Automated Fault Detection from 3D Seismic Data Using Artificial Intelligence. Examples from the North Sea, West of Shetland and Australia

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An essential first step in understanding the structural history setting up the petroleum systems associated with oil and gas reservoirs is the accurate delineation and interpretation of the fault network. However, description of structural information and its subsequent impact on reservoir performance is one of the most generalised components within modern basin and reservoir modelling workflows, partly because of the complexity of the task and the time constraints forever present in the G&G workflows. As we move forward in a new era of understanding brought about by machine learning techniques, the speed and accuracy of fault delineation upon delivery of new seismic data enable regional and field assessment to benefit from the most up to date information and ensure significantly better-informed exploration and development decisions.

A semantic deep learning network transfers knowledge between an interpreted seismic dataset and an uninterpreted one. The insights of the geoscientists, e.g. their interpretations of faults provide the training for the network. This allows assimilation of recently acquired and alternative datasets, thus avoiding the issues associated with available data remaining 'on the shelf' and not being used to update the structural understanding and corresponding models. With this in mind, a Foundation Network was developed to identify faults in a seismic cube. In this network the Artificial Intelligence is closely aligned with the interpreters' way of working, allowing tightly coupled interaction as appropriate for the dataset and the individual interpreter's workflow. This enables the retention and transference of experience between geographical areas, basins or structural styles, or the transference of company knowledge between interpreters, assets and basins. The Foundation Network now has been tested and QC'ed on over 60 previously unseen 3D datasets.

A workflow is presented in which an AI fault attribute can be quickly derived using the Foundation Network on a 3D seismic dataset. The data is first analysed by the network to provide a first-pass fault attribute. The network is then fine-tuned using a small amount of interpretation to adjust and account for subtle geologic details specific to 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 analysed using other high-fidelity attributes and filtered based on criteria such as confidence or fault azimuth. As a final step, the fault cube can be co-rendered with a Frequency Decomposition RGB colour blend, providing QC of the AI fault attribute as well as greater geological understanding by combining structural and stratigraphic information. The final attribute and resultant fault interpretation are shown to be far superior to a traditional workflow.

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The automated components of the AI-assisted workflow have demonstrated tremendous value in capturing the intricate details of a realistic subsurface, 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 – 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 North Sea, West of Shetland and Australia.