Unlocking Cambrian Amin Reservoir Using Machine Learning and Conventional Deterministic Seismic Inversions, Sultanate of Oman

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Abstract

Amin reservoir is considered one of the most prominent deep gas reservoirs in north Oman. It was deposited in the Middle Cambrian as a succession of mixed alluvial and aeolian sandstones with minor variously developed siltstones and conglomerates in the lower part. In north Oman, Amin is well developed, with a thickness of up to hundreds of meters.

The main objective of the study is to de-risk an Amin exploration prospect utilizing deterministic full stack constrained sparse spike seismic inversion (CSSI). In addition to conventional seismic inversion, Machine Learning (ML) seismic inversion was tested to evaluate its robustness and to benchmark with the theory-based seismic inversion (CSSI). Ultimately, the aim is reducing turnaround time to have a greater business impact.

The rock physics analysis indicates a good correlation between porosity and P-Impedance, making it feasible to invert for porosity using seismic data. The area is populated with a sparse sampling of wells penetrating Amin. There is only one well within the prospect area and due to hole conditions, which affect the quality of the wireline logs, it was not used. Generally, a good quality of well-to-seismic ties is observed, and the extracted average wavelet is stable and representative.

The CSSI inversion utilizes a single input wavelet to deconvolve the seismic. In contrast, the ML inversion does not require any wavelet as an input. In general, both techniques are yielding comparable results at well locations with some variations away from the wells. However, when comparing the inverted absolute P-impedance with the well's actual P-impedance in cross-plot, the results from CSSI show a better match compared to ML. The discrepancy might be attributed to the fact that the ML is using the seismic velocity model to compensate for the lack of low seismic frequencies, whereas the CSSI is using the well-base P-impedance model. The processing velocity does not show an optimal match with the well's P-velocity. In addition, it has a narrow frequency bandwidth (< 3 Hz). In the meantime, other approaches are explored to compensate for the lack of low seismic frequencies in the case of ML.

Considering the differences between the CSSI and ML in the low frequency end, the band-limited impedance was used for the purpose of de-risking the prospect. Areas where the band-limited impedances from CSSI and ML come into an agreement were considered the optimal locations for the upcoming wells. The results from the newly drilled wells shall be cross-checked with the inversion predictions from both CSSI and ML to build confidence in the techniques and their products and ultimately update the CSSI and ML results.