The effects of seismic data conditioning on density estimates from PP-PS joint pre-stack inversion: An example from the Athabasca oil sands

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Density is a key attribute for differentiating lithologies and fluid compositions in Athabasca oil sands reservoirs, and estimates of density from PP-PS joint pre-stack inversion (Russell et al, 2005) in recent years have demonstrated the benefit of adding multi-component data to the inversion work flow (Zhang, and McMillan, 2018).

The degree of uncertainty in a density estimate is determined by several parameters, including seismic data quality, an existing geologically-representative low frequency model and petrophysical information. The objective of data conditioning is to enhance signal-to-noise ratio, to preserve AVO amplitude-variation and to expand useful angle range, all of which serve to improve matching seismic data with well-synthetic, to improve prediction accuracy and to reduce the uncertainty of inversion. This talk will demonstrate the effects of data conditioning on density estimates using a case study from the Athabasca oil sands.

In the Jackfish project expansion area, which is located approximately 200 km south of Fort McMurray, Alberta, two sets of PP-PS joint pre-stack inversions were performed on the same input data (seismic, both PP and PS; wells and geologic data) by two different companies (Company A and Company B). No conditioning work was done by Company A, though Company B performed customized seismic data conditioning prior to inversion. The comparison between input and conditioned gathers are shown in Figure 1.

Two density volumes (from Companies A and B, respectively) were compared at 45 well locations. Approximately two-thirds of leads in the study area have been improved and cross-correlation with measured density well logs \( n = 45 \) have been improved from 65\% (in the case of Company A) to 86\% (Company B). Figure 2 shows an example of estimated density from the two inversion workflows.

Since the inversion work was done by two different companies, the data conditioning workflow may not be the only cause of differences in the density estimates between these two versions, however data conditioning is certainly the most important step in the inversion processing, and the primary reason for differences observed between the two datasets.
Figure 1. Input and conditioned PP & PS angle gathers for two sets of joint PP-PS inversion (Company A and Company B). In each case, PP angle gathers are shown above (a) and PS angle gathers are shown below (b). Input angle gathers from Company A are shown in the left two frames, Company B’s conditioned gathers are shown in the middle two frames, and the difference between the two are shown to the right. Data conditioning was found to enhance signal-to-noise ratio, preserve AVO amplitude variation and expand the useful angle range.
Figure 2. Two density estimates from joint PP-PS inversion (Company A (left), and Company B (right)). Density volumes are superposed with density log curve, the results were compared at 45 well locations. Approximately two-thirds of leads in the study area have been improved and cross-correlation with measured density well logs (n = 45) have been improved from 65% (in the case of Company A) to 86% (Company B).

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References