CHAPTER 5

Discussion and Conclusion

5.1 Discussion

Pre-stack inversion study for lithology delineation had been started with rock physics study of compressional velocity and density relationship (Gardner's relation or V_P-Rho crossplot). The crossplot of each well can be clearly discriminated lithology trends to sandstone and shale (Figures 3-8 to 3-12). Another rock physics study that is compressional velocity and shear velocity relationship (Greenberg-Castagna relation or V_P-V_S crossplot) can also distinguish lithology, even if it was less clearly than V_P-Rho crossplot. The V_P-V_S crossplots were shown in each study interval (or formation/unit) to identify sandstone and shale trends (Figures 3-13 to 3-15). Results of the rock physics study indicated to feasibility of lithology delineation using deterministic inversion.

The AVO models had been studied using well log data (V_P, V_S and density) of each well and deterministic wavelet, and then the results of AVO classes were represented. For all example of sandstone in the study area, the AVO plots were shown reflection coefficient of top and bottom sandstones change with increasing incidence angle. They can be classified to AVO class IV for water sandstones and AVO class II and IIp for gas sandstones (Figures 3-16 to 3-18). The sandstones of each well were summarized into AVO crossplots between gradient and intercept of Aki and Richards' 2 terms equation (Figure 3-19). The AVO study implied that AVO response can be classified in reservoirs of each well, so it was possible to do pre-stack seismic inversion.

The time-depth correlation is important to do seismic-well tie not only using in seismic inversion but also in other geophysical works such as seismic interpretation. The checkshot data is necessary data for time-depth calibration with sonic log before synthetic traces were generated using sonic and density log, and then well to seismic correlation was done.

Therefore time-depth correlation was separated to 2 phases. The first phase was performed before starting seismic inversion for correcting seismic time and well depth to same position. This phase was used deterministic wavelet (Ricker wavelet) to generate synthetic traces and to do correlation. The zero phase wavelet of this step was not used in seismic inversion because it is theoretical wavelet, and real seismic data is not zero phases. Another phase of time-depth correlation is a step in seismic inversion processes. Wavelets of this phase can be extracted from angle gathers seismic using well after the first phase was done only. The wavelets were extracted to a few numbers based on total degree of angle gathers and were rotated the phase to match with seismic data and symmetric shape of cross-correlation between synthetic and seismic traces.

The initial strata model that is low frequency model was created from picking horizons and well logs (V_P, V_S and density) combining with seismic stacking velocity to cover low frequency content of 0 to 12 Hz. The frequency content of stacking velocity is 0 – 2 Hz, and frequency model using well logs cover 2 to 12 Hz. The initial models consist of P-wave velocity (V_P), S-wave velocity (V_S), acoustic impedance (Z_P), shear impedance (Z_S), density, V_P/V_S and Poisson's ratio (Figures 4-5 to 4-8).

The pre-stack seismic inversion generated the inverted models of Z_P, Z_S, density and V_P/V_S using seismic angle gathers, initial strata models and extracted wavelets. The angle gathers was converted from super gathers which was considered incident angle at the shallowest reservoir to 45 degree (Figure 3-23). To consider results of the pre-stack inversion at section along wells, the values of Z_P and Z_S at D-36 well matched more than Z_P and Z_S at R-2 and S-2 well (Figures 4-13 to 4-15). The lower section below horizon U (pink horizon) of Z_P in S-2 well and the upper section above horizon U of Z_S in R-2 well were shown poor quality match. Also in the inverted density models of 3 wells, the results were not good match. However, they were final results with optimized inversion parameters.

To evaluate the pre-stack inversion with a well that had not used in the study was represented in section along B-35 well (Figure 5-1). The inverted Z_P section above horizon U (pink horizon) was good match with well data, but the section below the horizon U was poorly match. The inverted density section was also represented quite poor match as other wells. This can be referred that the inversion data below the horizon

U or formation 1 was low reliable. However, the Z_P section below horizon O (brown horizon) in red box matched with well data again.

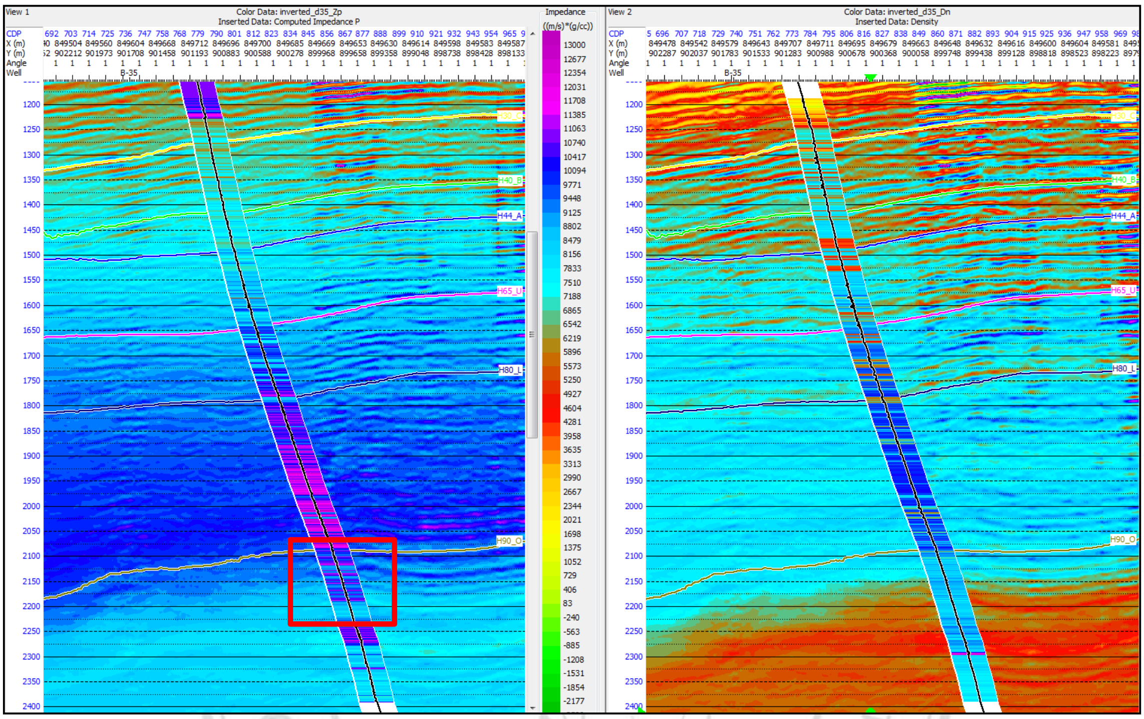

Figure 5-1. Sections along B-35 well of inverted Z_P (left) and inverted density (right) overlying their well log

The vertical resolution of seismic which is referred to the ability to distinguish two seismic events corresponding to top and bottom of layer is usually taken to be $\lambda/4$, and λ is predominant wavelength in data (Chopra et al, 2006). Moreover, Widess (1973) proposed $\lambda/8$ to the resolution limitation. The vertical resolution may be a problem for this study area because average thickness of sandstone in the area is less than 10 meters, but the vertical resolution at section below horizon O is 30 meters ($\lambda = 120$ so $\lambda/4 = 30$) and the resolution limitation is 15 meters ($\lambda = 120$ so $\lambda/8 = 15$).

The lithology delineation was considered lateral distribution using horizon slices along pre-stack seismic inversion volumes of Z_P, Z_S, density and V_P/V_S. By the way, the volume results were not covered S-2 well due to problem of computer error during running the inversion volumes. Delineation of sandstone trends using seismic inversion was analysed from low values representing in Z_P, Z_S, and density slices. However, in the study area, sandstone trends can be hardly predicted in each formations and units. As each horizon slices in Figures 4-19 to 4-23 were tried to estimate low value trends of inversion to sand channels, but they had few evidences to assure the interpreted channels even considering with final well reports. For inverted V_P/V_S slices, they should be used to estimate hydrocarbon with relative low values, but they cannot be defined any patterns inside the interpreted channels (Figures 4-17 to 4-21).

The related problem of poor matching in pre-stack seismic inversion may be cause of seismic acquisition parameters. Seismic data of this study was acquired in 1997 with streamer length of 2.4 km for this survey. The short length of streamers affected to low incidence angle at deeper part of seismic data (Figure 5-2). This affected to generation of angle gathers for pre-stack seismic inversion.

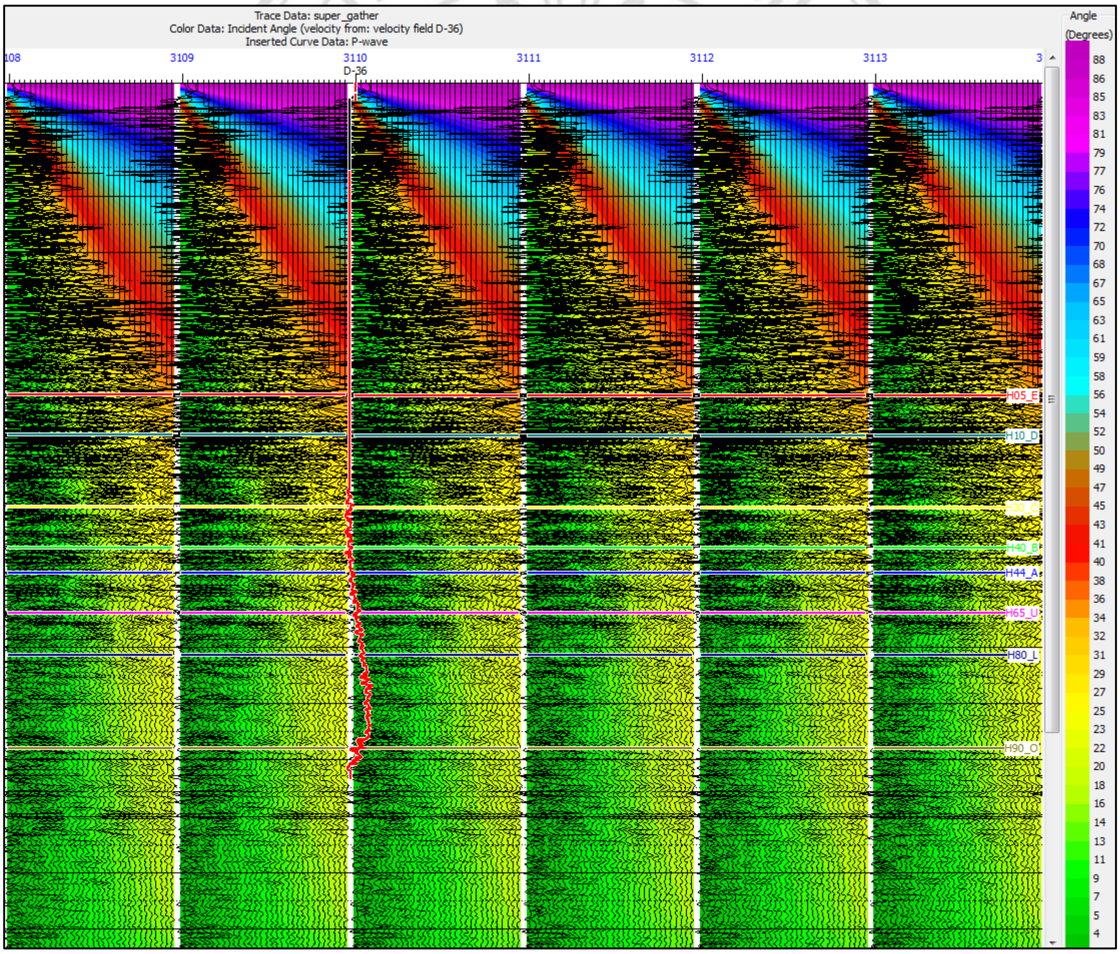

Figure 5-2. Super gathers overlying with incidence angle and picking horizon show low angle of 21 degree at horizon O (the deepest horizon).

5.2 Conclusion

In Oligocene (Formation 0), the pre-stack deterministic inversion can delineate lithology to sand channel trends, but too few evidences of well data proved and confirmed low values of inverted P-impedance, inverted S-impedance and inverted density to be sand channels. Although the comparison between P-impedance log and P-impedance volume presented quite poor correlation at all well.

In lower Miocene (Formation 1, Unit 2A and Unit 2B), both P-impedance and S-impedance logs displayed better correlation than inverted impedance in Oligocene. However, the horizon slices which are extracted from these inverted volumes are hardly to use for delineating the lithology.

In middle Miocene (Unit 2C, Unit 2D and 2E), some well data is not covered for some units such as D-36 well is not covered Unit 2D to Unit 2E, and R-2 well is not covered Unit 2E. The zones of inverted volumes without well data were extrapolated the inverted values, so these zones were less reliable than the zones of available data. The lithology can be delineated clearer than lower Miocene, but it also had few evidences to confirm the sand channel trends. Upper Miocene (Formation 3) had not been considered in this study.

5.3 Recommendation

This pre-stack inversion operates within wide area approximately 670 km^2, so the inversion parameters are optimized for whole area with different structures and variant depth. It is better to study seismic inversion in the interesting area such as western part and eastern part which are proved the hydrocarbon by development wells. The inversion parameters will be proper with depth, structure and stratigraphy of study area.