Pilot Study - Resolving Low Energy Sands Through Deep Learning High Resolution Seismic Inversion

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Abstract

Deep learning applications in quantifying subsurface rock properties have lately shown great potential when compared with conventional seismic inversions. There are quite a few challenges in conventional seismic inversion techniques such as the assumption of constant phase, stationarity of wavelets, noise free data, etc which is inconsistent with non-stationary time series field seismic signals. The conventional inversion process also lacks the ability to add to geological information that can otherwise be obtained from legacy seismic datasets.

To overcome conventional inversion challenges, we demonstrate a workflow highlighting the power of deep learning to characterize unseen thin sands from legacy seismic data for both synthetic and field cases. The first step of our workflow involves random noise attenuation in the legacy seismic data. The target acoustic impedance logs are divided as “low” and “high information regimes” using Shannon’s entropy measurements. For training the network we employ an approach that separately models the low and high information target acoustic impedance logs. The acoustic impedance is predicted away from the wells using the trained model.

We demonstrate the performance of our deep learning- based inversion on synthetic data from the Marmousi model. Similar workflow was applied on a dataset from Arq field South of the Partitioned Zone (S-PZ) between Saudi Arabia and Kuwait as part of a pilot study with Chevron. The study area is characterized by compartmentalized anticlinal structure which is cut by near-vertical normal faults. Identification and assessment of low energy, thin reservoir beds on conventional seismic data with a bandwidth of 5-60 Hz was a significant challenge in this area.

Conventional seismic inversion yielded impedance models with poor resolution. Deep learning driven high-resolution processing was applied to the data leading to an enhanced bandwidth of 5-180 Hz. The high-resolution volumes attempted to resolve the reservoir distribution patterns of the thin low energy sands of the S-PZ field in the impedance domain. The learnings from the S-PZ data revealed opportunities for investigation between conventional and deep-learning workflows. This study showed promise for deep learning-based approaches to resolve low energy sands and provide more information than traditional workflows.