CHAPTER 5

DISCUSSION AND CONCLUSION

According to Chapter 1, Chapter 3 and Chapter 4 present the applying of the conventional processing, the linear *tau-p* processing and the parabolic *tau-p* processing with synthetic and real seismic data. The result of each processing is discussed and concludes in this chapter.

5.1 Discussion

The purposes of this study are enhancing deep seismic signal by using *tau-p* processing and compare the efficiency with conventional processing. The steps processes of each method are applied to test with synthetic seismic data for investigation and then applied to real seismic data.

5.1.1 Synthetic seismic data

The geological model used in this study (Figure 1.1 (a)) consists of low penetration of the seismic energy in deeper part. After applying Finite-Difference Modeling (2nd order) for acoustic wave equation from Seismic Unix® software to the model, synthetic seismic shot records will be obtained. They present the primary reflectors at a zero time offset at about 430, 700, 1165, 1820, 2115, 2857 and 3306 ms, respectively (Figure 1.1 (b)) and the multiples at about 1000 and 1500 ms. A gain recovery is applied to correct amplitude attenuation resulting in amplitude increasing at the deeper signal..

Conventional processing is applying predictive deconvolution in *t-x* domain (Figure 1.7 (b)) to attenuate multiples and improve signals. This method is not adequate to multiples attenuation and improves signals although their algorithms have a good conceptual basis. The performance of predictive deconvolution is not constantly effective since the interval times of multiples arrival are only periodic for the near zero offset while multiples are not periodic at nonzero offset (Yilmaz, 2001). Thus, it could be inferred that the non periodic of multiple with offset would comparatively reduce an ability of predictive deconvolution in removing multiples (Poomvises, 1998). The multiples remained after conventional processing at about 1000, 1500 and 2450 ms in shot record (Figure 3.13 (b)), velocity energy spectrum (Figure 3.14 (b)) and brute stack section (Figure 3.15 (a)).

Linear *tau-p* processing is designed to process in CMP domain because it helps to maintain purity in the plane-wave decomposition (Diebold and Stoffa, 1981). Then compute supergather, summing nearby CMP over offset, to improve quality at the expense of possibly smearing geology. After applying supergather, the seismic traces are increased, 30 to 90 traces, but the characteristic (intercept time, moveout and velocity) of signals and multiples have not change, that are shown in CMP before supergather (Figure 1.2) and CMP after supergather (Figure 3.2). The plane-wave decomposition of the supergather can be obtained using linear *tau-p* transformation (Figure 3.3 (a)). In applying this transformation, data aliasing will be found so HVF is applied to correct this problem (Figure 3.3 (b)). Predictive deconvolution is applied in the linear *tau-p* domain because multiples have a constant period and uniform amplitude decay along each p trace (Figure 3.4 (a)). The results of linear *tau-p* processing showed that the signal is uniform along offset, correct the far offset problem in conventional processing, but it is not adequate for non periodic multiples that is shown in shot record (Figure 3.13 (c)), velocity energy spectrum (Figure 3.14 (c)) and brute stack section (Figure 3.15 (b)). As the supergather increased the number of seismic traces, the time cost of processing also increased.

Parabolic *tau-p* processing is designed to process in CMP domain. Because in CMP domain, primary reflectors will be flatten events and multiples are approximately parabola events after NMO corrected (Figure 3.7 (a)). Each event is separated by applying parabolic *tau-p* transform, the flat and parabolic events in *t-x* domain are transformed to $q = 0$ and $q > 0$ in parabolic *tau-p* domain, respectively

(Figure 3.7 (b)). Then the frequency filtering is computed from equation (2.39) to reduce aliasing problem during parabolic *tau-p* transform. The scaling (sign square) is applied to increase the relative of signal to random noise ratio and followed design multiples muting in the parabolic *tau-p* domain (Figure 3.8). The re-scaling (sign square root) is applied to preserve the relative amplitude variations after inverse parabolic *tau-p* transform back to *t-x* domin (Figure 3.10 (b)) (Spitzer *et al.*, 2003). Spiking deconvolution is applied to restrict the amplitude for sharper signal then follow by inverse NMO correction and picking the new velocity function (Figure 3.11). The results of parabolic *tau-p* processing showed that the signal is uniform along offset and multiples are the highest attenuation that is shown in shot record (Figure 3.13 (d)), velocity energy spectrum (Figure 3.14 (d)) and stack section (Figure 3.15 (c)).

5.1.2 Real seismic data

The full step of each processing method referred in Figure 3.1 is tested with real seismic data with 14-kilometers-long profile in the Sukhothai Province. The common steps for each processing are elimination ground roll by using frequency-wave number (*f-k*) filter, enhancing signal to noise ratio, residual static, stacking and migration. The difference technique of each process is how to enhance signal to noise ratio of seismic data. For the conventional processing, predictive deconvolution will be applied in time-offset (*t-x)* domain to eliminate multiples. For the *tau-p* processing, HVF and predictive deconvolution will be applied in linear *tau-p* domain. For the parabolic *tau-p* processing, scaling and muting multiples will be applied parabolic *tau-p* domain. Each processing has two velocities picking, after the enhancing S/N step and after residual static correction because the signal is improved and the static is moved, respectively.

The raw data showed a strong refracted wave and ground roll energy (Figure 1.4). It causes of reflected wave energy are weakness when consisted in the velocity energy spectrum (Figure 1.5). The muting zone is designed in *f-k* domain, Figure 1.10, to attenuate ground roll energy.

The result of conventional processing, the reflectors are improved after applying predictive in *t-x* domain deconvolution shown at about 1600 ms in shot record in Figure 4.16 (b). The stack section (Figure 1.13) showed a strong energy at the shallow part (0-500 ms) and a weakly energy at the deeper part because low penetration of seismic energy.

In linear *tau-p* processing, the reflector signal are improved after applying HVF and predictive deconvolution, shown in supergather (Figure 4.4 (b)) and velocity energy spectrum (Figure 4.5). The brute stack section (Figure 4.6) showed the result is not different with the conventional processing because the predictive deconvolution in linear *tau-p* domain is useful in marine data for reverberation and non-surface related multiple attenuation for a long period time but for land data it has not been used so much. Comparing with marine data, land data contains strong linear noise, has static problems, are generally nosier and does not have water bottom multiples. The multiples in land data usually are weaker in amplitude and not continue across section (Li and Hubbell, 2006).

In parabolic *tau-p* processing, the reflectors energy are improved after applying sign squaring (Figure 4.9 (a)) and muting multiples (Figure 4.9 (b)). The sign squaring is used to attenuate random noise and muting multiples is used to attenuate coherent noise (multiples) in parabolic *tau-p* domain. The brute stack section (Figure 4.12) showed the processing has the potential to improve significantly the signal to noise in the deep part (compare with other processing). To compare deep seismic energy in each processing, it will be shown in common shot record (Figure 4.14), velocity energy spectrum (Figure 4.15) and brute stack section (Figure 4.16).

5.2 Conclusion

1. The application of *tau-p* processing in synthetic seismic data made more understanding in characteristic of seismic signal and noise in each step of processing.

2. Conventional processing is useful to attenuate multiples at near zero-offset, presented in synthetic model processing but they remained at the far-offset. The processing in real data showed deep seismic energy is weaker because of high absorption energy in the shallow part.

3. Linear *tau-p* processing shown that predictive deconvolution in linear *tau-p* domain correct the far offset problem in conventional processing. It is useful to enhance S/N and improve deep seismic signal in the synthetic data processing but is not effective in land seismic data.

4. Parabolic *tau-p* processing is useful to enhance S/N and improve deep seismic signal that are shown in synthetic and real data processing.

5 The S/N are increased by scaling and muting in the parabolic *tau-p* domain which the scaling and muting is used to attenuate the random and coherent (multiples) noise respectively.

5.3 Recommendation

1. The parabolic *tau-p* processing is suitable for structural interpretation but is not suitable for amplitude analysis e.g. amplitude versus offset (AVO) because of true amplitude energy is loss.

2. For more effective, the parabolic *tau-p* transformation should be use as high resolution transformation to minimize smearing problems (Sacchi and Ulrych, 1995).

3. For preserve the true amplitude energy and more effective to attenuate multiples, should be create the multiples model by designing from muted zone (Figure 3.8) in parabolic *tau-p* domain and then subtract with the real data.