From fault likelihood attributes to automatic fault building

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Summary

Fault interpretation is a key step in seismic structural interpretation and it also lays the basis for proper quantitative interpretation, inversion and modeling. If the working area has lots of faults, the structural interpretation can be very time-consuming. Because of noise, and different background experiences of the interpreter, the results can also be subjective. In this abstract, based on a real 3D seismic data set with lots of different faults, I will demonstrate a workflow that calculates an attribute (fault likelihood) to better delineate faults for automatic extraction. By replacing most of the manual work with the computer algorithm, we not only dramatically improve efficiency and save time, but also generate objective results. Some challenges to this will be discussed.

Introduction

Using seismic attributes to help to interpret faults is not a new idea. During the past two decades different people have been discussing the use of coherency (Bahorich et al. 1995), volume curvature (Chopra et al. 2007) and spectral decomposition etc. to interpret faults. In recent years, fault likelihood (Hale 2013), which is a combination of different attributes, has been utilized. This increases the clarity and accuracy so much that automatic fault extraction from the attribute is now possible.

Theory and Method

As stated in the previous section, fault likelihood attribute is a combination of different attributes. The attribute I am using is semblance with three-dimensional scanning; that is, structure oriented semblance. As illustrated in Figure 1, the semblance is calculated along the local structural trend. Since the local structures have already been taken into account by volume curvatures, they can be used as well. Different signal processing is then applied to the results which is then followed by a skeleton calculation. The final results are fault likelihood attributes which show probability of faults exist at each location.

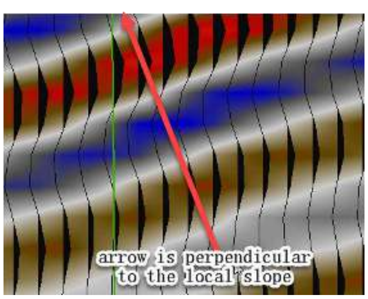

Figure 1 Illustration of structure oriented semblance

After fault likelihood attributes are calculated, the next step is to extract and build the faults automatically. These are illustrated in Figure 2 and Figure 3. Firstly, fault lines (the color lines in Figure 2) are extracted from the fault likelihood attributes (the lines in grey). These should delineate the faults; with small branches excluded. Secondly, fault lines with similar shapes are grouped into a single fault. And lastly, a triangular mesh is created to form the final fault surface.

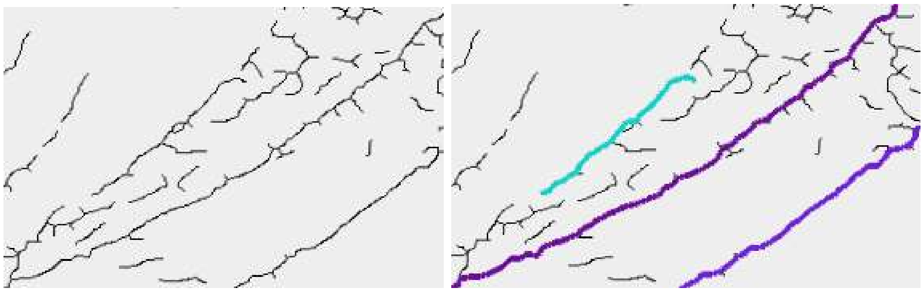

Figure 2 Fault likelihood and the extracted fault lines

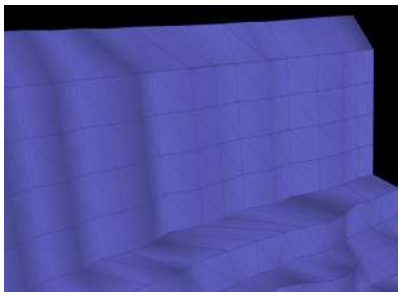

Figure 3 The fault surface

Examples

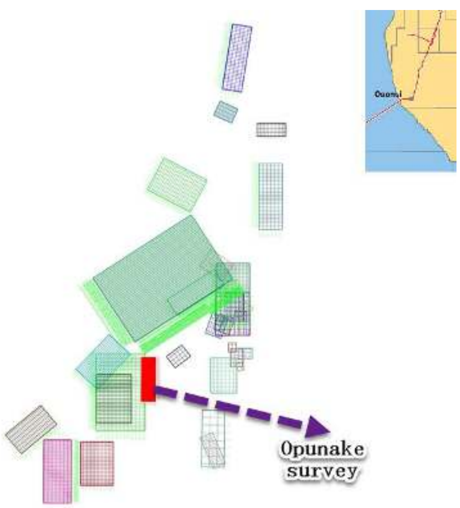

Figure 4 The overview of the survey

We use a subset of the Opunake offshore 3D seismic survey (Taranaki Basin in New Zealand) to demonstrate the workflow. Figure 4 is the map view of Taranaki Basin, where the red rectangle is the survey used in this abstract. Figure 5 shows a vertical section of the 3D seismic data (a) and its co-rendering with the calculated fault likelihood attributes (b). The original seismic data is in blue-red color and the fault likelihood is in grey color where the darker the color, the higher possible a fault exists. From these figures, it can be seen that faults that could be identified by most interpreters are clearly indicated by the calculated attributes. However, a small number of the faults identified by the fault likelihood attribute may be missed by some interpreters. Figure 6 shows the full set of faults extracted from the area.

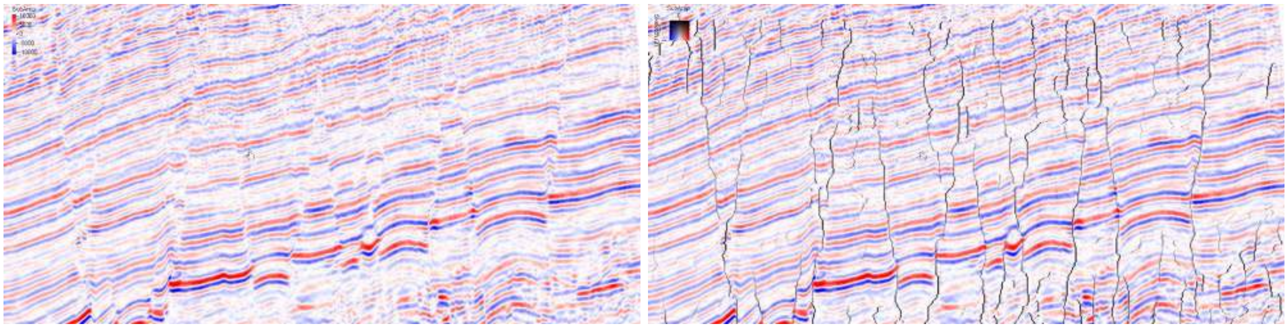

Figure 5 (a) A vertical section of 3D seismic data, (b) co-rendered with fault likelihood attributes

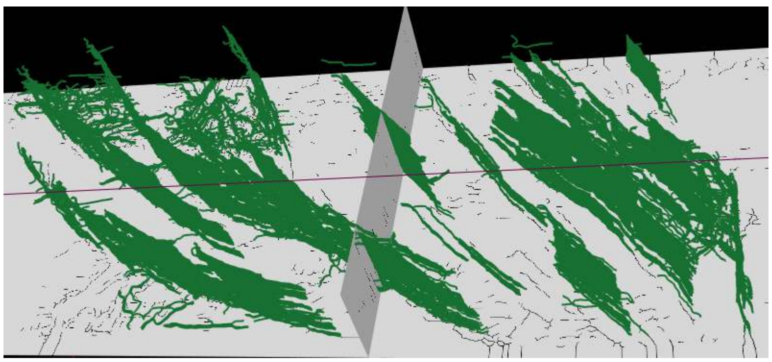

Figure 6 Extracted faults displayed in 3D along with fault likelihood attributes in cross line and time slice

Conclusions

A workflow from a fault likelihood attribute calculation to automatic fault building is introduced with a real 3D seismic data set as an example. In practical work, there are still many challenges. For example, in poor data quality areas with lots of fractures, the calculated fault likelihood attributes may only show traces of faults or even nothing at all. In the fault building stage, the same fault may be split into two or even more fault segments because of missing information in the area.

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References

1. Bahorich, M., and Farmer, S., "3-D seismic discontinuity for faults and stratigraphic features: The Coherence Cube," The Leading Edge, Vol.14, No. 10, 1995, pp. 1,053-58.
2. Dave Hale, "Methods to compute fault images, extract fault surfaces, and estimate fault throws from 3D seismic images." GEOPHYSICS, 78(2), 2013, O33-O43.
3. Satinder Chopra and Kurt Marfurt, "Curvature attribute applications to 3D surface seismic data." The Leading Edge, 26(4), 2007, pp. 404-414