A Comprehensive Pre-Migration Solution for Multiple Attenuation in South of Oman

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Abstract

Multiple contamination in seismic data from the south of the Sultanate of Oman is challenging due to the combined presence of short-period surface and internal multiples generated in the upper section. This multiple contamination is particularly dominant in the Haushi interval and prevents consistent geological interpretation of main geological targets. We present an innovative workflow to attenuate multiples in the pre-migration pre-stack domain based on a dataset from this region.

The workflow involved least-squares multiple imaging to obtain a reliable reflectivity of multiple generators in the near surface. Surface and internal multiples were modelled using a one-way wave-equation propagation method with the obtained near-surface reflectivity and the denoised pre-stack data. The detailed velocity model of the near surface obtained through Multi-Wave Inversion and Full-Waveform Inversion indicated the main velocity contrasts responsible for generating interbed multiples. Using corresponding intervals of the reflectivity, three internal multiple models were generated. An off-line flow including harsh surface and internal multiple subtraction, followed by depth migration and stack, was designed to obtain a multiple-free image over the whole section. This multiple-free image was de-migrated to produce a pre-stack, pre-migration primary model. The primary model was key to preserving primary energy without compromising multiple removal in the final simultaneous joint subtraction of all models.

The data-domain pre-stack demultiple workflow was applied to a blended node wide azimuth (WAZ) survey of about 1000 km2 with a fold of 2800. The predicted multiples showed a good match with the recorded data. The results after adaptive subtraction allowed the weak primaries hidden below the strong overburden-generated multiples to be revealed. The availability of an initial result was the key enabler of an iterative flow in which a pre-stack primary model obtained through a Kirchhoff demigration helped preserving the intricate target structure located at 1-1.5 km below the topography. All the results were validated in the migrated domain using a 50 Hz Reverse Time Migration over the whole area and assessed through cross-correlation between a well synthetic and the seismic at target interval. The demultiple flow revealed the geology of the Haushi interval, enabling a clear interpretation of the main events. High-definition imaging of reflectors like the Ghadir Manqil allowed better understanding of the deep basin architecture. In addition, tomographic velocity updates took advantage from data with reduced multiple content.

Effective pre-stack, pre-migration demultiple was made possible by generating accurate surface and internal multiple models using a near-surface reflectivity from least-squares multiple imaging. A primary model generated using demigration enabled the simultaneous adaptive subtraction of multiple models without compromising either multiple removal or geological event preservation, which was the trade-off faced in previous workflows applied in similar processing projects. The demultiple flow applied to this case study allowed the production of images that helped the exploration team to mature this underexplored area with more confidence.