The Value of Re-Processing Legacy Onshore Seismic Data with Advanced Workflows

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Abstract

As an alternative to acquiring new data, the use of modern processing workflows and algorithms can be used to re-process legacy seismic data, leading to improved imaging for exploration or field development. In the following case study from the Sultanate of Oman, we will demonstrate the added value in re-processing a vintage seismic dataset. We will discuss the acquisition parameters, the challenges and the modern processing techniques used to mitigate them.

This 2017 seismic acquisition was located onshore Oman and covered an area of approximately 140 km2. Receiver stations were positioned every 60 m along lines with a 480 m separation, and shots every 30 m were acquired along shot lines with a 300 m spacing. The nominal fold was approximately 500 on a 30 m x 15 m grid. A low frequency sweep was used producing frequencies from 1.5 – 86 Hz. Well data were available in the area, including a recent vertical seismic profile (VSP). Compared to modern acquisitions in the region the dataset could be considered sparse and low fold. A pre-stack time image was generated at the time of the acquisition and was deemed as being of fair quality for horizon and fault interpretation.

The objectives of this re-processing were to maximize the resolution of the seismic image while maintaining amplitude fidelity and enhancing fault characterization. Well known challenges of onshore data in the Middle East included strong multiples and a high noise content due to the complex near surface. An added challenge for this dataset came from the presence of large sand dunes. After calculating and applying accurate dune static corrections, an advanced denoise flow was applied. Surface wave attenuation was achieved using low rank sparse inversion (Sternfels et al., 2015) to model the ground roll energy and a matching pursuit radon was applied to attenuate residual noise. Wave equation deconvolution (Poole et al., 2022) using least squares multiple imaging was utilized to model and attenuate surface multiples, alongside the more traditional convolution-based approach (SRME). Utilizing the provided VSP data, an initial velocity model was generated and cross-checked against the available sonic logs. The initial Vp model was combined with an anisotropy model coming from Backus averaging and regional knowledge. Two multi-layer, non-linear slope tomography updates were run to update the velocity model and enhance the image. Kirchhoff depth migration was performed, followed by a post migration flow targeting random and linear noise attenuation in addition to radon de- multiple, wide azimuth residual move out correction using common image gathers (CIG) and a comprehensive post stack sequence.

An advanced signal processing flow for denoise and de-multiple, combined with advanced velocity model building and depth imaging resulted in a high-resolution seismic image, meeting the objectives of the project, and bringing new life to the legacy seismic data.

References:

Poole, G., Farshad, M., Jin, Z. and Li, B. [2022] Wave-equation deconvolution: A short-period demultiple tool for streamer, OBN and land environments. First Break, 22, 59-64.

Sternfels, R. Viguier, G. Gondoin, R. and Le Meur, D. [2015] Joint Low-rank and sparse inversion for multidimensional simultaneous random/erratic noise attenuation and interpolation. IFEMA Madrid, Madrid, Spain.