Application and comparison of discontinuity detection methods in 3D post-stack seismic data

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Abstract

Detection of seismic discontinuities has gained prominence in recent years due to the increase in the quality of acquired seismic data, thus allowing a better prediction of structures such as faults and fractures, contributing to improve of the interpretation of conventional and non-conventional seismic data. This work aims to compare different discontinuity detection methods, some already widely used in the oil & gas industry. The methodologies used in this work were applied to pre-stack time-migrated 3D seismic data from the Alto de Cabo Frio region located between the Santos and Campos Basins. The following techniques were used in this study: DECFRA (Detection of Faults and Fractures), which is used to identify faults and fractures through a PWD (Power Wave Destruction) filter to destroy plane waves; M.S.A. (Minimum Similarity Accumulation) is an attribute for highlighting faults, channels, salt edges, and other seismic features. The algorithm calculates and accumulates the minimum similarity values in the roundness of each sample, originating the visualization attribute; TecVA (Amplitude Volume Technique) is a technique that calculates amplitude maps and vertical and horizontal seismic sections that are used to enhance subsurface geology. It derives seismic trace envelope (zero phase), assuming that every positive or negative seismic reflection has geological significance, being represented with an interface between layers; S.T.F. (Spatial and Temporal Filtering) is a filtering technique that uses three steps to detect discontinuities in post-stack 3D seismic data: in the first step a horizontal filtering (inline followed by crossline) is applied to attenuate most of the events horizontal and sub-horizontal, in the second stage a Hilbert transform is applied in each dimension of the volume to obtain the complex volume. In the last step a phase rotation is applied in each dimension of the amplitude volume; the coherence attribute (eigen) which is calculated by measuring the similarity between features, where similar features are mapped with high coherence coefficients, while discontinuities have low coherence; and AFE (Automatic Fracture Extraction) which uses signal processing combined with steps based on intelligent geological rules and a set of interactive tools to allow automated interpretation of faults and fractures. AFE's main input is the coherence attribute (eigen) previously generated. A visual comparison of the attributes generated by the different methods was carried out through seismic sections inline, crossline, and time slice, observing the main features of discontinuities, which are more prominent. In conclusion, it was found that some techniques are more suitable for detecting certain structural features such as folds, bedding, channels, etc., while other methods are better used for detecting faults and fractures.