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Abstract

The Exmouth Sub-basin represents part of the intracratonic rift system of the Northern Carnarvon Basin, Northwest Shelf, Australia. Hydrocarbon exploration has resulted in the discovery of a variety of oil and gas accumulations; however, the distribution and contribution of different petroleum systems elements is poorly understood, partly due to limited high-quality seismic data coverage, resulting in relatively low hydrocarbon success rates in a basin with proven potential. The new 12,000-km^2 Exmouth multimeasurement streamer 3D broadband survey covering variable water-bottom topography ranging from ~50 m to 1500 m, which extends to the edges of the basin and provides a more comprehensive picture.

To expedite the whole data processing and imaging process and deliver a superior depth imaging product sooner for seismic interpretation, full-waveform inversion (FWI) was introduced early in the project life cycle and run in parallel with acquisition and preprocessing for a more efficient depth imaging workflow. The survey acquisition was divided into five swaths, and the raw hydrophone data sets of the completed swaths were delivered onshore to start the near-surface FWI model building while the acquisition continued for the remaining swaths. Two frequency bands of FWI updates up to 15 Hz were performed concurrently with the demultiple process; hence, common image point (CIP) tomography could start with a reasonably good overburden velocity model upon completion of the demultiple process. The first frequency band update using adjustive FWI was aimed to correct the low-wavenumber, large-scale velocity errors in the model, and this enabled the second frequency band update of FWI to use least-square objective function at a higher frequency band to correct small-scale velocity errors to further improve the velocity model.

FWI successfully corrected the background velocity trend and captured the shallow velocity variations in the complex overburden, providing a more accurate velocity model for subsequent CIP tomography, which usually suffers from a lack of offset/angle information in shallow-water environments. This whole workflow, combining advanced FWI algorithm and CIP tomography, resulted in a more accurate velocity model from the near surface through to the reservoir level, ultimately enabling the timely delivery of a high-quality depth image for enhanced geological interpretation. Due to the image uplift, we are now able to investigate in detail the complex tectonic evolution within the basin and link this to the deposition of source, reservoir, and seal rocks through time as well as its impact on the petroleum systems.

In this case study, we demonstrate the advantage of FWI to delineate the velocity contrast in the overburden with having early model building in the preprocessing stage, and the benefit of this tailored workflow to meet the objectives of the multimeasurement streamer 3D broadband processing in the Exmouth Sub-basin.