Two Alternative Seismic Fault Interpretation Techniques—Part One

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This is Part One of an expanded article describing two alternative seismic fault interpretation techniques. These were summarized in my "Rocks-2-Digits" web log; however, I also thought that they might be of interest to those who may not have seen them already. Part Two, which will be published next month, will show how shaded relief maps can be used to delineate very small faults.

Technique #1—Horizontal Fault Interpretation

As a standard practice, interpreting faults on a seismic workstation is usually done on vertical seismic displays (VSDs) of 3D seismic volumes—that is, on inline, crossline or arbitrary line presentations. However, this can sometimes be problematic and/or very time consuming in a complexly-faulted area. One factor is that faults are best seen on lines oriented in a dip direction, and in a complex area there may be several different fault orientations within a seismic volume, causing the interpreter to change line directions frequently. For a correct interpretation, the initial fault interpretation picks must be connected properly.

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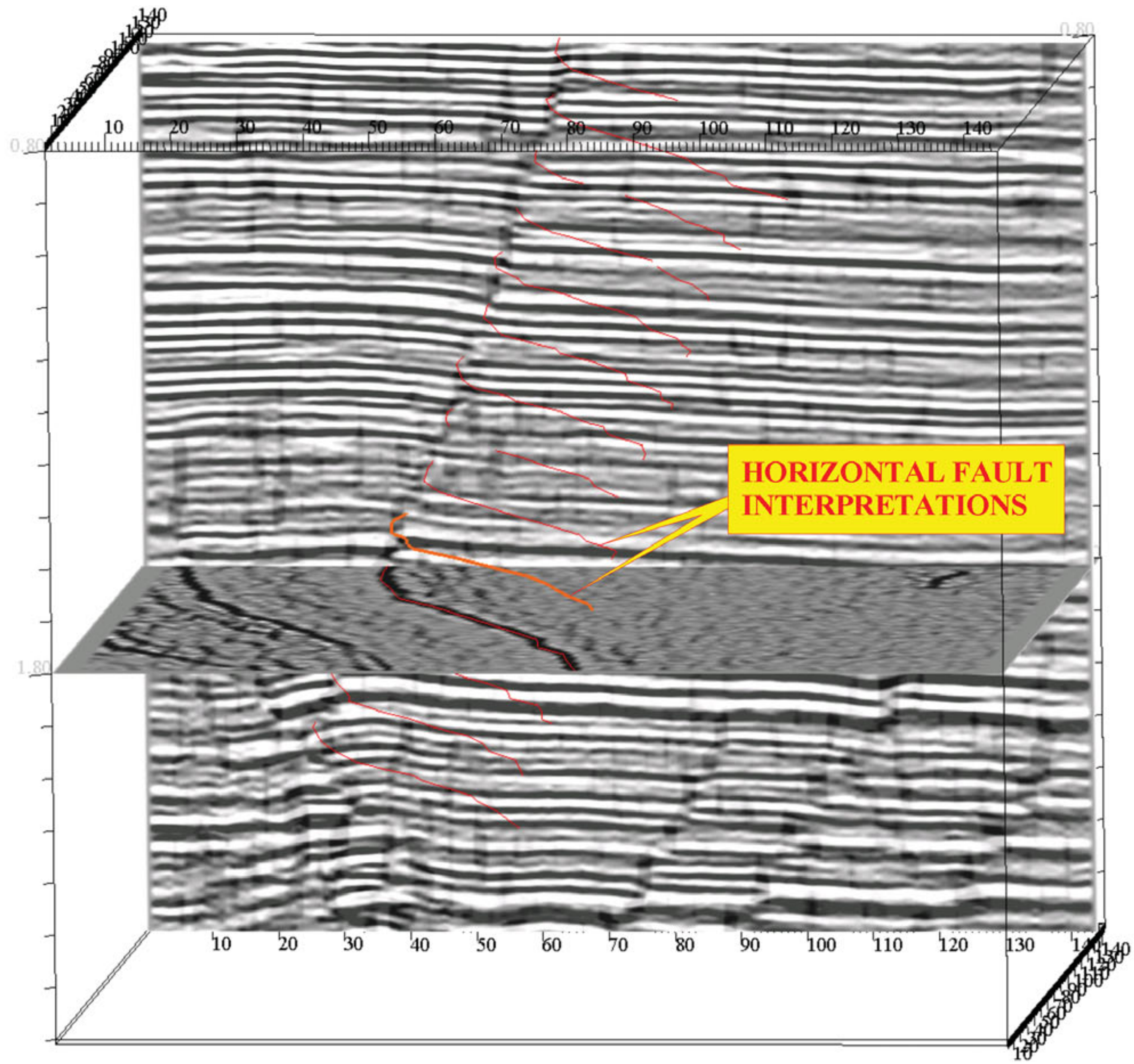

Figure 1. An oblique view of a 3D seismic volume, illustrating the regularly spaced, horizontal fault interpretations (brown lines). These were picked on time slices such as the one shown at 1.8 seconds, against the backdrop of a Coblended (migration and Ridge Enhancement) vertical seismic display.

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An easier, quicker and more accurate method than using VSDs for this is to interpret faults in the horizontal domain, as illustrated in Figure 1.

Here's a brief description of the method that I use for this:

1) Generate and/or load a coherency-type seismic attribute volume into the workstation project. I usually create a Ridge Enhancement attribute (in dGB's OpendTect software), an alternative to a coherency volume, as shown on the time slice in Figure 1.

2) I then use Seismic Micro-Technology's (SMT) 2d/3dPak to interpret the fault discontinuities (black areas of minimum similarity in the example) on time slices at 100-millisecond (ms) increments. The time slices should be spaced according to the nature of the fault—some faults require closer time spacing, whereas on other faults, a larger time spacing may be sufficient.

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3) The next step is to switch to the seismic visualization module (I use SMT's VuPak module) and scroll through the time slices to assign the faults that are connected and continuous to an already named fault—for example, the RED FAULT. Note that the fault interpretation done in step 2 can also be done in the visualization mode. Any necessary fault editing can also be done in this step.

4) While still in the visualization module, display the fault interpretation in a continuous surface mode, and check for any fault "kinks" (unrealizable geometries). A correct fault surface should be relatively smooth, whereas improperly interpreted or assigned fault segments are immediately apparent, with dramatic kinks or gyrations in the fault surface.

5) The final step, while not absolutely essential, is to scroll through the vertical seismic lines as another quality control process.

When this workflow is completed, you have a very robust fault plane map. This can then be used to accurately determine the intersection of the horizon and fault surfaces, which by definition is the fault polygon outline, indicating the missing section on a structure map of that horizon.

An additional animated illustration for the Horizontal Fault Interpretation Technique, which couldn't be properly displayed here, was posted on my "Rocks-2-Digits" blog on 12/11/07. Go to http://txresources.com/rocks2digits/, scroll the calendar back to December, and then click on the 11th. The direct address is http://txresources.com/rocks2digits/2007/12/11/horizontal-fault-interpretation/. ■

Additional Reading

Thorseth, J., Riley, G., Atalik, E. and Us, E., 1997, "3-D Seismic Interpretation Using the Coherency Cube: An Example from the South Embra Precaspian Basin, Kazakhstan," *The Leading Edge*, Vol. 16, June 1997.

Pedersen, S.I., Skov, T., Hetlelid, A., Fayemendy, P., Randen, T. and Sønneland, L., 2003, "New Paradigm of Fault Interpretation," Expanded Abstracts, SEG Annual Meeting.

Pepper, R. and Bejarano, G., 2005, "Advances in Seismic Fault Interpretation Automation," AAPG Search and Discovery Article #40169, modified from the Annual Convention Poster Presentation, June 19-22, 2005.

Worrel, A., 2001, "Rapid and Accurate 3-D Fault Interpretation Using Opacity and Optical Stacking to Reveal Geologic Discontinuities," *The Leading Edge*, Vol. 20, December 2001.

Biographical Sketch

Mike Cline is an exploration geophysicist and has been consulting since 1985. He has a diverse range of computer-oriented seismic interpretation experience in the energy industry, which became the basis for his company's name, Technology/Exploration Resources, LLC (dba T/X Resources). He holds active memberships in the SEG, AAPG, HGS and GSH, and is licensed by the TBPG (Geophysics). He is a past-Chairman of the Houston Geological Society Personnel Placement Committee, and was responsible for the HGS GeoJob Bank website during 2000-2005; he is also a past member of the HGS Website Committee. In addition, Mr. Cline has authored numerous articles and given oral presentations and in-house seminars on the subject of computer applications relating to geophysical interpretation. His contact info can be found on his website at http://txresources.com/main/index.php.