New Interpretation Assets from Computer Assisted Interpretation

Introduction

Computer assisted picking of seismic reflectors is mature technology in our industry. Computer assisted picking of faults is new and algorithm development has caused us to re-examine the processes that seismic interpreters use as well as the goal of the interpretation. We have added some new displays to our seed based horizon propagator that illuminate both the process and the structure picked. We have also recently introduced new capabilities for computer assisted fault picking which produce additional information for the interpreter. All examples use a 3D seismic dataset from offshore Indonesia.

Horizon Picking

Our 3D seismic horizon propagator accepts user defined seed points and then tries to expand from these points to the survey boundary following the paths of best correlation. In the process of propagation the path from seed point to picked point is naturally part of the process and is commonly stored and displayed. The seed points are commonly called ancestors; the propagated points are commonly called descendants; and the path between the two is commonly called heredity. We have added bookkeeping to record the number of ancestors and descendants of each picked point. These are simple scalars with no notion of connectivity. When the number-of-descendants [NOD] data is displayed in map form it looks very similar to a watershed where the seed value is the estuary and points with many descendants are the tributaries. It is easy to confuse this display with a plot of heredity. The differences are subtle. The NOD points have no notion of connectivity but obviously a point cannot have a high number of descendants without one or more of its neighbors also having a high number of descendants. The main difference is that the NOD map identifies the significant points to propagation in a similar fashion to a river map for a watershed. Figure 1 shows a NOD map from a single seed point at the water bottom with blue representing many descendants and yellow and red few. This map shows the course of propagation with paths avoiding channels and faults but with no particular grain. Figure 2 shows a combination map of the number of ancestors and descendants. This map highlights spatial discontinuities in generations caused by channels and faults acting as barriers to propagation. Figure 3 shows a NOD map for a channel seed. Here the propagation is meandering within the channel apparently following the thalweg except in the areas that appear to be over-bank deposits where propagation is more treelike. These slides represent the extremes of propagation paths. Most reflectors exhibit paths that indicate preferential grains within each fault block together with indications of faults and channels or other interruptions in the reflections. Another auxiliary result of propagation, that is not displayed, is a map of pick quality which could be used to drive estimates of pick uncertainty.
Fig. 1 A map of the number-of-descendants from a water bottom seed in the center of the surface.

Fig. 2 A combination map of the number of ancestors and descendant, red is few blue is many.
Fault Picking

We have recently introduced a new tool to our interpretation suite. This function takes an interpreter’s fault picks made on parallel sections or z-slices and snaps and tracks the user’s picks to discontinuities detected in the seismic volume. This function is very much user driven in contrast to automatic techniques and is equivalent to the interpolation and snapping operations of rubber-band horizon picking, except in this instance the result is a fault plane segment rather than a linear horizon pick.

Figure 4 shows the comparison between the manual pick and the snapped pick in section view. This example was specially chosen to illustrate the difference between the two fault picks. The computer assisted pick will honor the discontinuities detected in the seismic data. The interpreter’s pick will include much judgment. The fault may not be continuous, it may be composed of many small relay faults that the interpreter chooses to represent as a single fault. The interpreter may decide that the deeper part of the section is not properly imaged because of minor velocity errors and then place the fault picks in the general area of the fault. However interpreters currently pick horizons based on the seismic image so to produce a coherent interpretation we should pick faults using similar criteria. Once we have an integrated interpretation we will be able to refine it using external geologic constraints or refine the imaging and repeat the process.
Figure 5 shows a typical comparison of interpolated manual picks in plan view on a z-slice. In general the two picks agree but the tracked pick follows the discontinuity more closely and contains detailed information about the fault shape in the strike direction. When the geology is properly imaged the shape of the faults in both strike and dip direction will vary with the strength and brittleness of the rock units and the forces causing the fault. This information can be captured from the data. Deeper in the section the seismic data will be of lower frequency so the shape in the dip direction will be more band limited.

Figure 6 shows a smoothed view of the fault. This view is chosen to show the consistency of the shape of the fault along strike with respect to depth. Unsmoothed views are better viewed on z-slice animations. The statistical comparison of manual versus tracked faults can also be used to drive estimates of picking uncertainty for faults.

The prime intent of computer assisted fault picking was to empower interpreters. This tool does allow interpreters to be less precise in their definition of the fault vertically when tracking produces reliable results and will produce detailed fault surfaces from sparser interpretation. These results will improve as we add more geologic knowledge to this process.

Fig. 4 Comparison of manual fault pick in blue versus tracked fault in purple
Fig. 5 Comparison of manual fault pick in blue versus tracked fault in purple on a z-slice

Fig. 6 The final tracked fault shown in 3D. The surface has been smoothed for this format.
Conclusions

These computer assisted techniques display local shape information for horizons and faults that can assist in structural and stratigraphic interpretation. If we are to generate unbiased estimates of picking uncertainty we need to use computer assisted techniques. We cannot rely on an interpreter’s judgment of uncertainty for every pick. Computer assisted fault picking is forcing us to address issues such as the goal for picking and uncertainty in the image. We also continue to inject knowledge of rock mechanics and structural geology into the algorithms. Faults are not planar and the shape of the fault carries useful information that we are beginning to extract.

Acknowledgements

We’d like to thank Clyde Petroleum for the use of their seismic and well data. We’d like to thank our colleague Mike McCabe for his combination ancestor and descendant display.