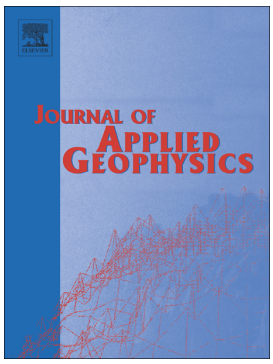

Improvement of pressure-saturation changes estimations from time-lapse PP-AVO data by using non-linear optimization method

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Improvement of pressure-saturation changes estimations from time-lapse PP-AVO data by using non-linear optimization method

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Abstract

First-order approximations of seismic parameters in AVO intercept and gradient changes are not sufficient to estimate changes in saturation and effective stress accurately. Analysis from an unconsolidated reservoir and a compacting reservoir show that we need to consider higher order terms in seismic parameters to reduce the inaccuracy of the estimates. Furthermore, improper approximation of rock physics parameters increase the error in the estimates. Here, we implement a non-linear optimization method to estimate changes in saturation and pressure using reflectivity equation directly. We test the applicability of this non-linear optimization method on synthetic data for both the above mentioned reservoir scenarios over an wide range of realistic saturation and pressure changes. We observe that the inversion results using the new method are reasonably good for both reservoir scenarios.

Keywords: AVO/AVA, Time-lapse, Nonlinear, inversion, Pressure, Saturation

1 Introduction

Hydrocarbon production induced reservoir property changes, such as saturation-pressure changes, could have significant effects on seismic parameters (Domenico, 1974; Nur, 1989). Many researchers investigated either the pressure change effect (e.g. Watts et al., 1996) or the fluid change effect (e.g. Landrø et al., 1999; Gabriels et al., 1999) of reservoirs. However, we need to investigate both the effects if the reservoir is affected by the both. Time-lapse amplitude variation with offset (AVO) could be used for this purpose (e.g. Tura and Lumley, 1999; Landrø, 1999; Landrø, 2001).

The conventional AVO inversion method proposed by Landrø (2001) requires partial stacked data (i.e. near and far offsets) of base and monitor surveys as inputs, where the near and far-offset stacked data should be treated as independent observations or seismic attributes. The method was then slightly modified by Meadows et al. (2001). While Landrø considered quadratic approximations of P-wave velocity in the case of pressure change only, Meadows et al. (2001) used quadratic approximations of P-wave velocity changes as a function of both saturation and pressure changes. He also considered differences in P- and S-wave impedances as input, instead of differences in PP-AVO attributes. Landrø et al. (2003) and Stovas et al. (2003) further investigated and extended Landrø's conventional method by incorporating changes in PS-reflectivity as an additional information. Their investigation showed that the combination of PP and PS stacked data improves the estimates of pressure-saturation changes compared to the conventional one (which is based on PP-AVO data only). Trani et al. (2011) showed that the PP and PS-travel