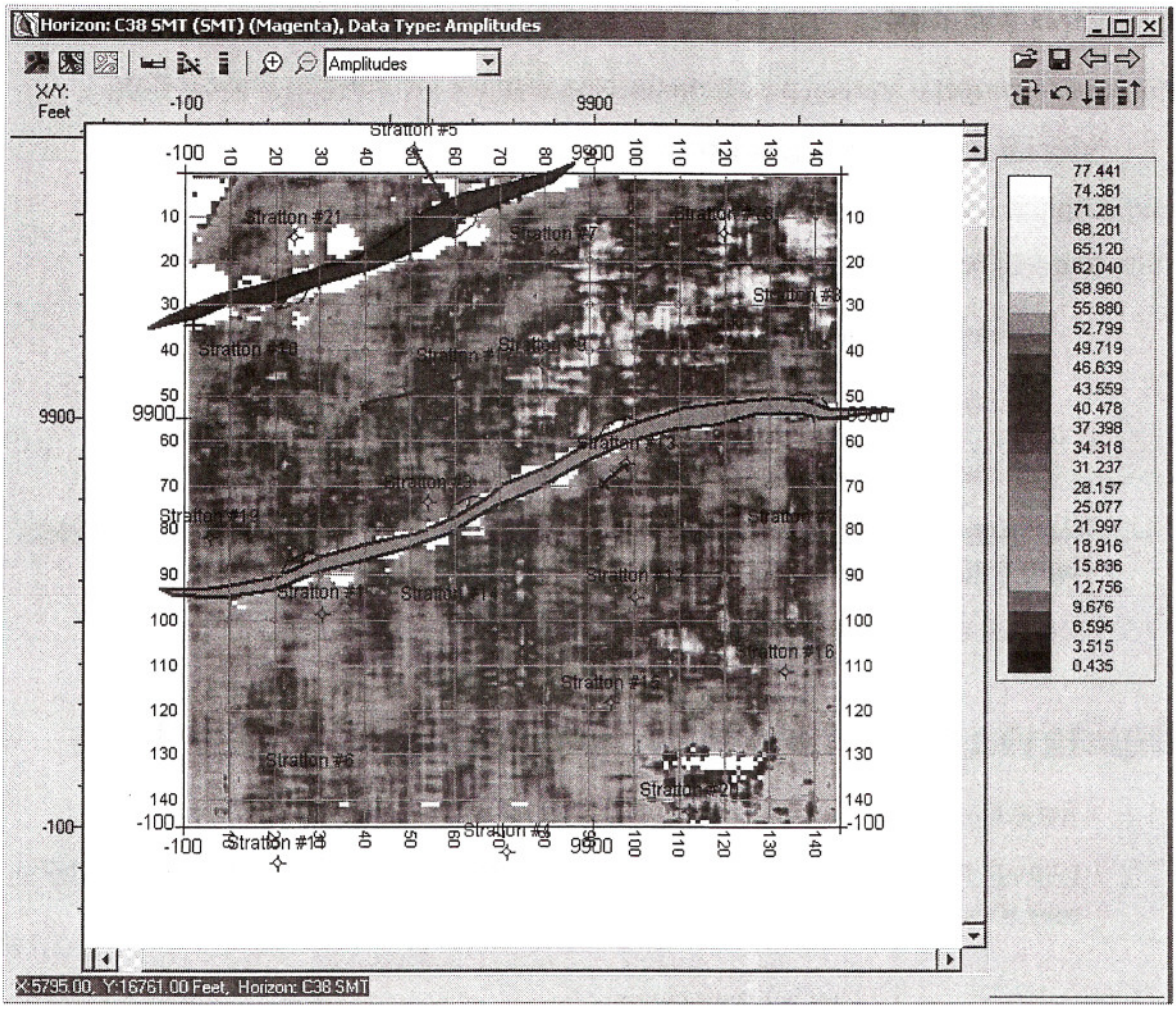

Figure 4.15 — C 38 Amplitude Map

4. To display the time map again, click on the down arrow near the top of the window beside Amplitudes and select **Time** from the drop down menu.

Contouring

Contours can be made without having the data to contour displayed on the **Base Map**.

1. Generate a time-structure contour map on the C38 horizon by selecting from the main menu bar, **Contours > Compute Contour** (Figure 4.16).
2. Select the **C38** Horizon and **Time Data Type**.
3. Accept the default **Contour Version 7.5**.
4. In the **Contour Overlay** area, **Replace** is the default and should be toggled ON.

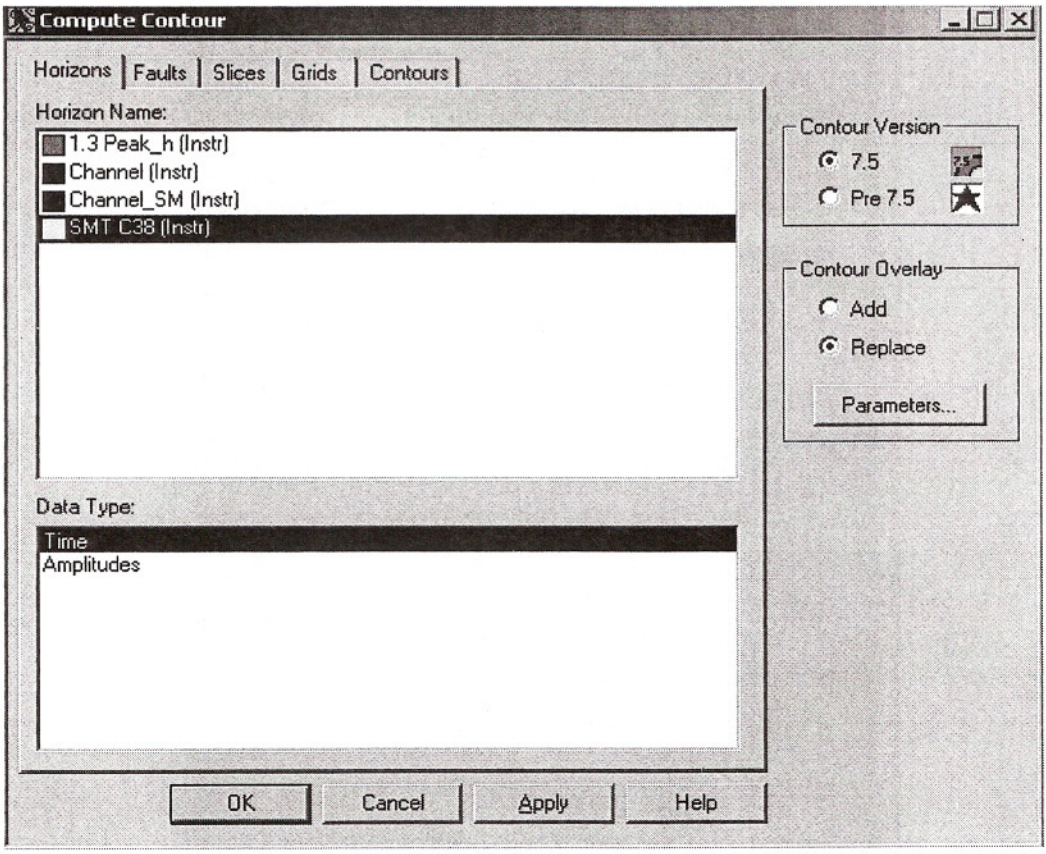

Figure 4.16 — Compute Contour dialog box with Horizons tab active

5. Click on the **Parameters** button to open the **Contour Parameters** dialog box.
6. In the **Contour Parameters** dialog box, the **Compute** tab is active by default (Figure 4.17).
7. On the **Compute** tab, click to place a check mark in the **Stop at Fault Polygons check box.**
8. Click to place a check mark in the **Color Fill** check box, which activates the **Select Contour Color Bar** area of the **Compute tab.**

9. In the **Select Contour Color Bar** area, toggle ON **Other Color Bar From File -->**, which activates the adjacent **Select** button.
10. Click on the **Select** button to open the **Open** dialog box.
11. In the **Open** dialog box, click to highlight and select the **Rainbow 50.CLB** color bar file
12. Click **Open**.

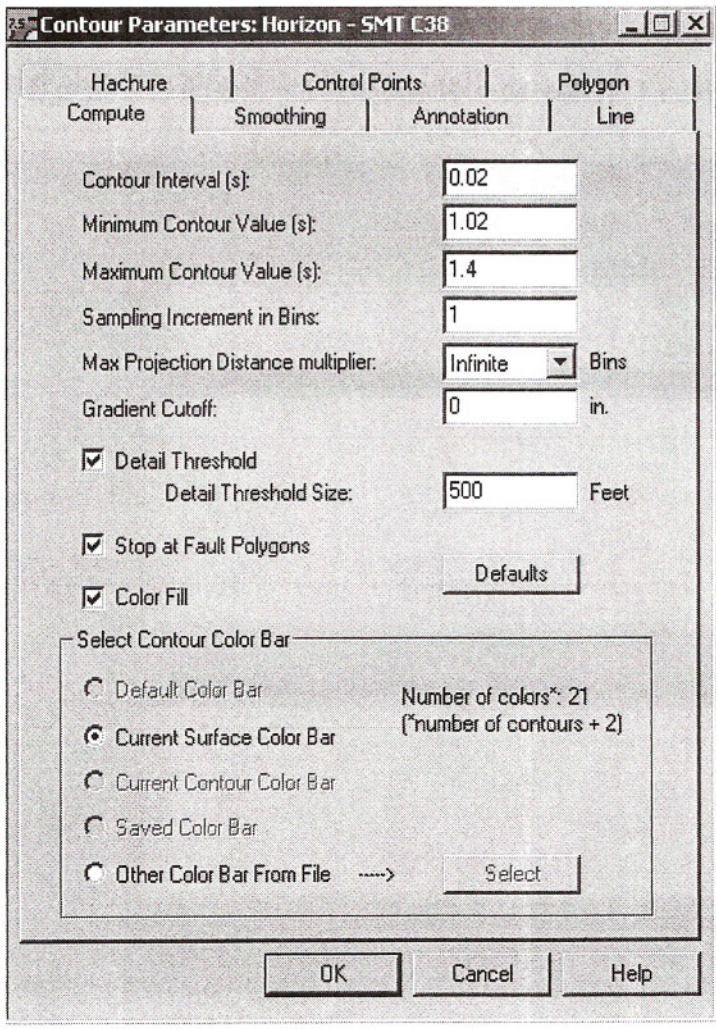

Figure 4.17 — Contours Parameters dialog box with Compute tab active

13. Click to make the **Smoothing** tab active.
14. In the **Smoothing** area, toggle ON **Hanning**.

    The **Hanning** filter resamples the contour line according to a fixed increment and then applies the filter to the contour, thereby producing a smoother curve.

    The **Bicubic Spline Interpolation** smoothing method consists of a bicubic interpolating spline that passes through the specified points to define the data control points.

Interpolation fits a curve to a known, finite number of ordered pairs called nodes. Bicubic-splines use a combination of splines to interpolate a finite set of nodes.

15. In the **Smoothing Level** area, toggle ON **High**.

    The greater the degree of smoothing selected (**Low**, **Medium**, and **High**) the greater the distance smoothing extends along the contour curve.

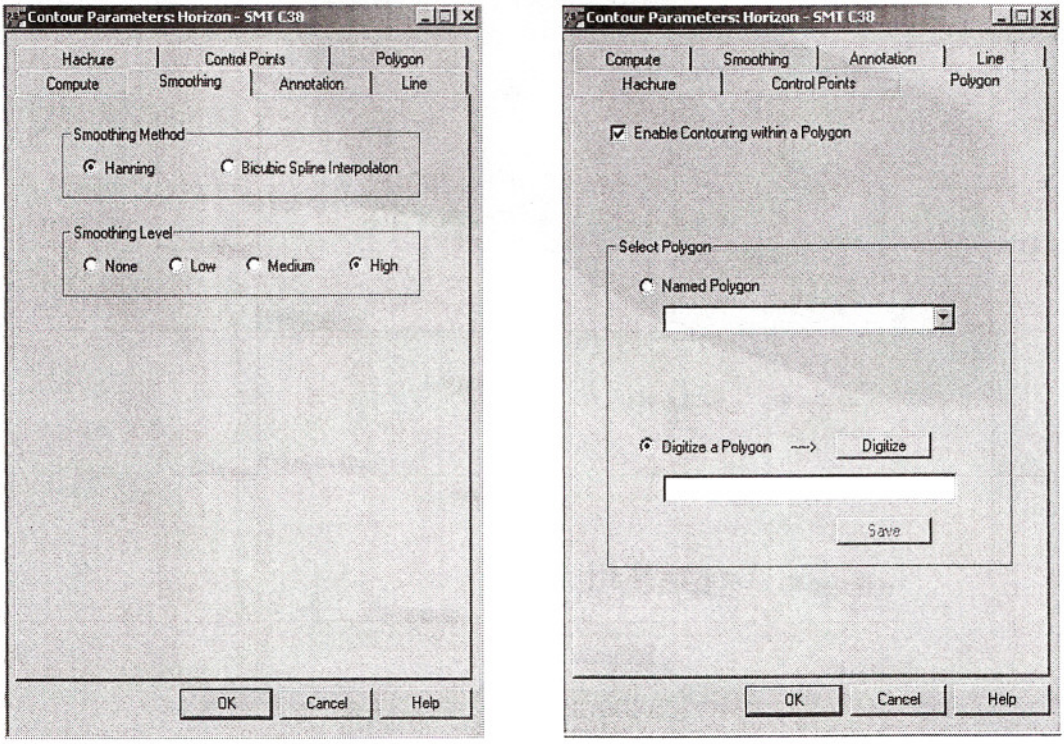

Figure 4.18 — Contour Parameters dialog box showing Smoothing and Polygon tabs active

16. Click to activate the **Polygon** tab, which allows options to constrain contouring inside a digitized polygon.
17. On the Polygon tab, click to place a check in the **Enable Contouring within a Polygon** check box.
18. Toggle ON **Digitize a Polygon --->**
19. Click on the now-active **Digitize** button and activate digitizing mode.
20. On the **Base Map**, draw a polygon around the fault block bounded by the **Major** and **Minor** faults.
21. Enter the name **Fault Block** and click on the **Save** button.
22. Click **OK**.
23. Click **OK** in the **Contours Parameters** dialog box.
24. Toggle ON **Decimate** for the **Color Bar** message that opens.

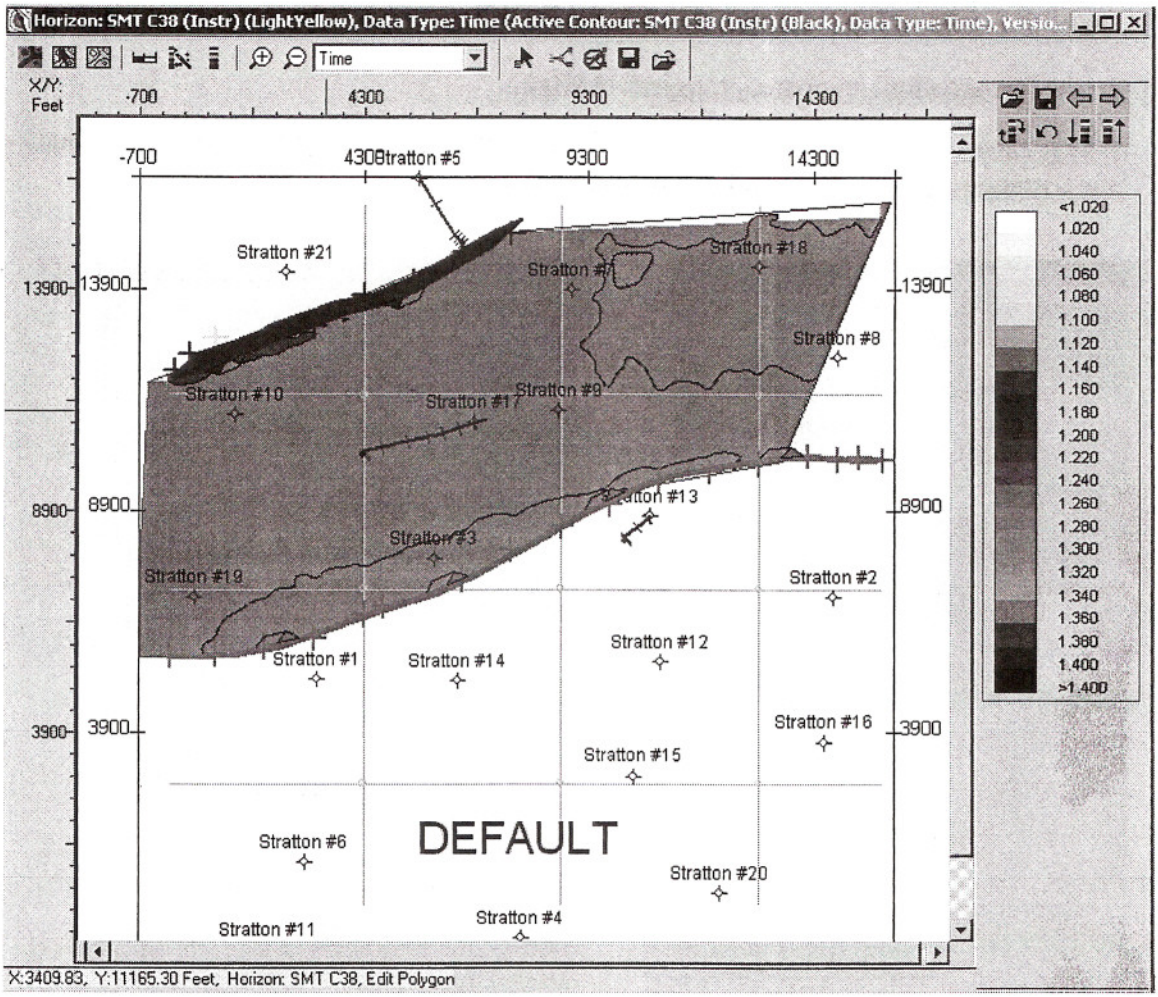

Figure 4.19 — Contour Map with Color Fill

25. Clear the **Base Map** by selecting **Map > Clear Base Map**. Answer **No** to the pop up window asking if you want to save the contours. Turn OFF the saved polygon, **Fault Block**, in the **Project Tree**.

26. On your own contour the **C38 Horizon**.

Note: Generated contours can be edited, although we will not do so in this class.

Saving Contours

1. From the main menu, choose **Contours > Save Active Set As** to open the **Save Active Contour As** dialog box.
2. A default name appears in the **Please enter or select a name for the current** text field. Use the default name if you wish, or create one of your own.
3. Click on **OK** to save the contours.

   The saved contours immediately appear in the **Project Tree**.