Automated Fault Detection from 3-D Seismic Using Artificial Intelligence — Practical Application and Examples from the Gulf of Mexico and North Slope Alaska

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9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

Understanding the fault network and structural history setting up the petroleum systems associated with oil and gas reservoirs has been an essential step in the E&P process for decades. However, description of structural information and its subsequent impact on reservoir performance is one of the most generalized components within modern basin and reservoir modeling workflows. Thankfully that gap is being closed as we move forward in a new era of understanding brought about by 'AI'-derived 3D seismic attributes which capture the intricate details of a realistic subsurface. Deep learning - a particular subset of machine learning, which in itself is a form of artificial intelligence - is carving a niche in the realm of seismic attributes given its well established strengths in image pattern analysis and recognition. With this in mind, a Convolutional Neural Network (CNN) was developed using a large amount of labelled data to identify faults in a seismic cube, assigning the detected fault a confidence score on a per voxel basis. Having now been tested and QC'ed on over 60 previously unseen 3D datasets, we call this CNN our 'Foundation Model'. We present a workflow in which an AI fault attribute can be quickly derived using the Foundation Model on a 3D seismic dataset. The data is first analyzed by the network to provide a first-pass fault attribute. The model is then fine-tuned using a small amount of interpretation to adjust and account for subtle geologic details specific to the structural regime of each unique dataset. This also has the effect of reducing false positives in the original output relative to the

true fault signal. The fine-tuned fault cube can then be analyzed using other high-fidelity attributes and filtered based on criteria such as confidence or fault azimuth. We then automatically extract fault sticks which are easily edited and grouped to form fault surfaces. As a final step, the fault cube can be co-rendered with a Frequency Decomposition RGB color blend, providing QC of the AI attribute as well as greater geological understanding. The final attribute and resultant fault interpretation are shown to be far superior to a traditional workflow using coherence algorithms. The automated components of the AI-assisted workflow have demonstrated tremendous value in significantly reducing interpretation turnaround times while simultaneously increasing accuracy and comprehensiveness of the interpretation itself. Likewise, the interpreter component - providing the fault ‘labels’ in the fine-tuning step and ultimately controlling which sticks are grouped together to form the fault network - is an absolutely vital element of the workflow as well. Examples demonstrating the practical application of the workflow will be shown using datasets from the U.S. Gulf of Mexico as well as the North Slope of Alaska.