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Enhancing seismic discontinuity attributes with creative workflows

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Summary

The seismic discontinuity attributes such as coherence and curvature are commonly applied to 3D seismic data volumes for determination of faults or fractures, channel and reef edges, and other geological features. Such attributes are very helpful in interpretation, though the quality of the attributes generated depends on the quality of the seismic data in terms of the noise and frequency content. Once the 3D seismic data reaches the interpreter's workstation, it is presumed that the data has undergone optimal imaging and that there are no processing artefacts. We believe this is true in most cases, and even if not, it is assumed to be the case for the purpose of this article. All seismic data must be preconditioned before computation of attributes is carried out, and we have demonstrated this in many of our articles published in this column over the last few years.

Another process that is usually encompassed in the preconditioning of seismic data is frequency balancing or enhancement of the seismic data. Both these processes need to be carried out carefully, the calibration of the seismic data with well data being the key to accepting or rejecting any such process.

Sometimes creative workflows are suggested to bring out more information from the seismic data that can help achieve the objectives set for any exercise. Such workflows may not necessarily follow the usual or routinely-followed attribute applications. One such workflow uses post-stack processing for enhancing resolution and any breaks or disruptions in different reflection campaigns on the seismic data. We describe the sequential steps in the workflow as follows:

1. Assuming that the input seismic data are preconditioned using structure-oriented filtering at the very least, the first derivative of the seismic amplitudes is computed, which has the effect of advancing the phase of the data by 90^{o}, so that the peaks and troughs of the amplitudes are transformed into zero crossings. Also, the frequency spectrum of the data shifts to the higher frequency side for the first derivative data.

2. The data in step 1 can be used for computation of attributes such as coherence or curvature, and they are likely to show crisper detail than running the same attributes on input seismic data. Another step that can be followed is to bandpass filter the data from step 2 in such a way so as to retain the frequency components with higher amplitudes and increase the apparent higher frequency content of the data.

3. Next, the absolute value of the first derivative is computed. This computation has the effect of flipping the negative derivative values to positive, so that now we have a series of only positive amplitudes separated by zero-derivative transition lines.

It may be mentioned that the sequence of steps stated above retain the relationship to variations in signal phase and frequency content through time.

Once these steps are completed, one can run energy-ratio coherence attribute on the input data in step 1, step 2 (first derivative), and then the data in step 3 (absolute value of first derivative with bandpass filter). One can notice the value-addition in terms of crisp definition of many of the lineaments on the coherence attribute on data from step 3. All the steps mentioned above can be quickly carried out by an interpreter on a workstation with the available interpretation software package.

Needless to mention, confidence in final interpretation of the lineaments would be gained by correlating the rose diagrams generated from such lineaments with the rose diagrams obtained from the image logs.