A new strategy for higher resolution time – lapse velocity inversion

MARIA KOTSI[1,2], JONATHAN EDGAR[1], ALISON MALCOLM[2], AND SJOERD DE RIDDER[1]

1. Total E&P UK, Geoscience Research Centre, Westhill, United Kingdom
2. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada

Time lapse seismic methods have been extensively used over the past two decades to monitor oil reservoirs under production. Time-lapse changes can result from amplitude changes and/or time shifts. Amplitude changes can be caused by new structures in the target area or reflectivity differences at interfaces. Time shifts are usually the result of physically shifted geological boundaries or velocity perturbations along the wave path. Understanding which of these two mechanisms control the observed time shifts is important to better estimate and interpret the time-lapse changes. Full Waveform Inversion (FWI) is a promising tool for time-lapse seismic imaging and shows promise for this type of imaging. However, for a successful application of FWI, low frequency data and large offsets are required; these prerequisites are difficult to meet when we are interested in a small region. FWI is robust in recovering amplitude changes but is often not able to resolve the kinematics. Image Domain Wavefield Tomography (IDWT) is a method that uses migrated images along with a warping function to deliver a velocity model of the subsurface. This method is better at recovering time-shifts and can be applied without long offset data. In real case scenarios, the 4D signal is a complicated combination of time shifts and amplitude changes. This can result in a decrease in performance in both methods, depending on the nature of the complication. In this study, we present a form of time-lapse waveform inversion that we call Dual Domain time-lapse Waveform Inversion (DDWI), in which we combine FWI and IDWT in a single inverse problem. We test DDWI on several synthetic examples, and we observe that the method delivers more accurate results when compared to each of the methods used separately.

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