[GC]Corendering – A Powerful Tool for Mapping Faults*

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General Statement

High-resolution 3-D seismic data provide geoscientists with tremendous opportunities to study subsurface structure and stratigraphy. When used appropriately, the visualization tools provided by seismic interpretation software packages facilitate structural interpretations and provide insights to relationships and features that otherwise might be hidden. In this column we illustrate the use of a technique known as corendering to assist fault interpretations in a structurally complex area. Simply stated, corendering is a computer graphics tool that allows an interpreter to view two data volumes simultaneously.

Many seismic interpreters continue to use amplitude volumes for fault interpretation. They use reflection terminations, reflection offsets, changes of dip and other lines of evidence to identify faults. Coherency and related attributes such as semblance quantify differences in trace shape between traces in a 3-D seismic survey. Simplistically, high coherency values correspond to laterally continuous reflections, whereas low coherency values are associated with sharp boundaries, such as those associated with faults, channel margins and other features. Although coherency volumes are commonly examined alone for fault mapping, the simultaneous display of coherency and amplitude volumes through corendering can be a powerful tool for identifying and mapping faults. The images presented here combine those two volumes by using color (conventional blue-white-red color bar) to display the amplitude information and shading (as if a light were shining on the data) to display the coherency attribute.

Example

A 300-square-kilometer 3-D seismic dataset from the Western Desert of Egypt (courtesy of Apache Egypt and the Egyptian General Petroleum Co.) provides an exceptional opportunity to illustrate the benefits of corendering amplitude and coherency data. This structurally complex area underwent multiple episodes of tectonic deformation in the Mesozoic and Tertiary.

A series of normal faults affects Cretaceous strata, but few of these faults extend down into the Jurassic and underlying strata. Furthermore, most of these normal faults terminate upward at a Paleocene unconformity. The basin geometry is controlled by a normal fault that strikes approximately NW-SE. The survey area contains three families of faults that trend roughly parallel to the principal fault. These fault families contain segmented normal faults, both with splays of the same family and between differently oriented families.

Figure 1a shows an arbitrary vertical transect and intersecting timeslice that illustrate the expression of the faults in the amplitude data. Although some faults are readily identified in the vertical transect, the expression of the faults in the timeslice is more cryptic. Figure 1b displays the same arbitrary line and timeslice, but this time corendering amplitude and semblance. Notice how the combination of coherency lineations and reflection offsets highlights the faults on both cuts through the data volume.

Similar corendered data displays were used to map more than 40 faults across the 3-D survey area. Many of these faults are shown in Figure 2. We assert that it would not have been possible to map many of these faults without the aid of corendering.

Conclusion

Picking faults in a 3-D seismic cube represents only the first part of a structural interpretation. The normal faults mapped in this project span isolated growth, isolated-yet-interactive growth, and coherent growth models. Analyses of these faults would provide fundamental insights into how families of normal faults grow. Additional work might include the generation of Allen diagrams or other types of fault-seal analysis. Fault networks might be studied to reconstruct the tectonic evolution of the study area. Whatever the ultimate goals might be, using corendering to improve fault mapping will improve the robustness of all subsequent analyses.

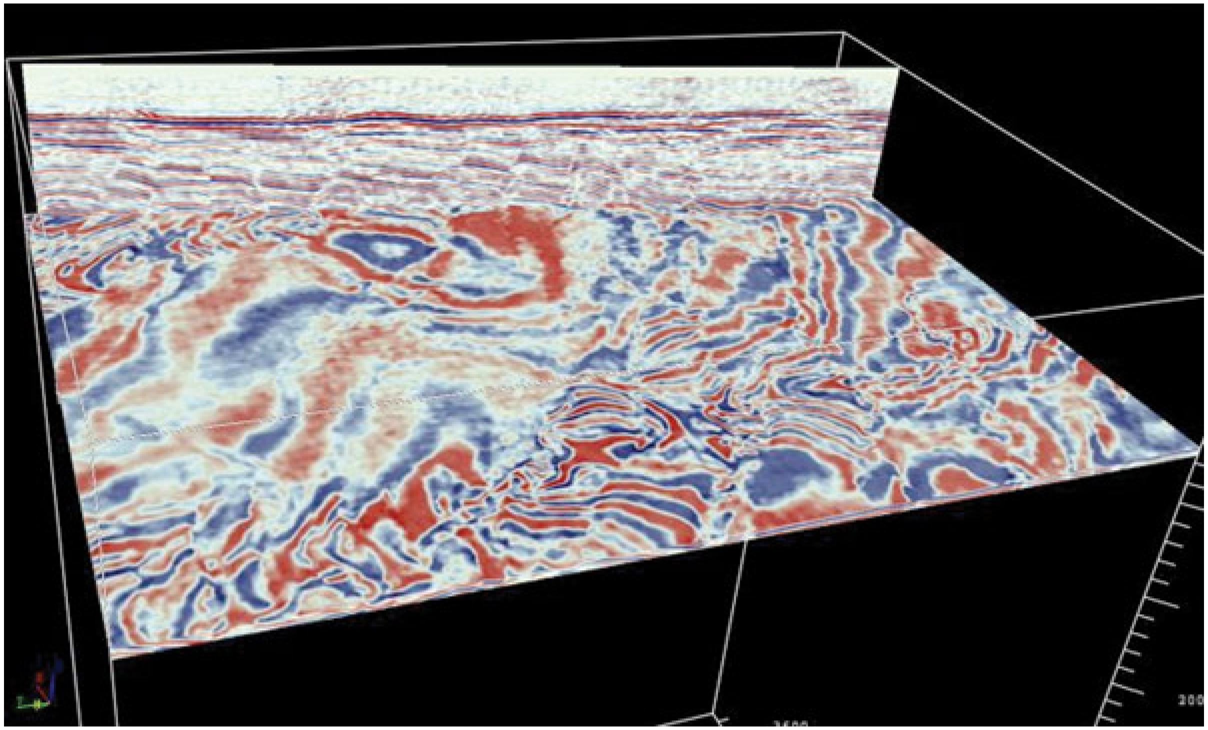

Figure 1a. Arbitrary line and timeslice through the 3-D seismic amplitude volume.

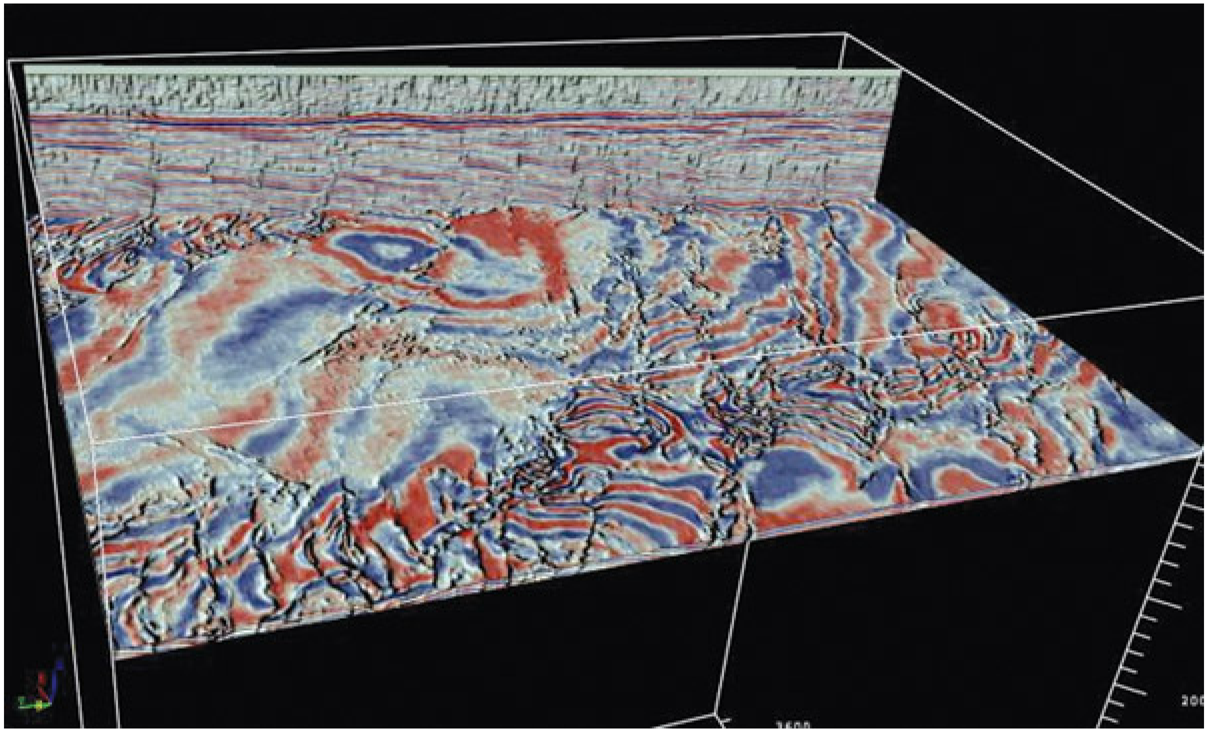

Figure 1b. Same timeslice and arbitrary line as in Figure 1a, but corendering amplitude (conventional blue-white-red color bar) and coherency attribute (black lines show reflection discontinuities). Note the improvement in fault definition compared to the conventional amplitude display.

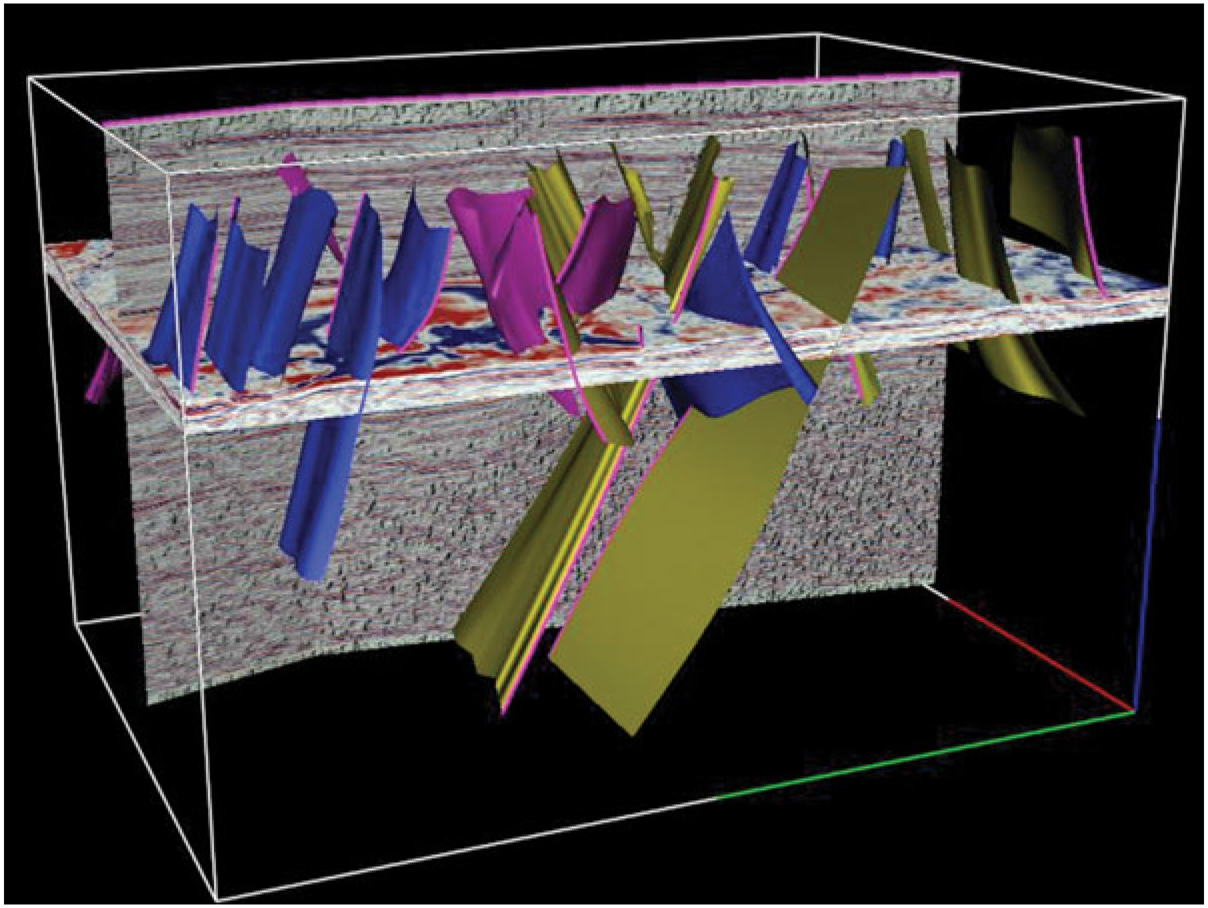

Figure 2. Visualization of faults and corendered seismic data. More than 40 faults were mapped in the data volume, but for clarity not all are shown in this display. Although seismic data quality deteriorates below the Cretaceous, most of the faults demonstrably die out downward at this level.