Chapter

3

Interpret Faults

Consideration should be given during an interpretation workflow as to when faults should be interpreted; first or concurrently with horizons. If your fault surfaces are interpreted first, autopicking (either 2D or 3D Hunt) of your horizons will stop at fault surfaces which may provide a more efficient workflow.

Interpret Faults

On seismic **Inline10**, several faults are prominently displayed. Interpret the most prominent faults as Unassigned faults across the 3d survey. Use a panning increment of 20 lines. Change the default unassigned fault color from black to yellow.

Follow the steps listed below.

1. Display **Inline 10** by selecting the line from the **Base Map** with your cursor, right click and select Inline 10.
2. In the seismic window, click the **Set Scales** icon and set the **Horizontal Scale** to **20** inches per Trace. Set the **Vertical Scale** to either **2** or **3** inches per second.
3. In the **Set Scales** dialog box and on the **Seismic** tab. Set the **Line Skip** increment to **20** and then click on **OK**.

   Now whenever the right arrow on the keyboard is hit, the line displayed will increase by **20**.

   If the left arrow is hit, the display will decrease by 20.

If a crossline is displayed, the up and down arrow keys will work likewise. The scroll window in the seismic line will change to the new increment.

You can also change the increment in the viewing toolbar field at the top of the seismic display by highlighting the number and typing in the new increment value.

4. Make sure the **Unassigned** fault is the only fault being displayed in the Project Tree. (*Uncheck boxes adjacent to other faults in the Project Tree*).

5. Change the Color Bar to **Blue to White to Brown.CLB** by clicking on the **Show Color Bar** icon and the **Select** icon located on the displayed Color Bar.

6. Select **Faults> Fault Surface Management** dialog box (Figure 3.1). Under the **Properties** tab choose the **Unassigned** fault in the **Fault Name** list. Change the **Fault Color** and **Label Color** to Yellow.

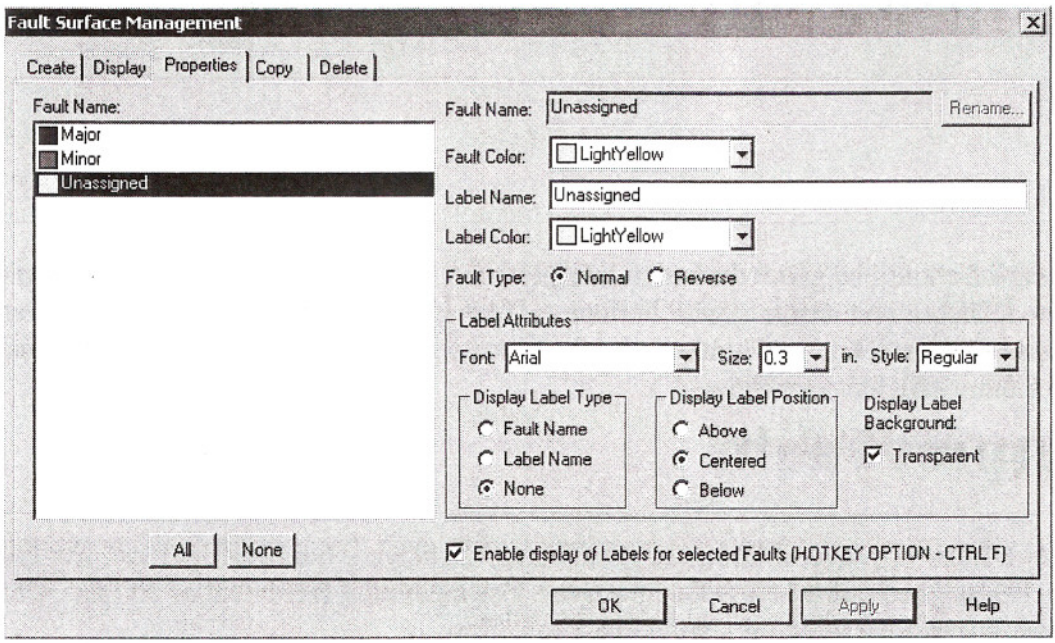

Figure 3.1 — Fault surface Management dialog box with Properties tab active

7. From the **KINGDOM Suite** main window menu bar, choose **View> Toolbars** to open the **Toolbars** dialog box.

8. In the **Toolbars** dialog box, click to place a check in the check box adjacent to **Faults Picking**.

9. Click **Close** to close the **Toolbars** dialog box and open the **Faults Picking** window (Figure 3.2).

Figure 3.2 — Faults Picking window

10. In the **Faults Picking** window, highlight **Unassigned** and either press the <**D**> key on the keyboard, or click on the fault digitize icon in the **Faults Picking** window.

11. Click the **Designated Vertical Display** icon in the seismic window.

12. Begin interpreting the unassigned faults. The number of points used to digitize the fault will vary from one interpreter to another.

Note: 2d/3dPAK has an auto-scroll function. As you approach the edge of your interpretation window, the view will automatically scroll. Just keep interpreting until you are ready to double click on the end of the fault. You may disable Auto Scroll in **Project > User Preferences > General** tab.

Editing Fault Segments

In order to edit your picks the picked fault segment must be active. The picked fault segment is active when the square nodes are present on the picked points. Point the cursor at tan inactive fault segment and click the left mouse button to make the fault segment active.

Available Fault Edits are listed in Table 1:below.

Table 1: Editing Fault Segments

Action	Instruction
To move a point	Activate the fault, left click and hold on a digitized fault point. As you move the mouse, the digitized point will also move. If you move a small distance, you may have to use the Esc key to undo the rubber band or get out of the Digitize mode
To move the entire fault line	First activate the fault, then hold the **Ctrl** key and left click and hold on any part of the fault line. Move the line to wherever you like and then release the mouse button and **Ctrl** key.
To delete the entire fault line	Click on the fault segment to make it active and then click the **Delete** key on your keyboard.
To add points	Left click once on an existing point to activate the fault, digitize new points, and double click on another existing point to terminate digitizing. The newly digitized points will replace points between the initial and final existing points that were selected.
To remove consecutive points	Left click on an existing point before the "bad" points, skip the "bad" points and double click on an existing point after the "bad" points. You can also get rid of individual points by double clicking on the individual points. However, you can't double click to remove first or last points.
Change the active fault	Left click on another fault to activate it, or right click on the seismic and from the pop-up window select **Set Active Surface**. Then toggle on Fault and choose a fault in the list to make it active.
<Ctrl>+C	Click <Ctrl>+C to copy a selection to the Microsoft clipboard.
<Ctrl>+V	Click <Ctrl>+V to paste the Microsoft clipboard.

1. Interpret an unassigned fault every 20 inlines across the 3D survey. Use the skills you have learned to navigate through the survey. Experiment with different line selections and orientations.

Time Slice

Once the faults have been picked through the entire 3d volume as Unassigned faults make a Time Slice and view the fault patterns on the Time Slice.

Follow the steps listed below.

1. Point the cursor at approximately **1.0** seconds in a vertical seismic window. Right click and select Display Time Slice **1.0**.
2. In the Time Slice hold down the F5 key to increase the seismic gain, enough to see the yellow fault intersecting crosses.
3. Make the fault crosses larger in **Project > User Preferences > General** tab. Enter a **Fault Intersection size** of **0.10**.

Assign Unassigned Faults

1. Right click on the seismic window and select **Fault Surface Management > Create** tab and enter a name, **Major**, and a **Red** color for the large normal fault. *You can also activate the **Fault Surface Management** Menu from the **Faults** main menu.*
2. Click on **Apply**.

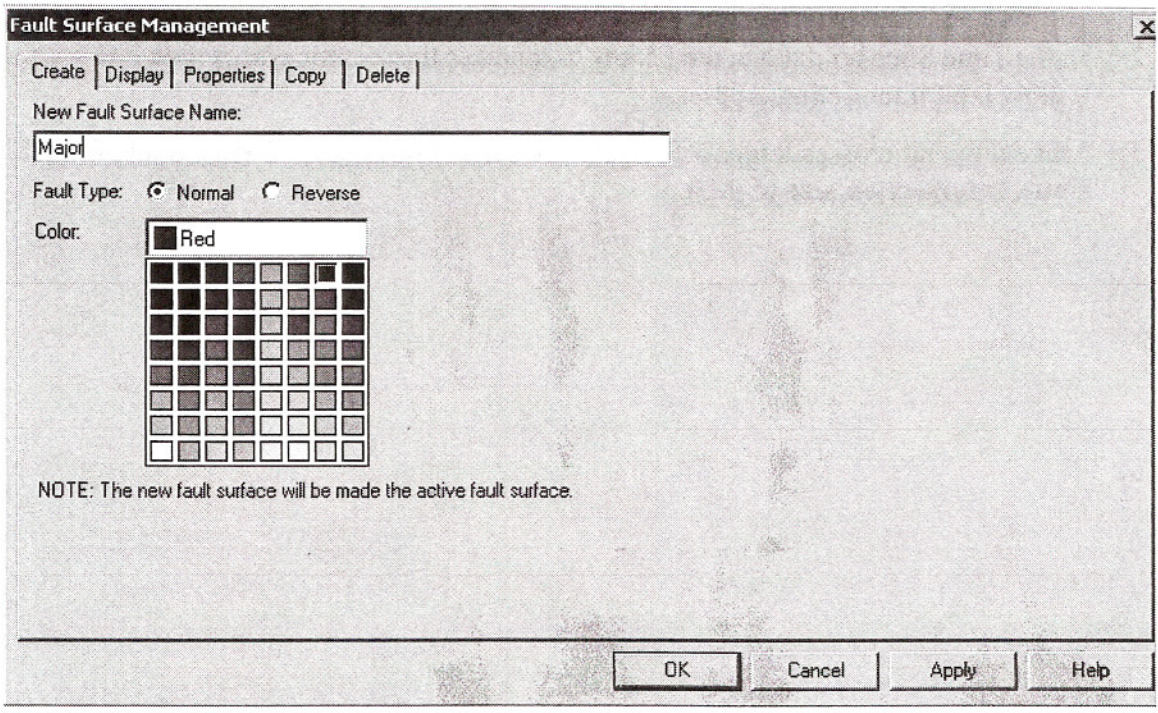

Figure 3.3 — Fault Surface Management dialog box

3. Create another fault. Enter a name, **Minor**, and a **Green** color for the antithetic fault and then click on **OK**.
4. The Major and Minor faults will be displayed in the Fault Picking Toolbar.
5. The most recently created fault, Minor fault will be the active fault. It is highlighted in the Fault Picking Toolbar.
6. Make the Major fault active by highlighting it in the Faults Picking Toolbar.

Note: If a fault does not appear in the **Faults Picking Toolbar**, make sure that the fault has been activated in the **Project Tree**.

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7. In the Time Slice, point the selection cursor (arrow) at one of the fault crosses for the Major fault in the north west corner of the 3d survey. While holding down the **CTRL**

key on the keyboard, left click on three additional yellow fault crosses for the Major fault. The selected crosses will display highlight markers.

8. On the keyboard, click the **A** key to assign the unassigned faults to the Major fault. The fault crosses will turn Red indicating the assignment was made.
9. Continue assigning the other crosses for the Major fault.
10. In the **Faults Picking** Toolbar select the **Minor** fault and in the Time Slice assign the unassigned faults to the Minor fault.

Table 1: Hot Keys for Assigning Faults

Hot Key	Function
A	Assigns an unassigned fault segment to the active fault
S	De-assigns a selected assigned fault segment to unassigned

Assign Faults on Vertical Seismic Display

Assigning unassigned faults on a vertical seismic view follows the same selection and assignment methods as discussed above when making assignments on a Time Slice.

1. Open a vertical seismic line containing an interpreted unassigned fault segment.
2. In the **Faults Picking** toolbar choose the fault "to assign to" by highlighting it.
3. In the vertical seismic window, click on the unassigned fault segment to make it active. Highlight marks will appear at the fault pick X's.aa
4. Click **A** on the keyboard or click the assign icon in the toolbar  .
5. If in error make the fault segment active and click S on the keyboard or the unassign icon in the toolbar  .

Display Assigned Faults

Once two or more unassigned fault segments have been assigned to a named fault, the **KINGDOM** software interpolates a fault plane through the assigned fault segments. This interpolated fault plane can be displayed in the **Base Map** and vertical seismic views.

1. Select **Faults > Fault Surface Management** and click on the **Properties** tab (Figure 3.4).

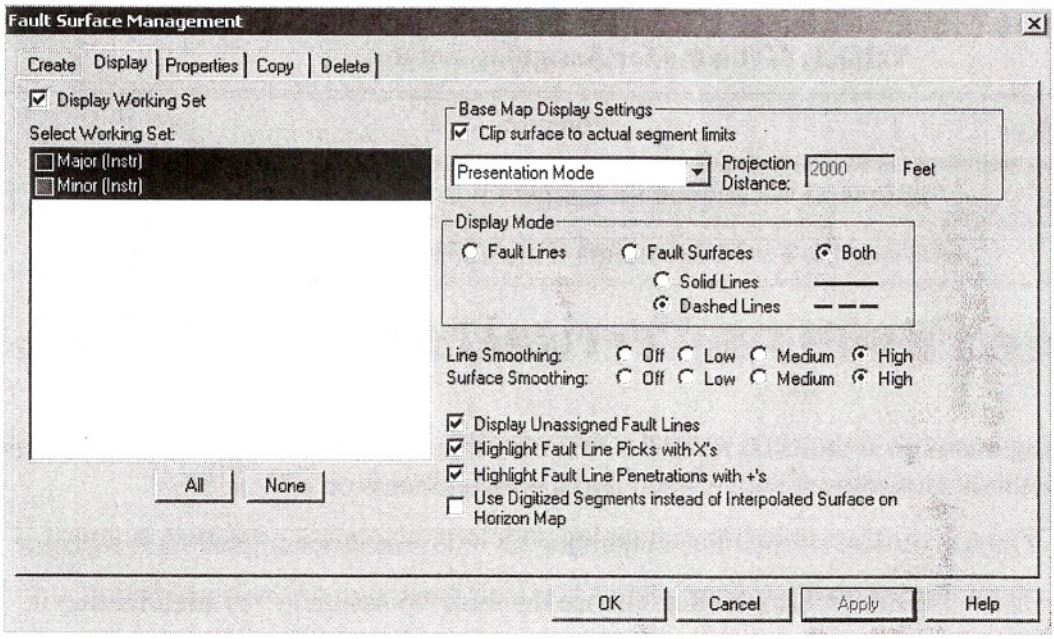

Figure 3.4 — Fault Surface Management dialog box with Properties tab active

2. Starting at the top of the dialog box:

   - Check **Clip surface to actual segment limits** - This feature will not extrapolate the fault surface across areas of no data.
   - Click the down arrow and select **Presentation Mode.**
   - Toggle ON **Both** and toggle **Dashed Lines** - The fault segments will be solid lines on a vertical seismic window and the interpolated fault surface will appear as a dashed line.
   - Toggle **High** for Line and Surface Smoothing.

3. Click **OK**.

Note: On a vertical seismic view, if an interpolated line is curved or "loopy" in appearance when you are using **Display Mode – Both**, you are probably placing your digitized

points too closely together in the vertical direction. Try removing some of the picked crosses. Double click on the cross to remove it. Try using High Surface Smoothing.

Display Fault Surfaces and Segments

Once an assigned fault has been picked on at least two lines, a fault surface is automatically created.

1. To view fault surfaces in the **Base Map** view go to the Project Tree and double click on the Major fault icon. *This will open a new Base Map with the Major fault displayed.*

   In the new **Base Map** the fault may be displayed as either a **Fault Surface** or **Fault Segment** by selecting your choice in the box near the top of the map window. The Fault Surface map is shown below.

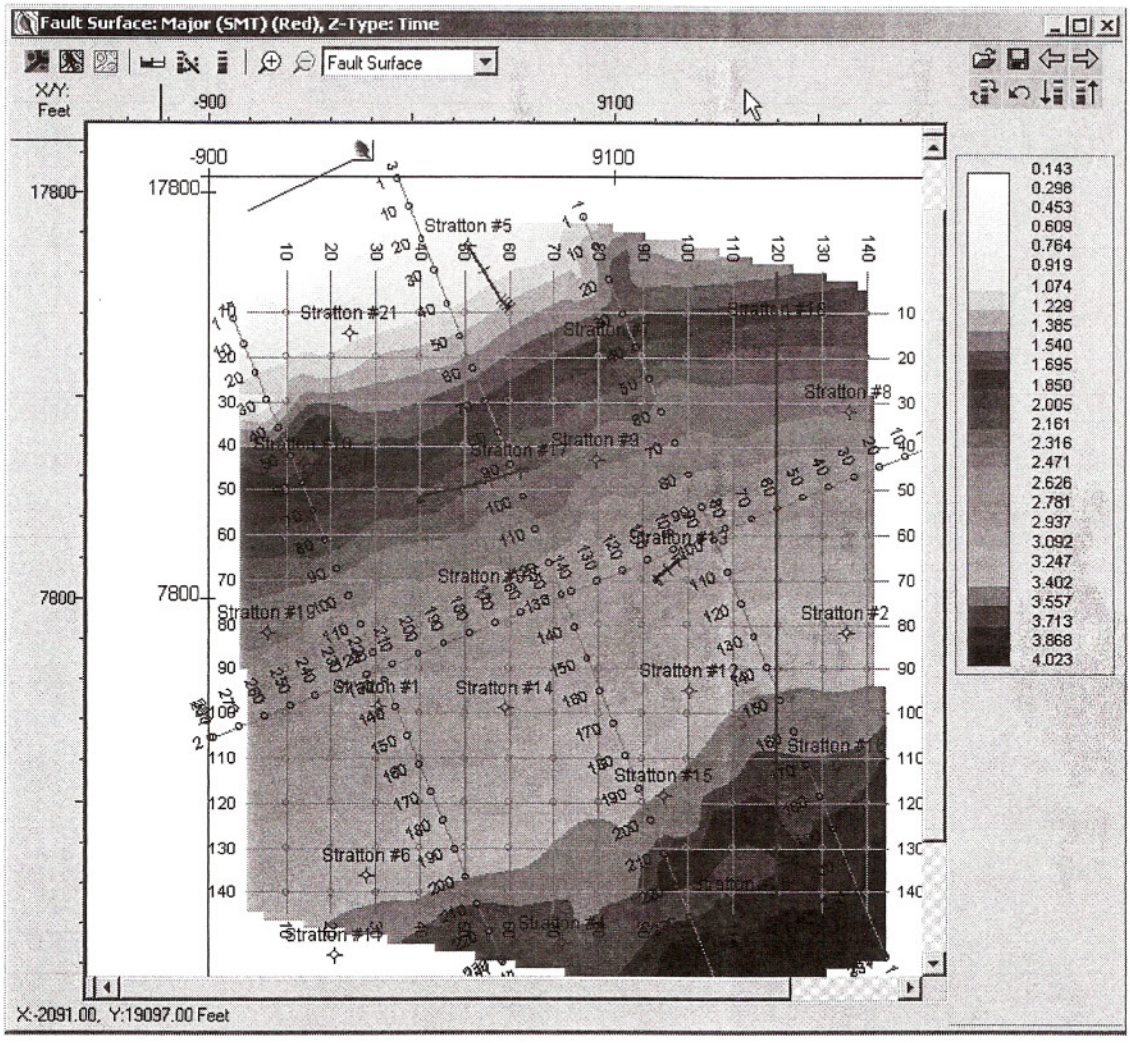

Figure 3.5 — Fault Surface with Rainbow 25 Colorbar

2. Change the display to fault segment to view the fault picks as displayed below in Figure 3.6.

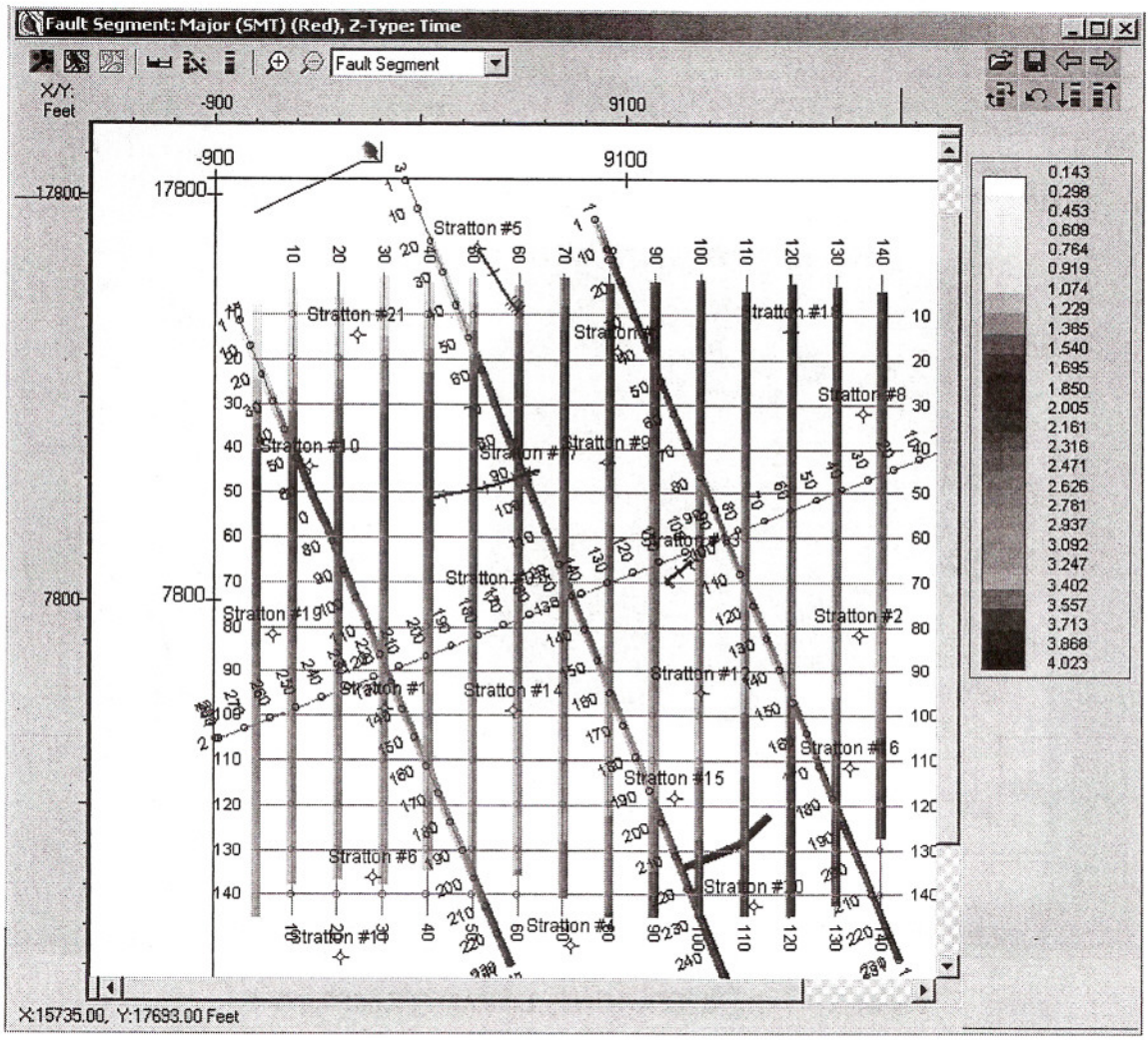

Figure 3.6 — Fault Segment with Rainbow 25 ColorBar

Pick Faults on Arbitrary Lines

1. To display a line with an arbitrary orientation through the survey, right click on a **Base Map** window, select **Digitize Arbitrary Line > Single Across Surveys**.

2. On the **Base Map**, left click on the starting point, continue left clicking on each bend in the line and then double click to end the arbitrary line selection.

   As shown in the Figure 3.7 below, an arbitrary line has been picked parallel to the strike of the Major fault.

   The interpolated fault plane will appear on the arbitrary seismic view as displayed in Figure 3.8.

   The red crosses are intersecting fault segments and the dashed line is the interpolated plane of the Major fault.

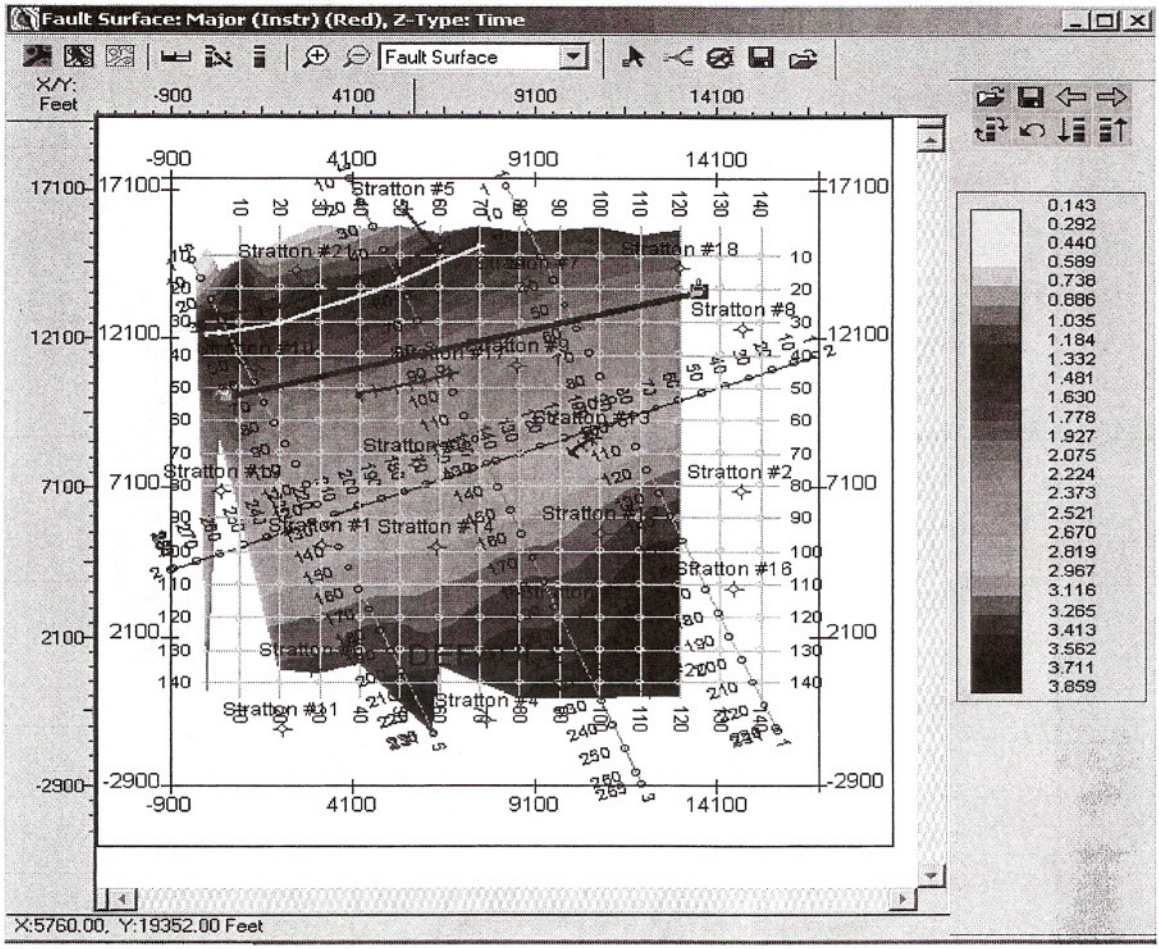

Figure 3.7 — Digitized Arbitrary Line Along Fault Surface

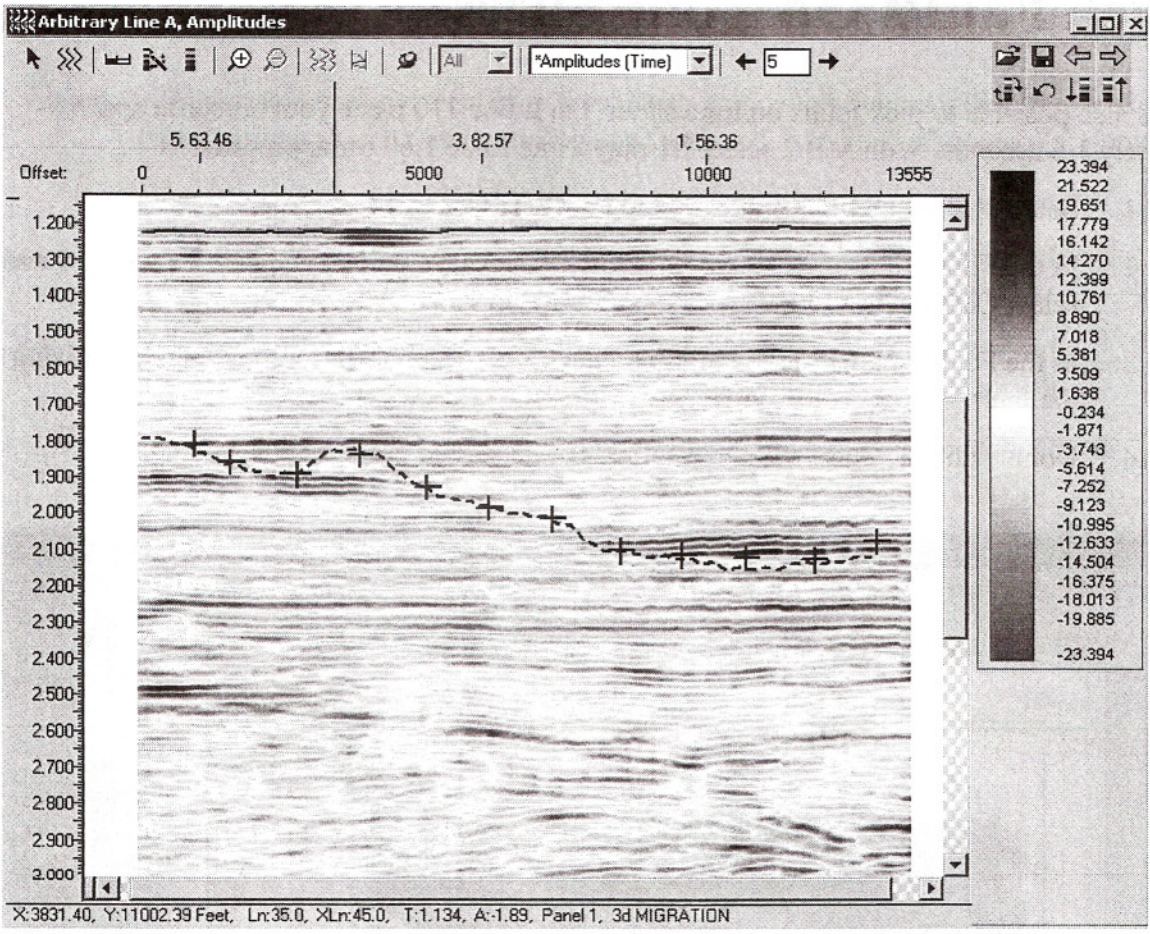

Figure 3.8 — Arbitrary Line with intersecting fault segments (crosses) and interpolated fault plane (dashed)

Since the line orientation of the arbitrary line is parallel to the Major fault, the projection of the fault surface are relatively flat on the line.

3. Open the Fault Picking toolbar (**View > Toolbars > Fault Picking**). Ensure that the Major Fault is turned on in the Project Tree.

4. Make the Major fault active. (*Either left click on a red cross in the arbitrary vertical seismic view or highlight the Major Fault in the Fault Picking toolbar*)

5. On the arbitrary line pick the Major Fault.

6. To save the arbitrary line, make the vertical seismic display active for the arbitrary line and select **Line > Arbitrary Line > Save As...** and name the line.

Pick Faults On Time Slices

It is also possible to pick faults on time slices. On Inline 110 place your cursor at approximately 1.6 seconds. With MB 2 select Display Time Slice 1.60 (or approximate).

1. Select the fault to interpret from the Faults Toolbar.
2. In the Time slice, click the down arrow in the Current display data type window and select Coherency1 (Time).
3. In the Fault Picking toolbar, click on the digitize icon (left icon) to begin digitizing the fault.
4. Double click to end the interpretation.

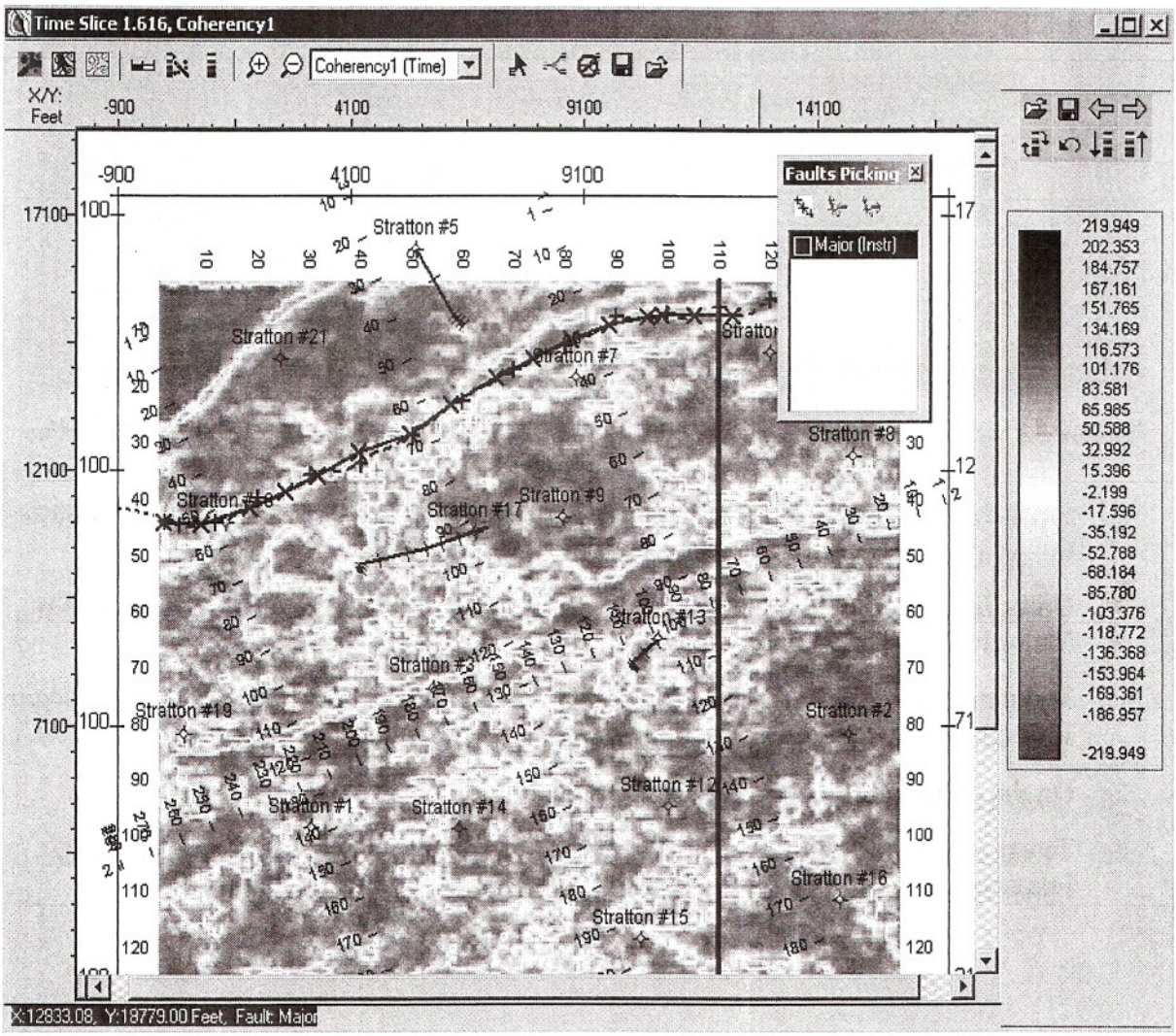

Figure 3.9 — Digitized Major fault on Timeslice with Coherency data type

Set Time Slice Skip Increment

1. Make the time slice **Base Map** active.
2. From the **KINGDOM** Suite main window menu bar, choose **View > Settings** to open the **Settings** dialog box.
3. In the **Settings** dialog box, click on the **Seismic** tab.
4. On the **Seismic** tab, enter the skip increment value in the **Slice Skip Increment** text field.

   Now, when you press the *up* arrow once on the keyboard, the slice that is displayed will display again at a time *decreased* by the slice skip increment.

   If you press the *down* arrow, the slice that is displayed will display again at a time *increased* by the slice skip increment.

   After the **Slice Skip Increment** operation is used, click on the survey to update the **Status Bar** at the bottom of the **Base Map** window, and then you can read the current time value at which the slice is displayed.

Fault Cuts

The following steps will demonstrate how to make a Fault Cut on a well path using a seismic fault displayed in a 3d seismic survey.

1. Display All Wells in the Project Tree.
2. Display the Main fault.
3. Open a vertical seismic display showing **Inline 14**. You may have to digitize the Main fault on Inline 14 to define the fault plane.
4. With the seismic display active, select **Logs > Settings**.
5. In **Log Settings** dialog box click the Scale and style Setup tab. Click the None button. This will remove any log curves that may be displayed on the vertical seismic line.
6. Click the **Define Curve Tracks** tab. Make sure that no tracks are selected. The Define Curve Tracks should be look similar to Figure 3.10. Click **OK**.

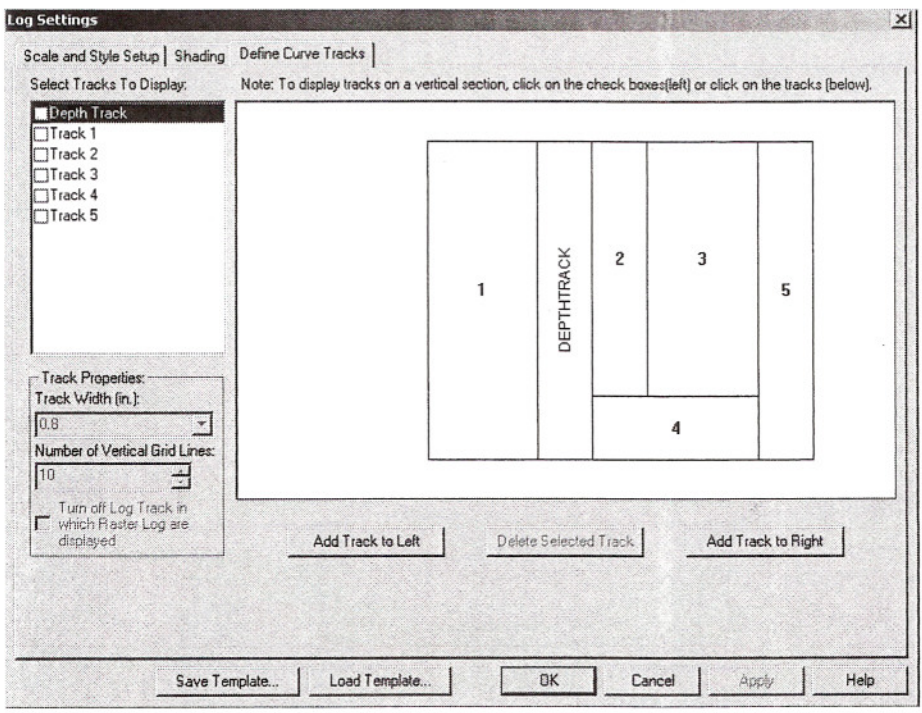

Figure 3.10 — Log Settings dialog box with Define Curve Tracks tab active

7. Zoom in to see the borehole intersecting the Main fault plane as shown in Figure 3.11.

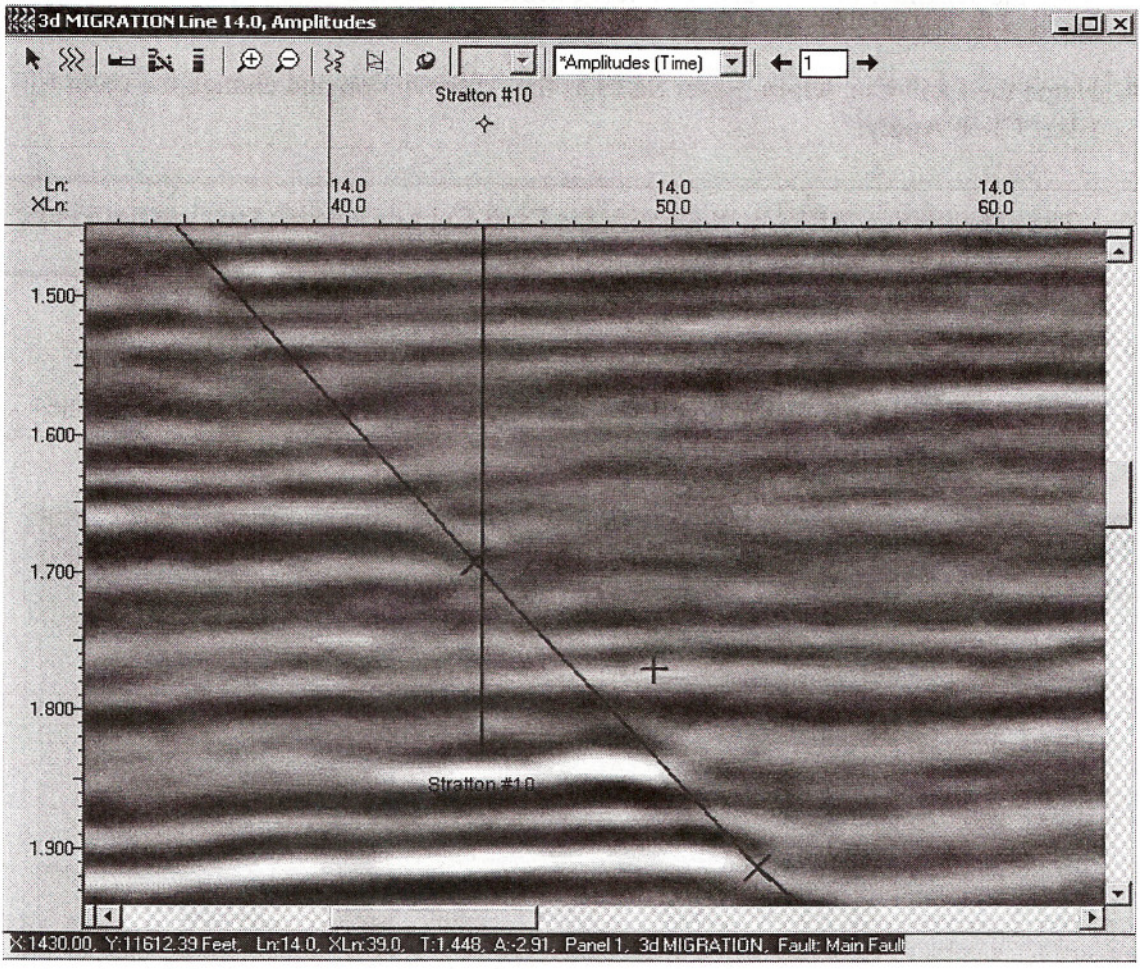

Figure 3.11 — Inline 14 with Stratton 10 well and Major fault

8. Point your cursor at the intersection and note the time in the status bar. (~1.697s)
9. Use the Correlation Polygon Tool (Tools > Correlation Polygon) to jump from the upthrown side of the fault to the downthrown side. Digitize a polygon over the upthrown negative amplitude at approximately 1.84 s and Crossline 49. Drag the polygon to the downthrown side and match the reflectors.
10. Note the Time shift in the correlation Polygon dialog box. (~0.145s).
11. Take half the value of 0.145s to be added and subtracted to the intersection point to determine the throw of the fault.

    Divide 0.145s by 2 = (~0.073s).

    For the Bottom Time add 0.073s to 1.697 = **1.77s**.

    For the Top Time subtract 0.073s from 1.697 = **1.62s**
12. Close the Correlation Polygon dialog box.

13. With the seismic inline 14 active, select **Faults > Fault Cut Management > Create** tab.

14. Name the Fault Cut, **Main**. Enter **SEIS** as the Abbreviation and change the color to Blue. Click **Apply**.

Note: The abbreviation, **SEIS**, will identify the Fault Cut as a seismic fault cut not to be confused with a fault cut from electric log correlations.

15. Click on the **Edit Fault Cuts** button located at the bottom of the dialog box.

16. From the **Fault Cuts** dialog box that opens shown below (Figure 3.12), select the Stratton #10 well from the Well List.

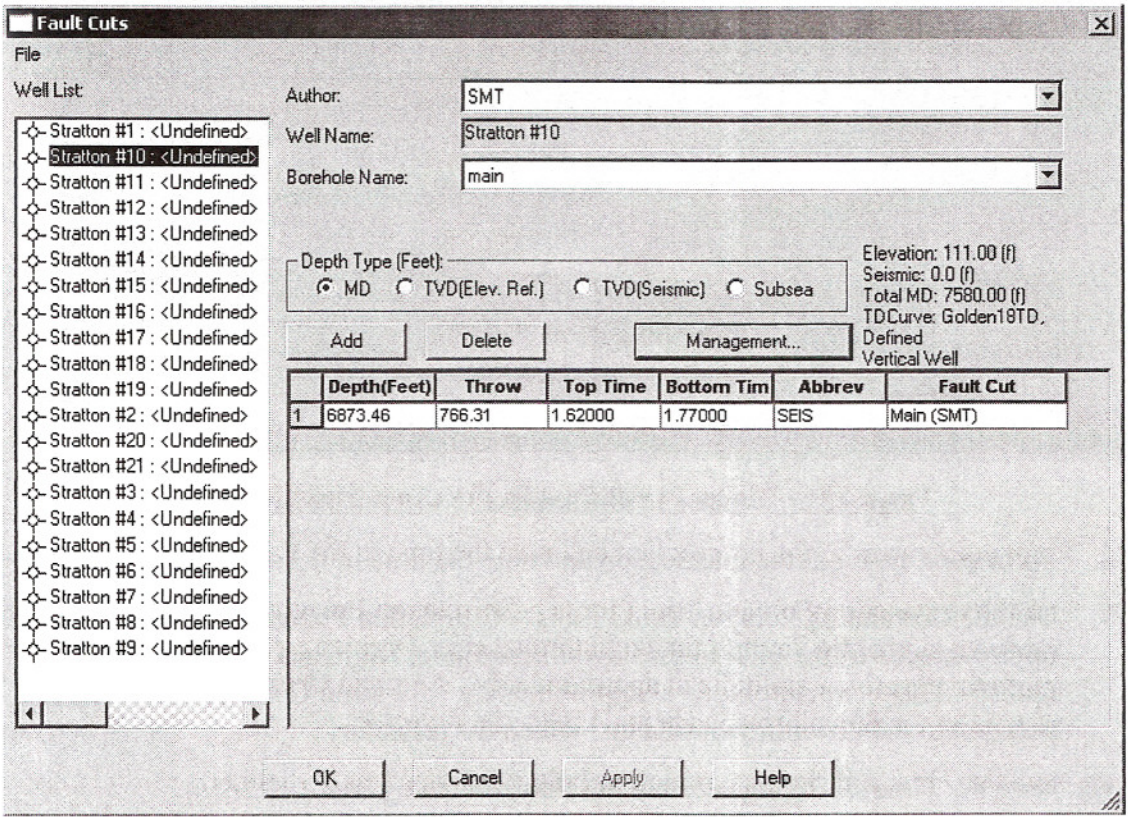

Figure 3.12 — Fault Cuts dialog box

17. Select **MD** (measured depth) for the **Depth Type.**

18. Click on the **Add** button to add a row.

19. Under the Fault Cut column, click the drop-down arrow and select Main.

20. For **the Top Time** enter **1.62s.** For the **Bottom time** enter **1.77s.**

21. Click OK. The Fault Cut is displayed on Figure 3.13.

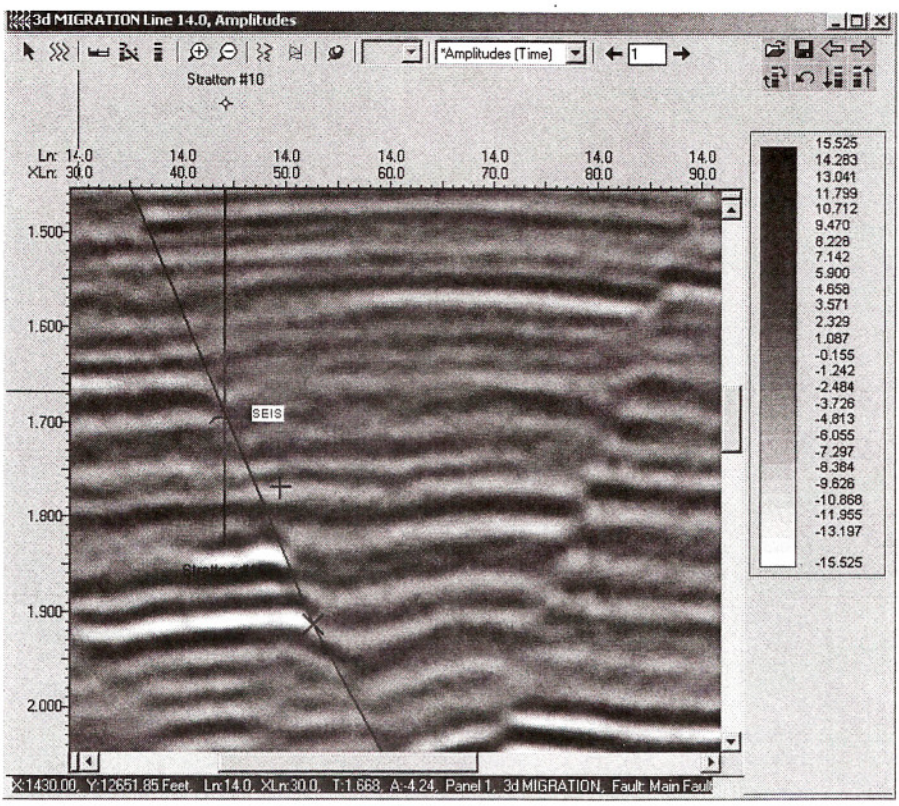

Figure 3.13 — SEIS Fault Cut displayed on Stratton #10 well on Inline 14