CHAPTER 7

DISCUSSIONS AND CONCLUSIONS

7. 1 Discussions

This study covers some qualitative and quantitative of seismic interpretation in Tui field, Taranaki Basin, New Zealand. The area has been investigated through using well log analysis, 3D seismic interpretation, seismic inversion both deterministic and stochastic, and porosity modeling.

Log prediction was done in the initial stage of this research recovering the log in some wells. Pateke-2, Kiwi-1, Tieke-1, Pateke-3HST1, and a part of Amokura-1 were known to not have sonic log. Also, there is a need to estimate the density log that affected by bad borehole situation in well Tui-1 that occurred in Kapuni D sand formation. All predictions were done based on the crossplot between sonic (slowness) and density in the wells that have good borehole condition. Most of the formations were predicted based on Kahu-1 while a few formations were based on Amokura-1. The regression trends were made based on the zonation created guided by Wyllie line. It is intentional to make a prediction based on each formation hoping reasonable log estimations. However, it is inevitable that the prediction made in some formations will neglect some factors such as the thickness of the formation used for estimating an equation and the heterogeneity of the lithology.

In term of thickness, Kapuni E Shale has thickness only 27m resulting a low accuracy of prediction (Figure 4.14 and 4.15 in chapter 4). Lack of data points made it hard to define the trend of lithology. Consequently some intervals in this particular formation do not fit nicely.

Though the result of estimation shows a quite good match between the original and the estimated one generally, Moki B Sandstone is considered a good example to demonstrate the heterogeneity issue (Figure 4.3 and Figure 4.4 in chapter 4).

As seen from the crossplot, a considerably big amount of data was not included in the zonation. This shows the variability of the lithology which is not simply sand and shale but also perhaps shaly sand and sandy shale as far as gamma ray distribution is concerned.

Turning to well seismic tie, most of the wells were successfully tied to the seismic with relatively good correlation (referring to Table 6.1 in chapter 6). However, two wells (Pateke-3HST1 and Kiwi-1) have been left at the beginning due to well seismic tie problem. Pateke-3HST1 is a horizontal well which is not easy to tie. Moreover, Pateke-2 which is situated just 500 m away from Pateke-3HST1 is considered to be able to represent the Pateke-3HST1. Kiwi-1, on the other hand, has a strong reflection from coal layer from North Cape Formation located just above the basement (Figure 7.1). This strong reflection technically correlates somehow to the basement. This is definitely incorrect causing miss tie along the well. So the decision was to leave the well.

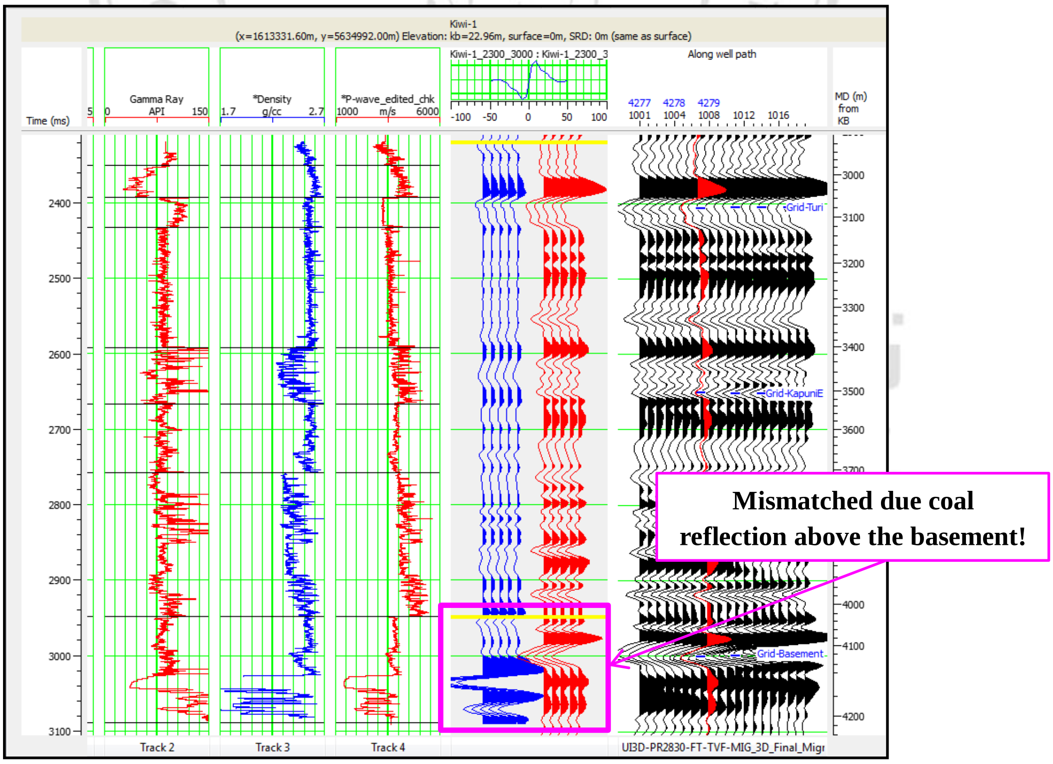

Figure 7.1. Well seismic tie overview of Kiwi-1 showing mismatched caused by the strong reflection from coal just above the basement.

Qualitative interpretation began by picking 5 fault sets over the area. One relatively big fault has been picked just in the north east part of Tieke anticline (Figure 7.2). One fault is in the north-east edge of the survey area. Two faults are in the north-west part of the study area. One relatively small fault is just a bit north west from the center of the survey area. Some might not affect inversion result but probably contribute to petroleum system (migration pathway). The faults are mainly the extension of the fault from the basement continuing up to the Kapuni D Sand. Overall, the Tui area is tectonically calm region in comparison to other region in Taranaki Basin.

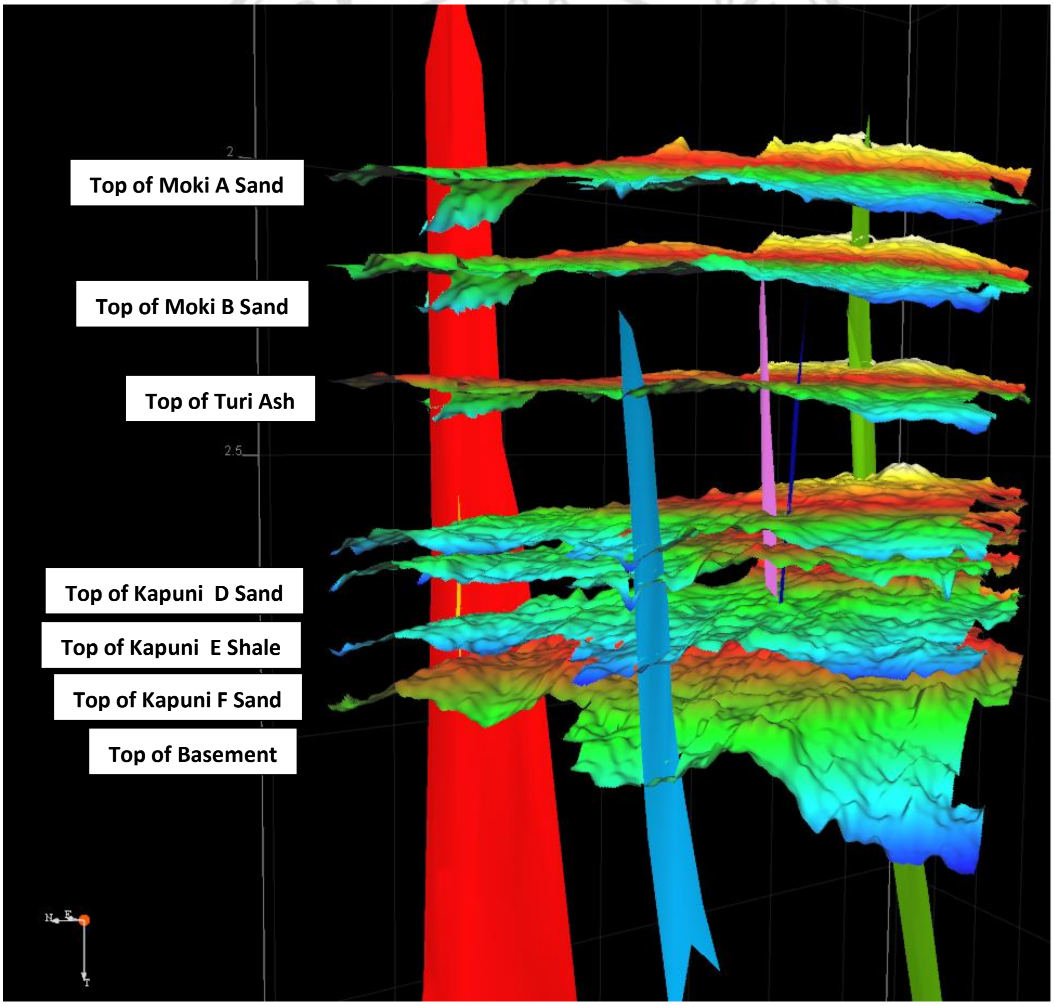

Figure 7.2. A 3D perspective view of 5 fault sets and 7 interpreted horizons in Tui-area.

Along with faults, seven horizons were picked marking the top of some formations in the area under review (Figure 7.2). In general, the beddings are gently dipping toward north-west. All the time structure maps are actually more or less sub-parallel one another. Some structural features are identified on the time structure map. As per the time structural map of Kapuni F Sand (the main reservoir), the most noticeable feature is the relatively big structural high in the southern part where Tieke-1 well was drilled on the crest of the structure (Figure 7.3). Another smaller anticline was observed further north-east of the survey area where Taranui-1 is located. Other smaller anticlines which are located in the north east part have the drilled wells already (Amokura and Pateke). However, there is a relatively big closure formed located approximately 6.5 km south-west part of the Taranui anticline. In structural point of view, this is obviously a good trap style. Four way dip closure is believed the best hydrocarbon trapping system as low risk of leakage.

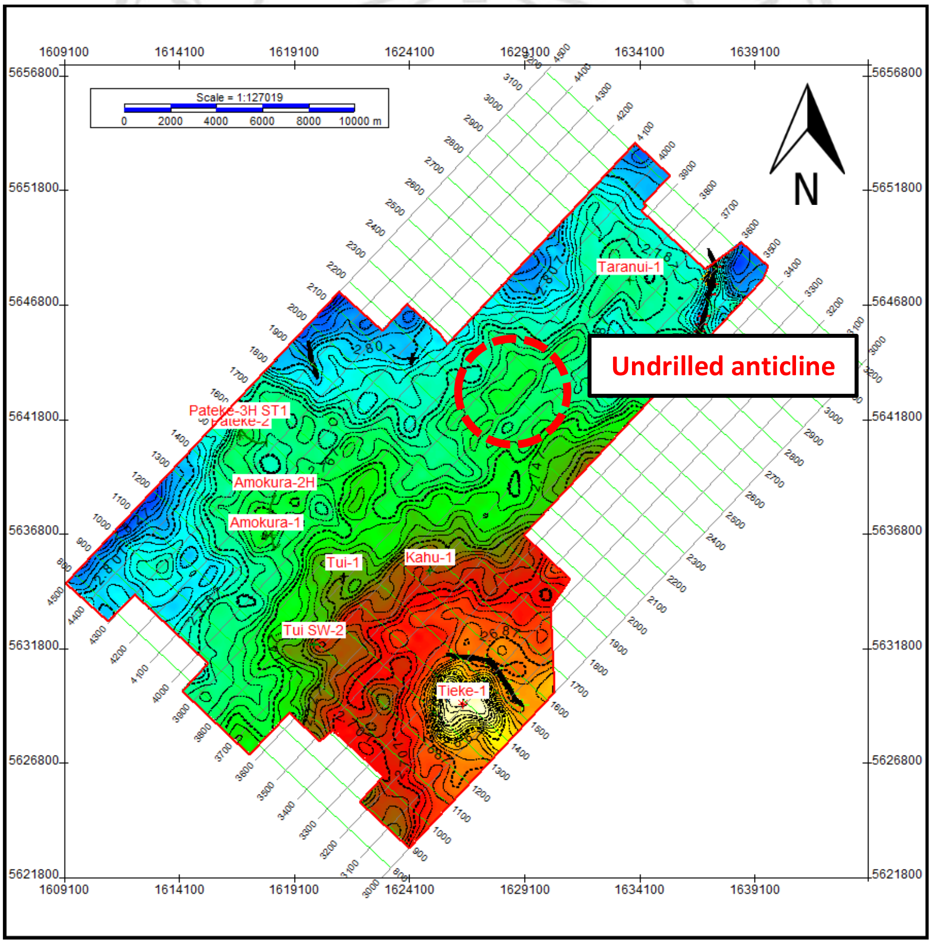

Figure 7.3. The time structure map of Kapuni F Sand showing a potential trap related to structural closure in red circle

Moving to the quantitative interpretation, building an initial model is crucial in performing inversion work. As previously mentioned, two wells were left due to well seismic tie issue. The rest of the wells were tried to be included in initial model. However, some of the wells including Amokura-1, Pateke-2 and Tieke-1 do not seem giving a realistic result for initial model. Thus those wells were not included in the model.

Investigating through the result of inversion, it is clear that the result from stochastic is far higher frequency than the deterministic one as much more layers are visible now in stochastic result (Figure 7.4). The algorithm used for stochastic was Stochastic Gabor Inversion. This algorithm principally aims to get high resolution RC and AI cubes by eliminating the time variant source wavelet from seismic signal. Also, it gets the bias from well logs to estimate reliable absolute AI. As a result, a high frequency AI model was obtained.

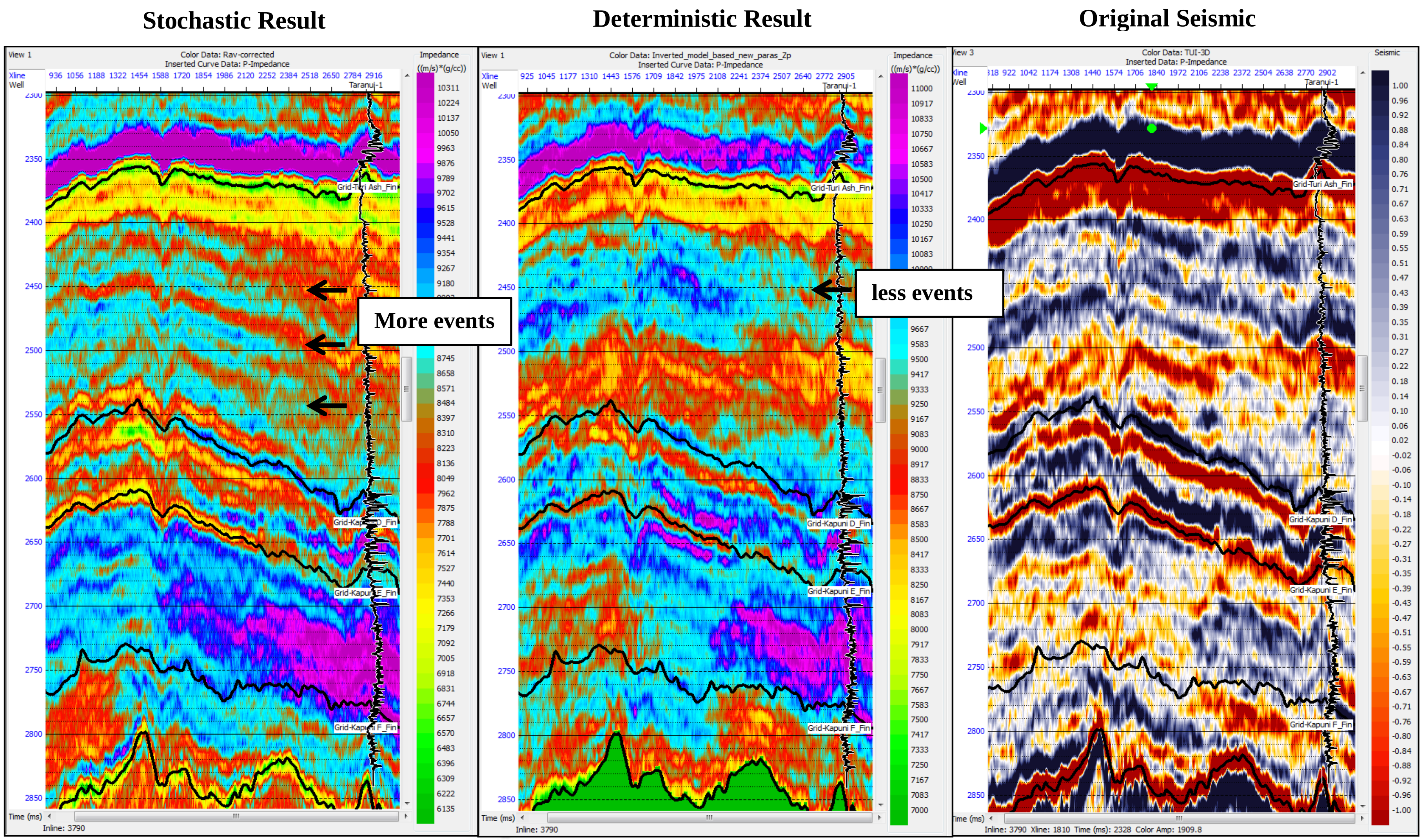

Figure 7.4. A cross section crossing Tui-1 well comparing the frequency of deterministic, stochastic and real seismic data. More events are observable in stochastic result compared to the deterministic one.

Figure 7.5a emphasizes the presence of structural closure in the proven reservoir, Kapuni F Sand. The porosity distribution slice shows a relatively high porosity area concentrated on the western side of the survey area surrounding structural closure. Figure 7.5b shows the impedance from both stochastic and deterministic agree with the area of low impedance in the structural closure (though both show low impedance area differently). Figure 7.5c shows the high probability of sand distribution at the top of Kapuni F Sand which is distributed well in almost entire survey area except the in the structural high of Tieke. As per the well reports, all the wells penetrated Kapuni F Sand except Kahu-1 reported to have up to 12 m of oil column. Knowing the fact that the sand covers the area where the low impedance pattern in the western side is still visible, it is likely that the low impedance pattern is associated with oil-bearing sand. Therefore, this potential trap can possibly contain oil as situated in the zone of low impedance area. Based on this consideration, the top of this anticline could be the best point to drill for the next plan.

Turning to the upper reservoir formation – Kapuni D Sand, Figure 7.6 shows the distribution of the sand in low impedance. As observed, the low impedance layering was concentrated in the middle of the survey area elongated from south-west edge of the survey to north-east edge of the area. However, lack of structural high in the top of this formation could be one of the reasons why most of the well did not find anything in this particular formation. Another possible reason is lack of charge.

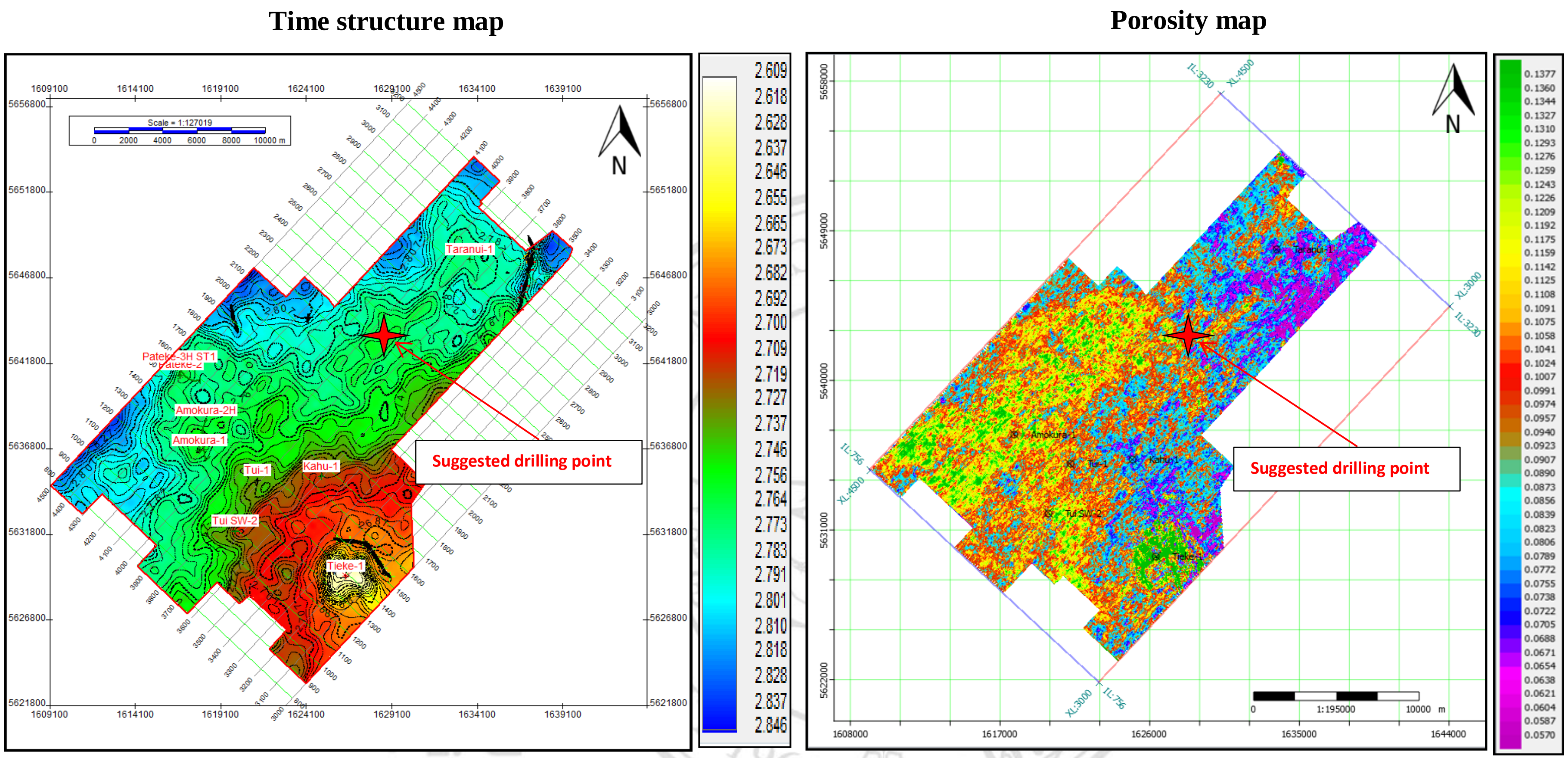

Figure 7.5a. The horizon slice of the time structure map, and porosity-derived-impedance from stochastic of the Kapuni F Sand. As per the two maps, the red diamond shows the best location for drilling as showing the structural closure associated with high porosity area which may associate with oil-bearing sand.

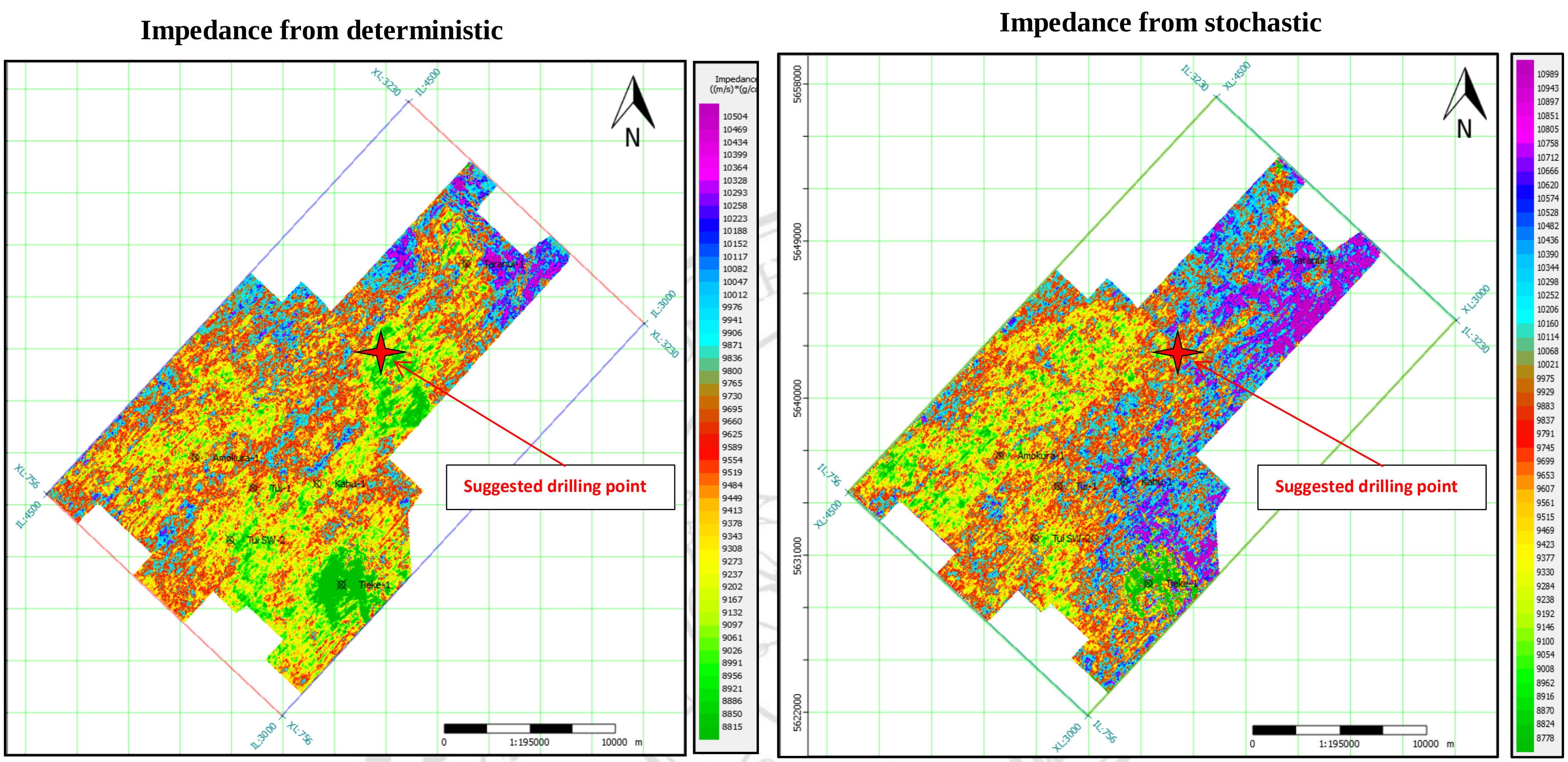

Figure 7.5b. The horizon slice of the stochastic and deterministic impedance map at the top of Kapuni F Sand. As per the two maps, the red diamond shows the best location for drilling as showing low impedance area.

Sand probability **Seismic slice**

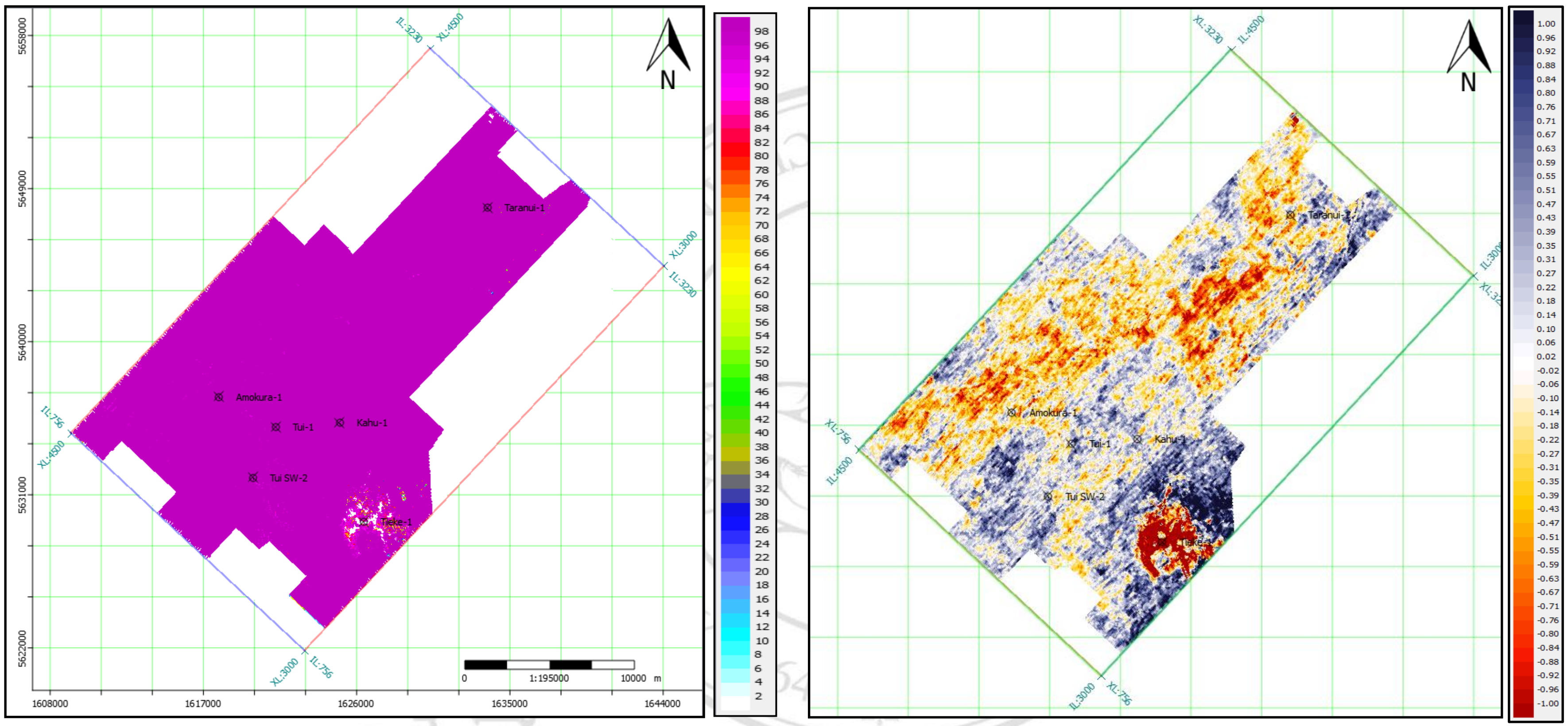

Figure 7.5c. The horizon slice of sand distribution and seismic slice at the Kapuni F Sand.

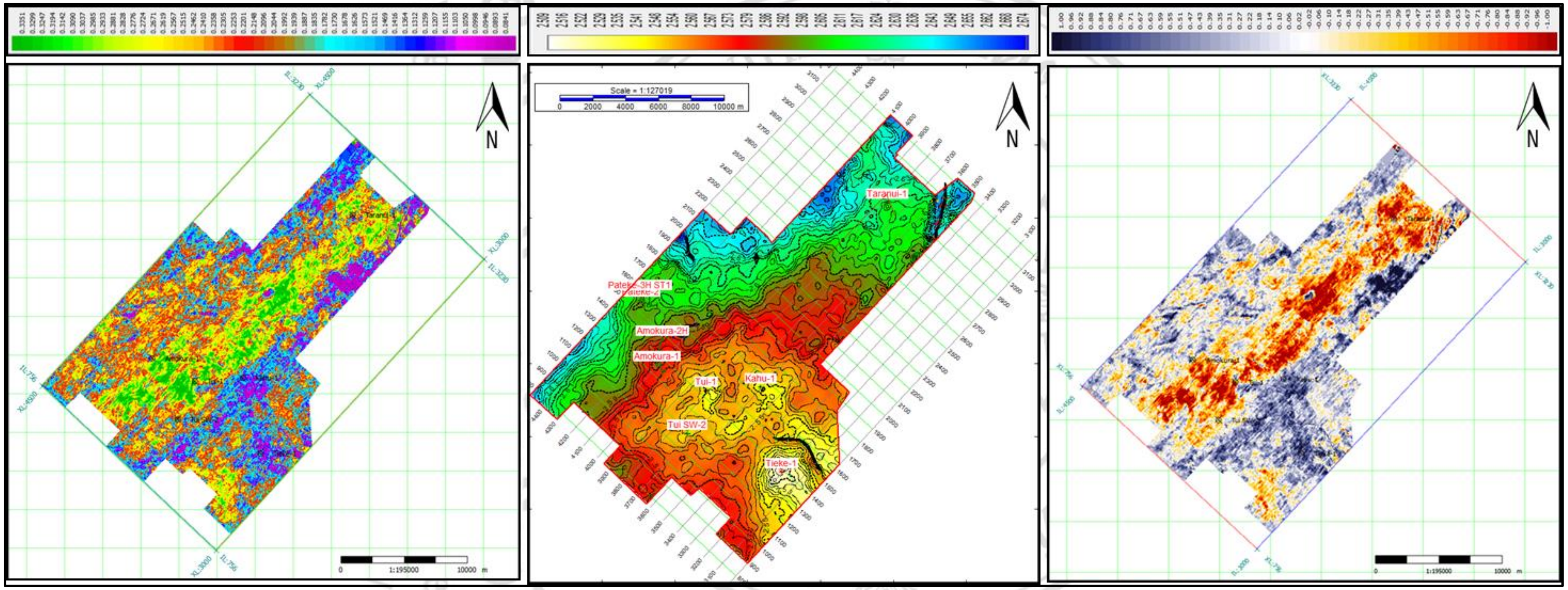

Figure 7.6. The horizon slice of stochastic inversion result, time structure map, and seismic slice at the top of Kapuni D Sand. The low impedance area are elongated NE-SW in the middle of the survey.

7. 2 Conclusions

The main goal of this study was to do reservoir characterizations in reservoir formations in Tui area, New Zealand. In addition to that, some basic structural interpretation was done in the area under review. The following conclusions have arisen based on the result of this research study:

- Seven time structure maps indicating some of the important reflections have been generated. Those horizons are actually the top of formations including Basement, Kapuni F Sand, Kapuni E Shale, Kapuni D Sand, Turi Ash Formation, Moki B Sand, and Moki A Sand. Some of the anticlinal features are identified in top of Basement, top of Kapuni F Sand, Kapuni E Shale, and Kapuni D Sand. The most remarkable anticline is located in surrounding Tieke-1 which is visible in those 4 horizons. The other noticeable anticlines are the one surrounding Taranui-1 and the undrilled one located approximately 6.5 km southwest of the Taranui-1 anticline which are both visible in Basement and top of Kapuni F Sand.

- Low-frequency component plays a pivotal role in seismic inversion work as will add valuable information to inversion result. This is because the seismic data actually lost its low and high frequency (bandlimited). The low frequency model was taken from the log information.

- It is inevitable that the stochastic inversion provides a more accurate prediction of reservoir distribution than the deterministic one. The deterministic one has a tendency to overestimate the reservoir distribution which may end up with overestimate the reserve and resource as well as incorrect position of drilling point.

- Probability distribution volume helps to semi-quantitatively show the chance of success in finding the target lithology. In Kapuni D Sand, the high probability of penetrating sandstone is not located at the top of formation but in the middle of the formation instead.

- The sand probability map shows a well distribution of sand in the top of Kapuni F Sand while the impedance map from stochastic shows a low impedance pattern in the western side of the survey. This likely indicates the low impedance pattern associated with the oil bearing sand. Looking at the structural map of Kapuni F Sand, an undrilled structural closure is identified in the area where low impedance distribution located. Therefore, a crest of the closure will be the best point to drill for future plan.

7. 3 Recommendations

The following recommendations are proposed to further study.

- In order to perform a full quantitative interpretation for reservoir characterization, it is crucial to have pre-stack data. Since stacking the data set especially full offset stacking will not preserve amplitudes perfectly so it is impossible most of the time to make a decision about fluid content also estimation the physical properties accompany high uncertainty.

- In case the pre-stack data are available, it is possible to extend the analysis to further lithology and fluid separation techniques. Elastic Impedance or extended elastic impedance can be a powerful technique for accomplishing such purposes. Additionally, Lambda-Rho and Mu-Rho attribute are believe to be more sensitive to fluid changes than acoustic impedance.