CHAPTER 4

Discussion and Conclusion

4.1 Discussion

The results discussed in Chapter 3 show the differences between Cartesian and log-polar coordinate systems mostly clearly in Gazdag migration method while 15-degree Finite-difference migration method gives us similar results for both systems. Gazdag migration in Cartesian coordinate system can collapse diffraction and image thin layers, steeply dipping, faults and high continuous reflectors better than 15-degree Finite-difference. The migration impulse response shows the priority of migration in log-polar of Gazdag and 15-degree Finite-difference methods. Those can handle high angle energy and the synthetic syncline data set was migrated in both coordinate systems by using Gazdag and 15-degree Finite-difference migration show that the images in log-polar coordinate give better results than Cartesian coordinate system. Migration within Marmousi synthetic dataset shows the priority of log-polar coordinates (Figure 4.1). Although the correct velocity model and a long seismic profile is necessary to view the complex geology structures in both coordinates systems.

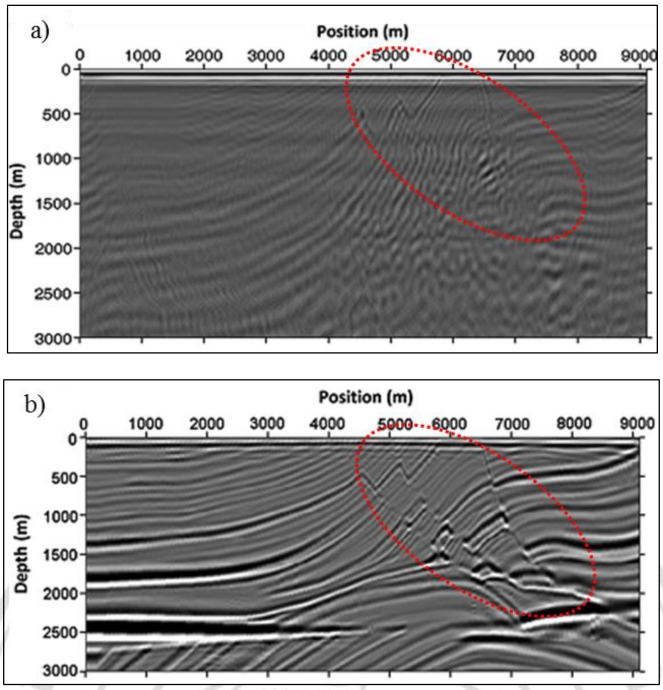

Figure 4.1 Migration section of Marmousi data set in log-polar coordinate system: a) migration in Cartesian coordinate and b) migration in log-polar coordinate (Naghadeh and Riahi, 2013a).

Gazdag migration in Cartesian coordinate system shows ability to image thin layer high continuity of channel but fault was image similarly with 15-degree Finite difference in both coordinate. While the results of 15-degree Finite-difference migration method show that there is little difference between imaging in Cartesian and log-polar coordinate systems. Instantaneous frequency sections show that the frequency of migration in Cartesian is overall slightly higher than log-polar coordinates. However for both coordinate systems, migration cannot completely collapse diffraction. It is suggested that the 15-degree Finite-difference migration method cannot deal with the diffraction parameter effectively within the function (Figure 4.3). In 1987, Yilmaz completed the migration base on 15-degree Finite-difference but this migration method cannot successfully focus the energy at the apex. In Figure 4.4 the Finite-difference migration for each degree approximation show that high angle-dipping reflector was imaged better in 65-degree approximation however 15-degree approximation still shows the diffraction.

In Figure 4.2 which is the diffraction, it was migrated with 15-degree Finite difference migration method using velocity 2500m/s include velocity 5, 10 percent lower and 5, 10 percent higher. The results show that 15-degree Finite-difference migration method cannot completely collapse diffraction hyperbola even using velocity 5 and 10 percent lower show more undermigration and velocity 5 and 10 percent higher not only show undermigration but also show overmigration.

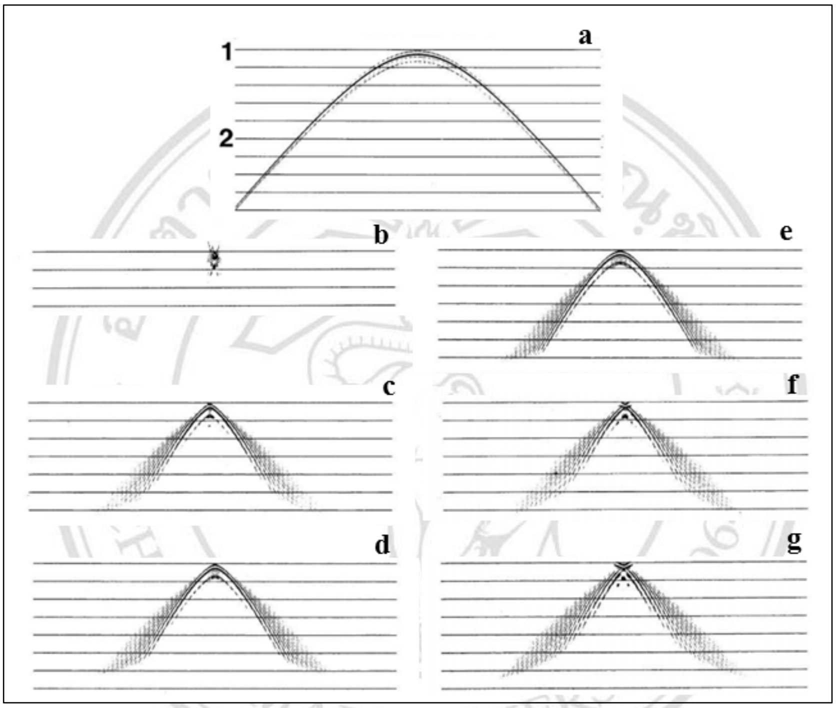

Figure 4.2 15-degree Finite-difference migration testing velocity error a) a zero-offset section that contains a diffraction hyperbola with 2500m/s velocity b) desired migration c) the medium velocity of 2500m/s d) velocity 5 percent lower e) velocity 10 percent lower f) velocity 5 percent higher g) velocity 10 percent higher (After Yilmaz, 1987).

Now, we are looking to improve in frequency content. Figure 4.5a and Figure 4.5b was shown the 15-degree Finite-difference migrated section of WNS324 in Cartesian coordinate compare with log-polar coordinate system after doubling the number of step size during interpolation. Figure 4.6 shows the Amplitude Spectrum after doubling the number of step size during interpolation, the frequency content of Cartesian and log-polar coordinate are similarly together. The comparison amplitude spectrum between the result after doubling the number of step size during interpolation of data set from cartesian to log-polar and the result without doubling the number of step size was shown in Figure 4.7, represented that after doubling the number of step size during interpolation obtain higher frequency.

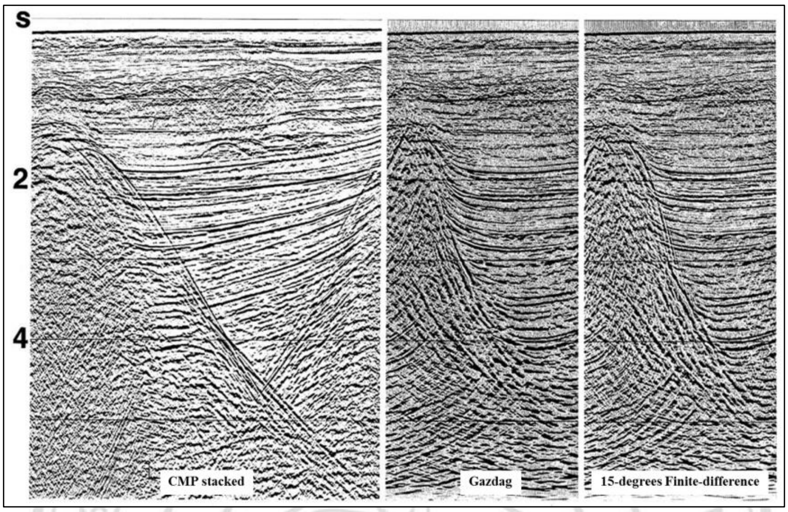

Figure 4.3 The stacked section and migration results including Gazdag and 15-degree Finite-difference migration methods (Yilmaz, 1987).

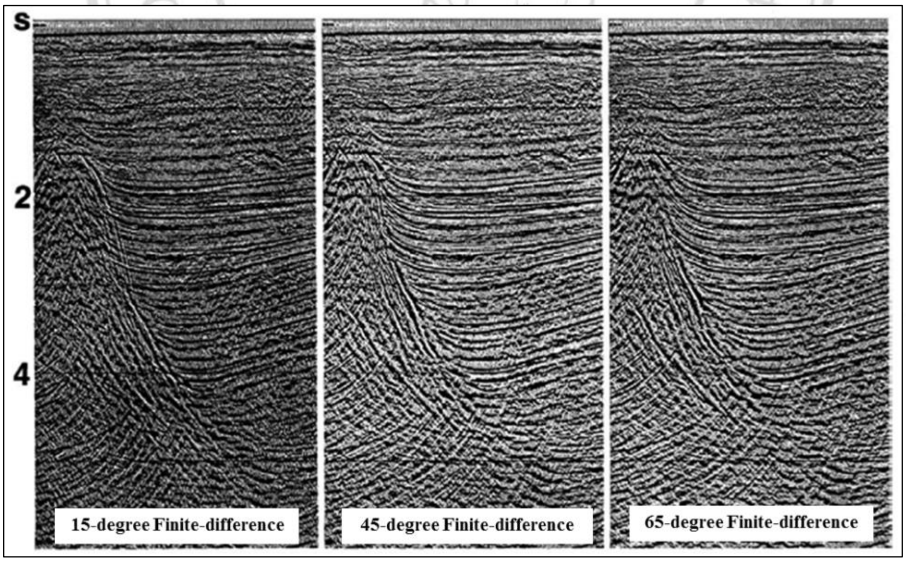

Figure 4.4 Finite-difference migration method for 15, 45 and 65 degree approximation (After Yilmaz, 1987)

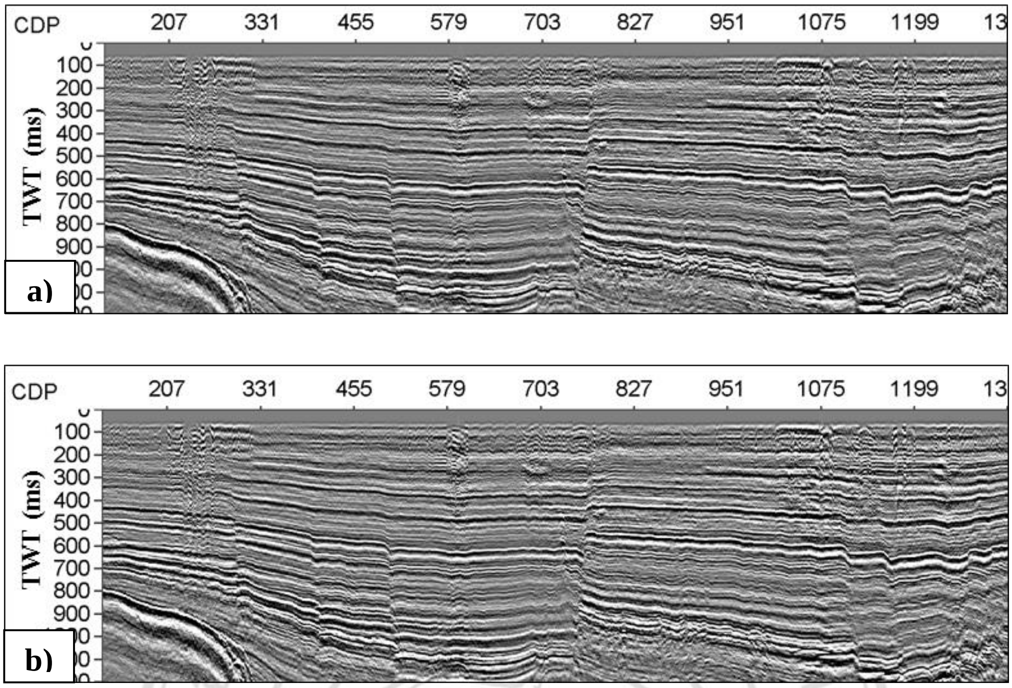

Figure 4.5 Migrated section of WNS324, 15-degree Finite-difference migrated section a) in Cartesian coordinate system b) in log-polar coordinate system after doubling the number of step size during interpolation.

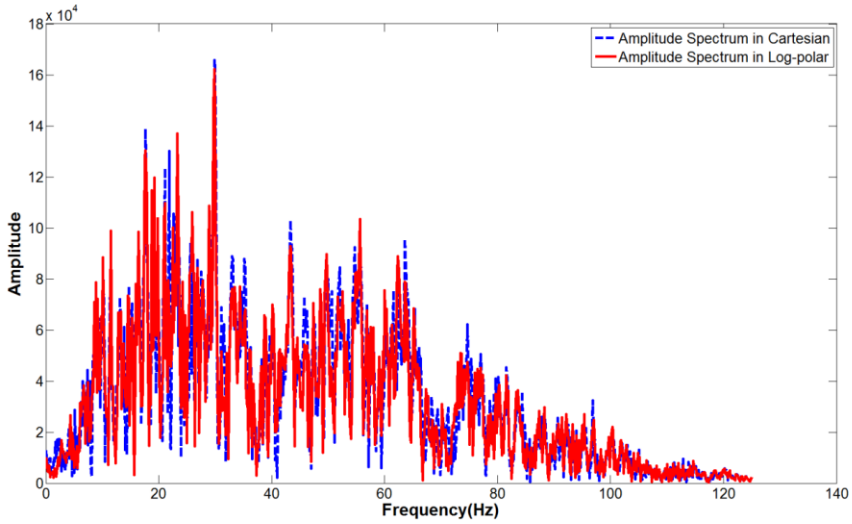

Figure 4.6 Amplitude Spectrum after doubling the number of step size during interpolation.

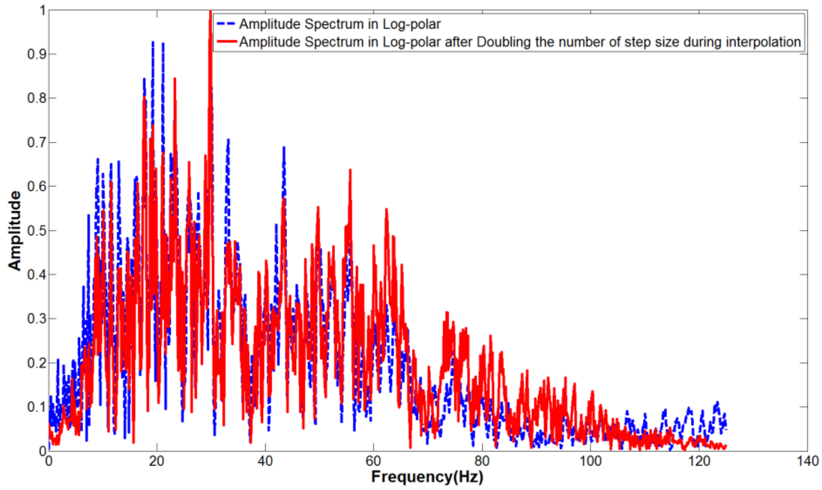

Figure 4.7 Comparison of amplitude spectrum in log-polar after doubling the number of step size during interpolation of data set from Cartesian to log-polar.

4.1.1 The additional area from coastal of California

In this study, we have the additional area from coastal of California includes five 2D post-stack seismic section that shows in Table 4.1 and Figure 4.8

Table 4.1 The addition area from coastal of California

Area	**Survey**	**Line**
Coastal of California	W-35-82-NC	WNC82025
		WNC82014
		WNC82012
	W-6-75-NC	W75520
	W-9-78-NC	W532A

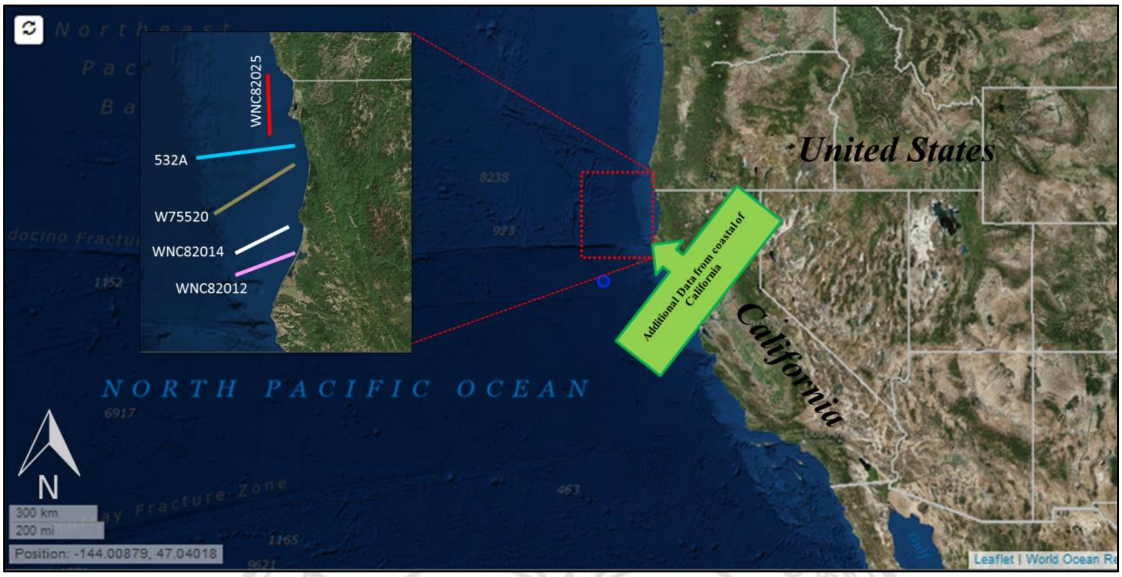

Figure 4.8 The additional area from coastal of California (USGS, 2015).

Unmigrated sections of the additional areas show in Figure 4.8 to Figure 4.12 include unmigrated section of WNC82025, WNC82014, WNC82012, W75520 and W532A.

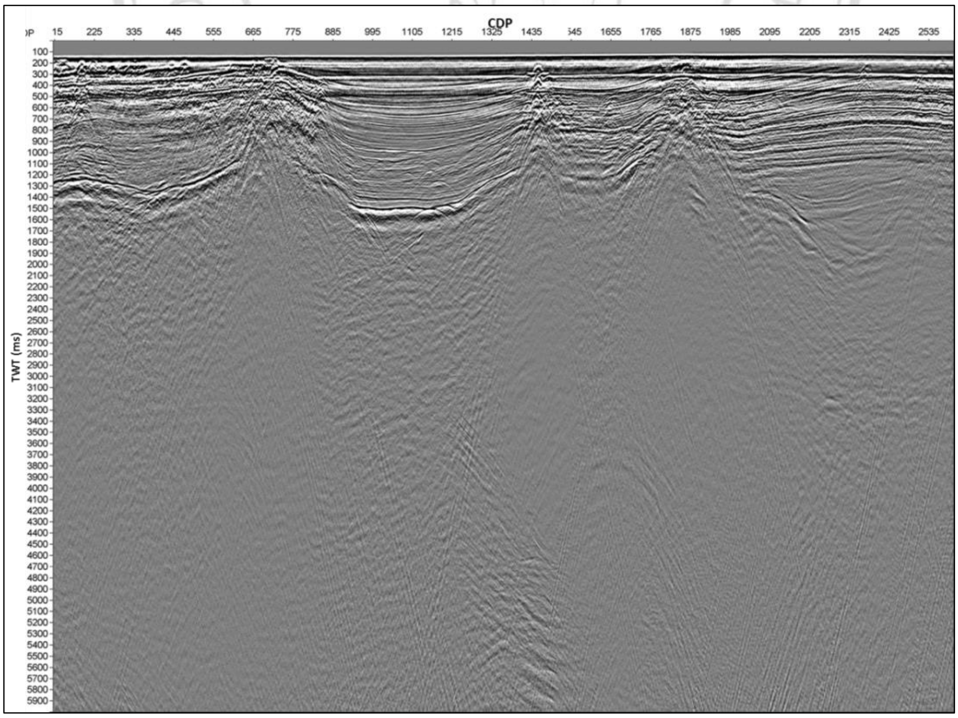

Figure 4.9 Post-stack unmigrated section of WNC82025, coastal of California.

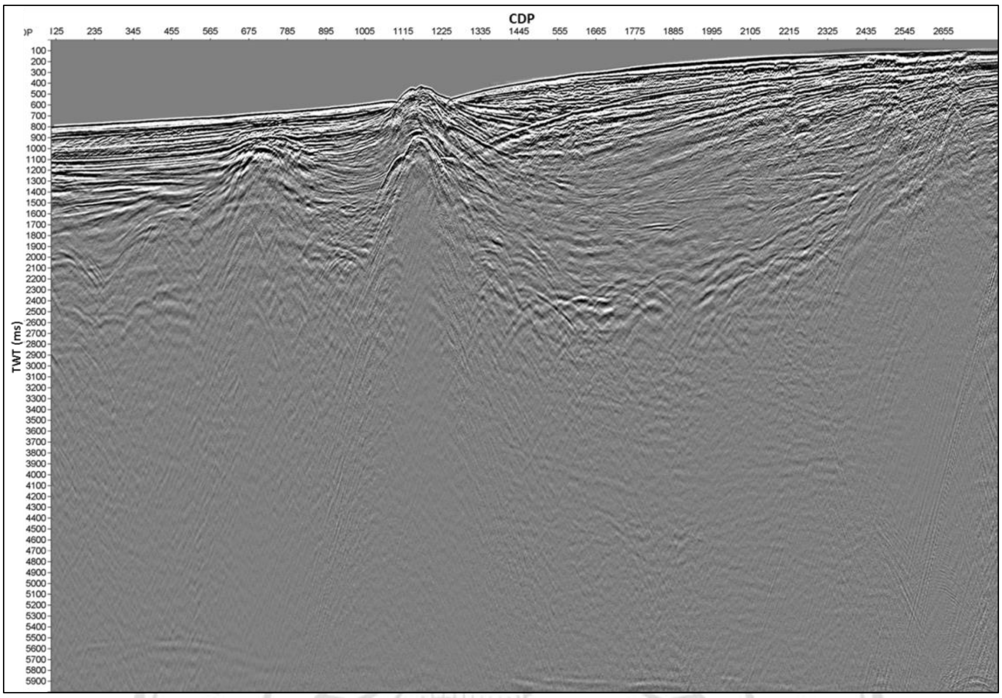

Figure 4.10 Post-stack unmigrated section of WNC82014, coastal of California.

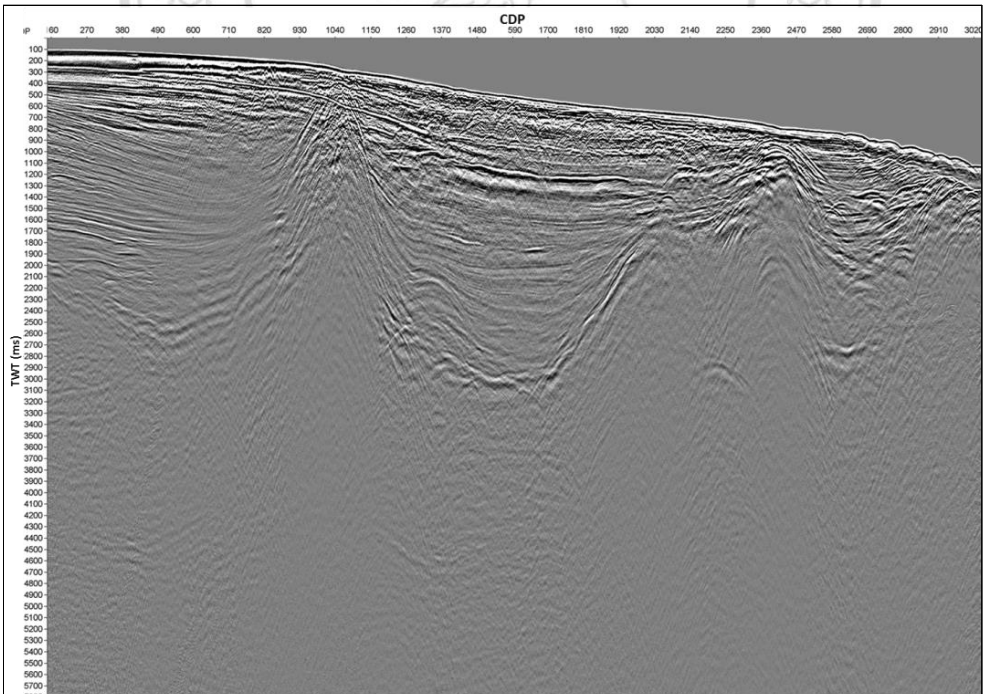

Figure 4.11 Post-stack unmigrated section of WNC82012, coastal of california

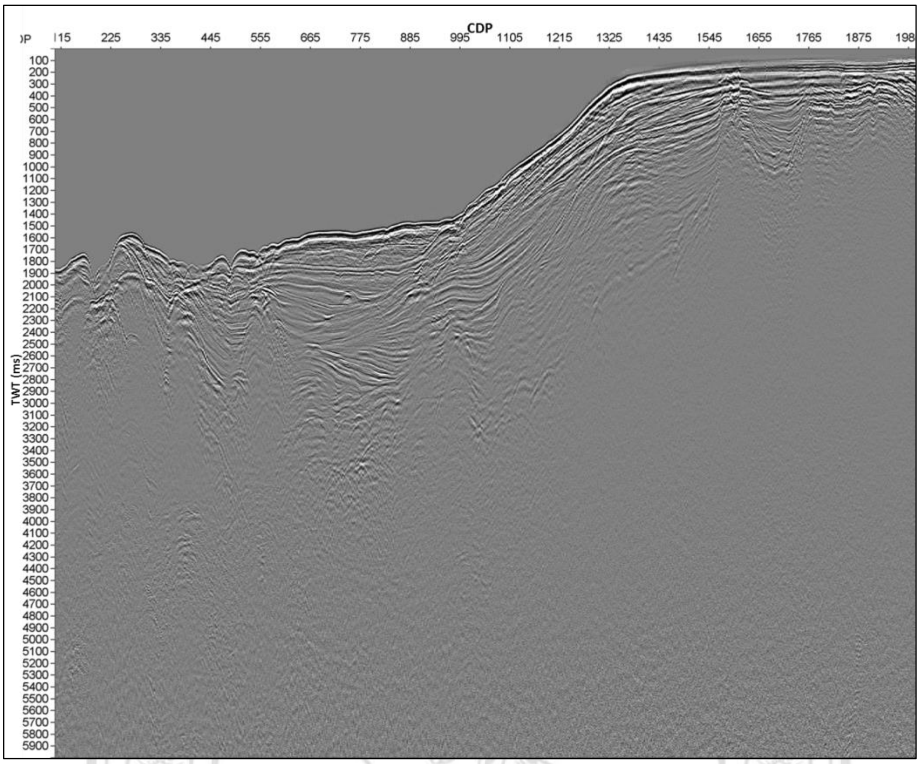

Figure 4.12 Post-stack unmigrated section of W75520, coastal of California.

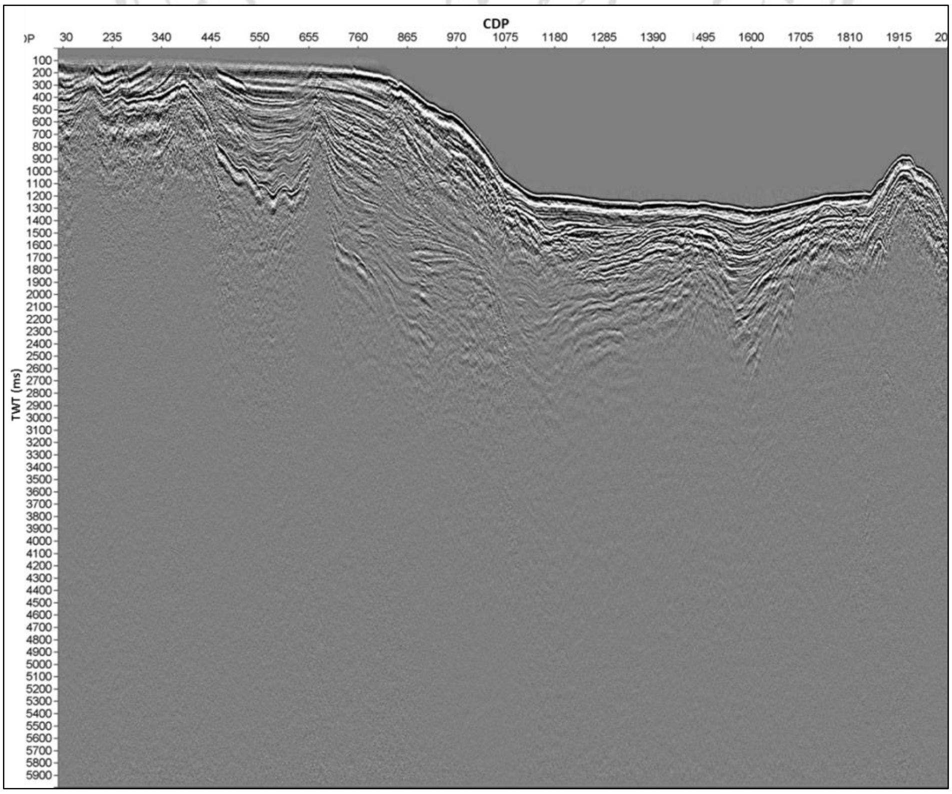

Figure 4.13 Post-stack unmigrated section of W532A, coastal of California.

4.1.2 The migration results of the additional area from coastal of California

1) Post-stack migration result of WNC82025, coastal of California: The Gazdag in Cartesian and 15-degree Finite-difference migrated sections of WNC82025 in Cartesian and log-polar coordinate systems are shown in Figure 4.14, Figure 4.15 and Figure 4.16. In this section, there is no obvious difference between two coordinate systems. The section in Figure 4.17a, Figure 4.17b and Figure 4.17c which are zoomed into the shallow part show the structure was imaged similarly in 15-degree Finite-difference in both coordinates, including the imaging of thin layers, channels and steep dip reflectors but Gazdag in Cartesian give higher resolution than 15-degree Finite-difference results. The estimated instantaneous frequency of those sections 15-degree Finite-difference in log-polar coordinate is a bit lower than Cartesian coordinate systems as shown in Figure 4.18b and Figure 4.18c.

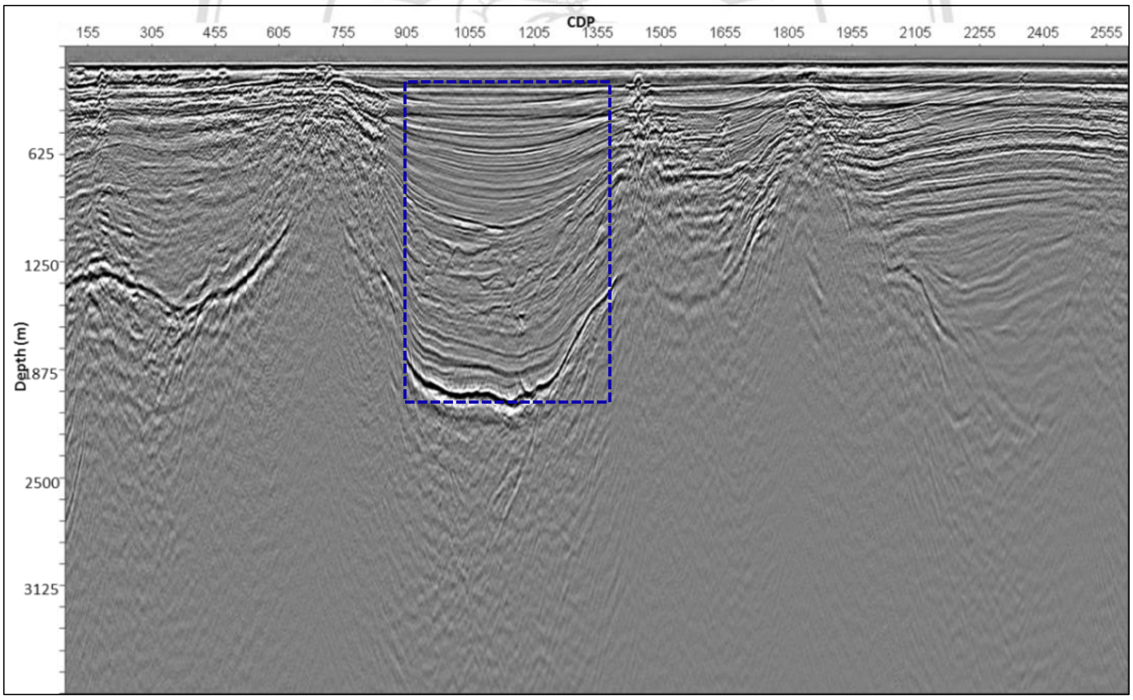

Figure 4.14 WNC82025-coastal of California, Gazdag migrated section in Cartesian coordinate system.

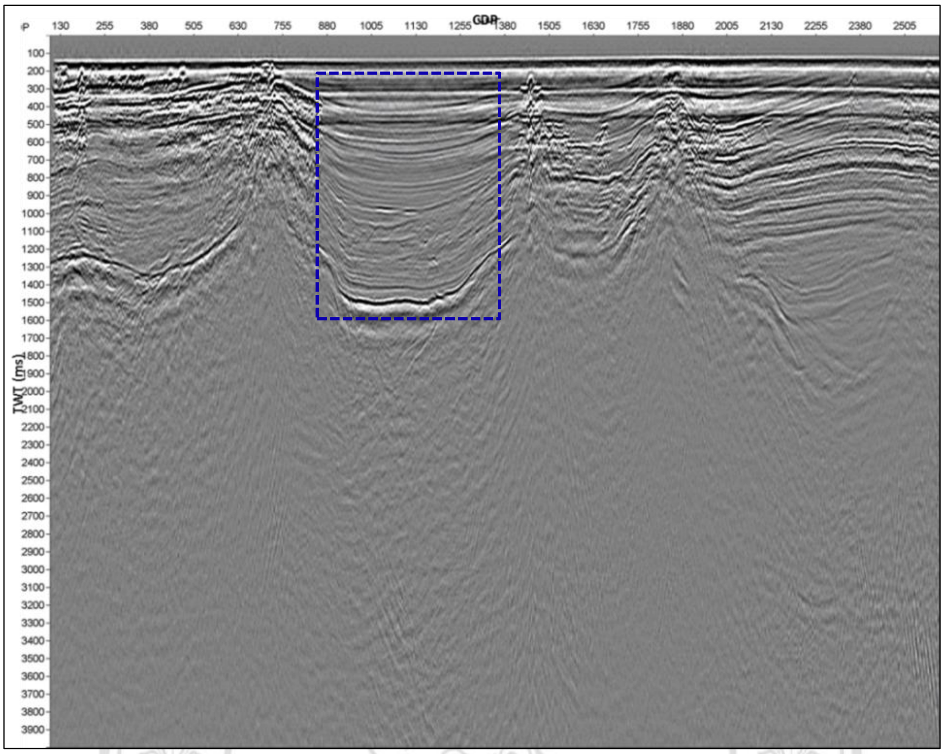

Figure 4.15 WNC82025-coastal of California, 15-degree Finite-difference migrated section in Cartesian coordinate system.

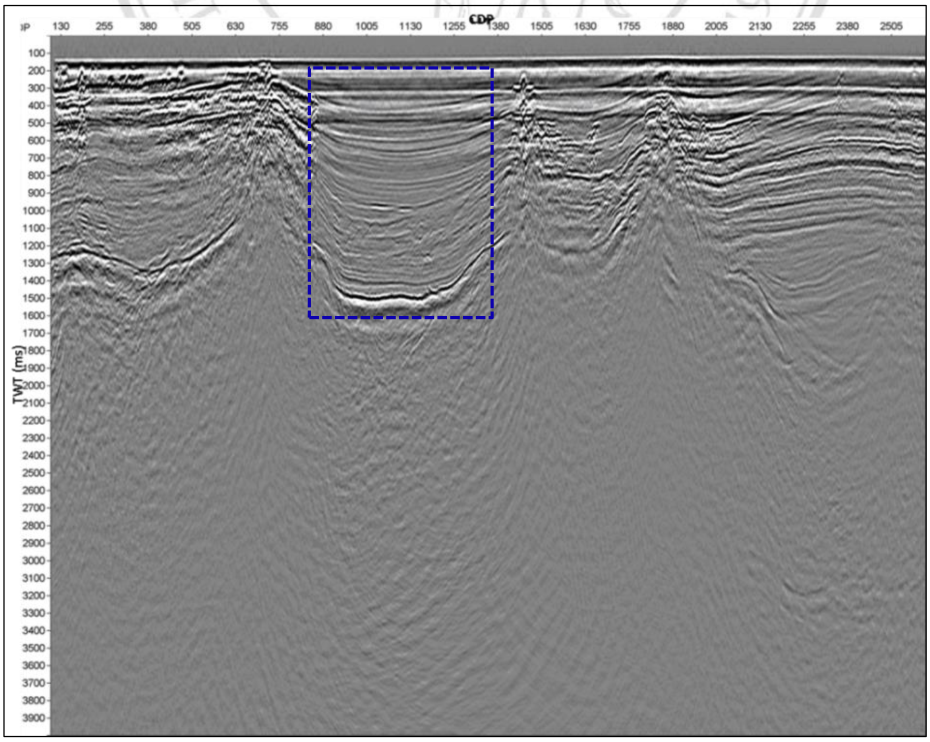

Figure 4.16 WNC82025-coastal of California, 15-degree Finite-difference migrated section in log-polar coordinate system.

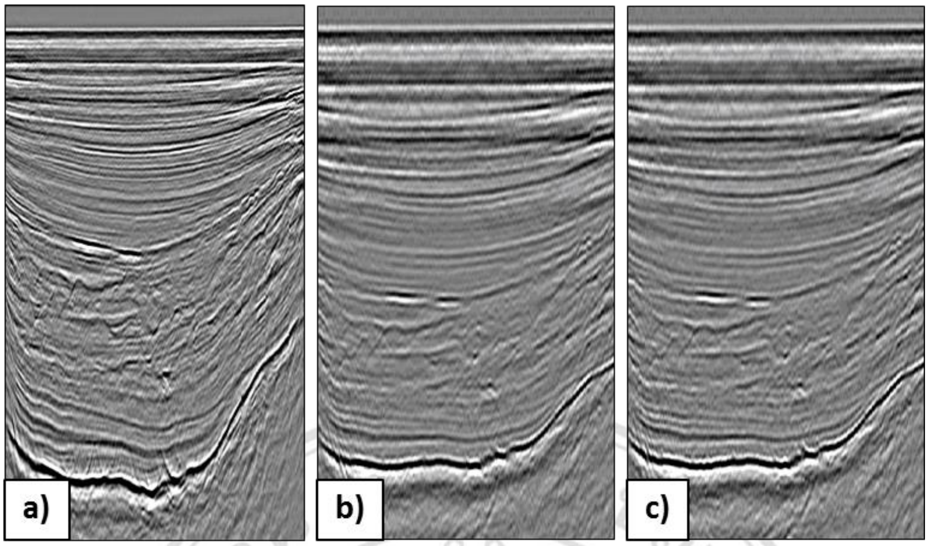

Figure 4.17 WNC82025-coastal of California: a) Gazdag migrated section in Cartesian b) 15-degree Finite-difference migrated section in Cartesian c) 15-degree Finite-difference migrated section in log-polar coordinate systems.

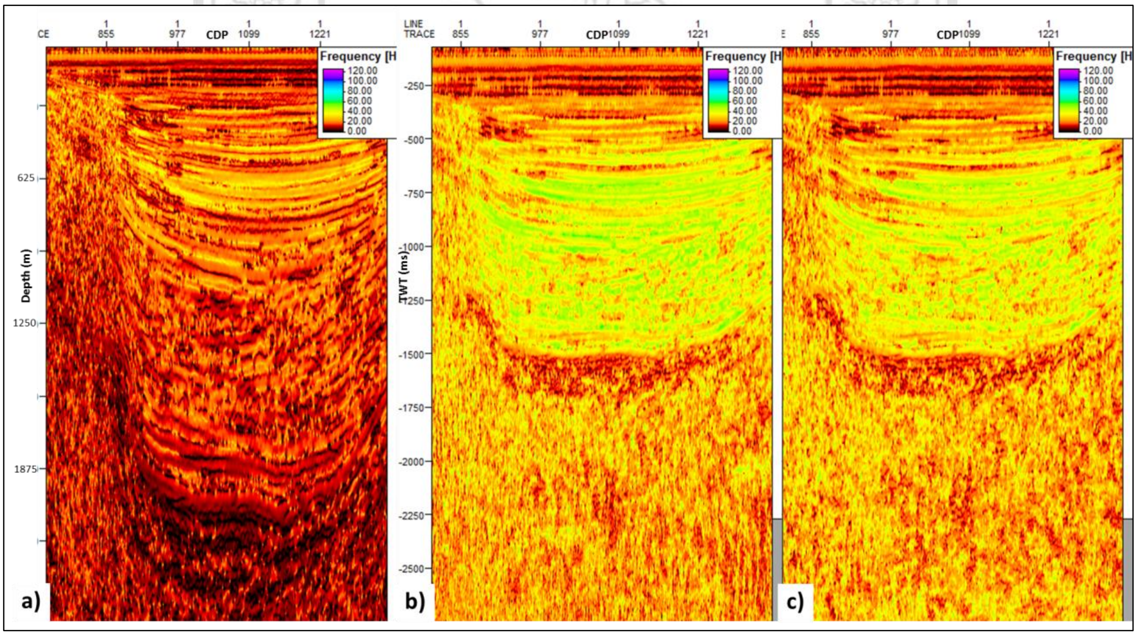

Figure 4.18 Instantaneous frequency of WNC82025-coastal of California: a) Gazdag migrated section in Cartesian b) 15-degree Finite-difference migrated section in Cartesian c) 15-degree Finite-difference migrated section in log-polar coordinate system.

2) Post-stack migration result of WNC82014, coastal of California: The migrated seismic sections with Gazdag and 15-degree Finite-difference migration method of WNC82014 including the estimated instantaneous frequency of those sections in log-polar and Cartesian coordinate systems, shown in Figure 4.19, Figure 4.20, Figure 4.21 and Figure 4.23, illustrate that 15-degree Finite-difference in log-polar coordinates has a frequency a bit lower than Cartesian coordinate system and higher than Gazdag migration in Cartesian coordinate system. The multiple reflections are shown at the shallow part of Gazdag in Cartesian and 15-degree Finite-difference in both coordinate systems. The comparison between the two coordinates of 15-degree Finite-difference shows a difference in the deeper part of this section (Figure 4.22b and Figure 4.22c) and also Gazdag migration in Cartesian (Figure 4.22a). The red arrows highlight the anticline which was collapsed to be narrow in 15-degree Finite-difference in log-polar coordinate system. Blue arrows highlight the diffraction tail Gazdag migration in Cartesian and 15-degree Finite-difference migration in both coordinate systems although they mostly were collapsed better in 15-degree Finite-difference in log-polar coordinate system image.

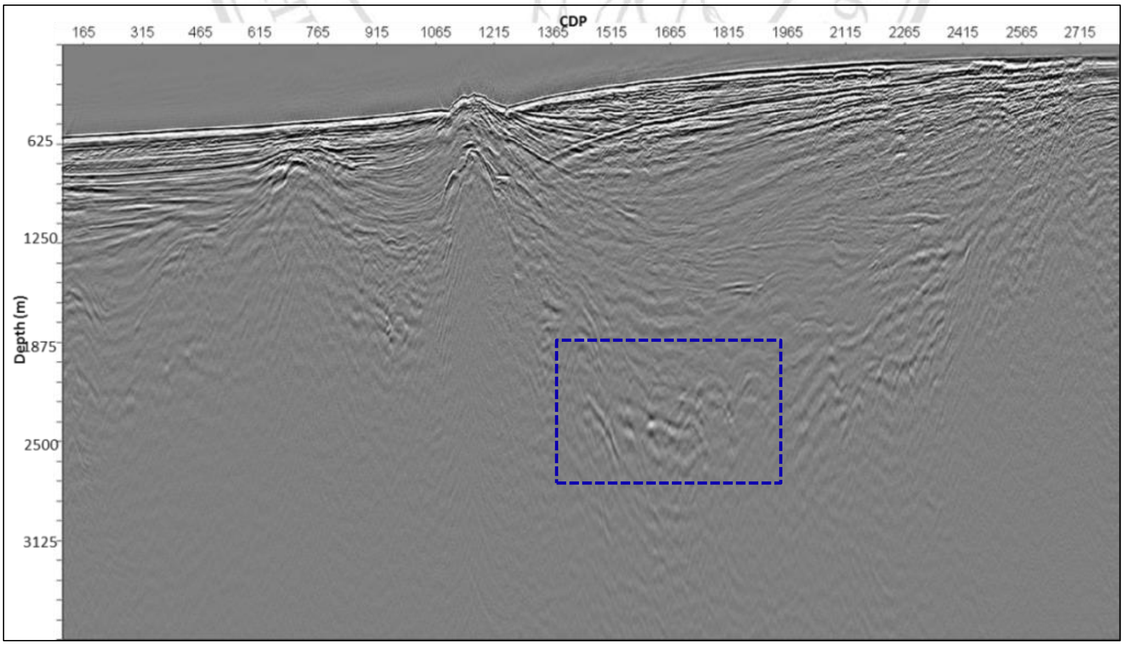

Figure 4.19 WNC82014-coastal of California, Gazdag migrated section in Cartesian coordinate system.

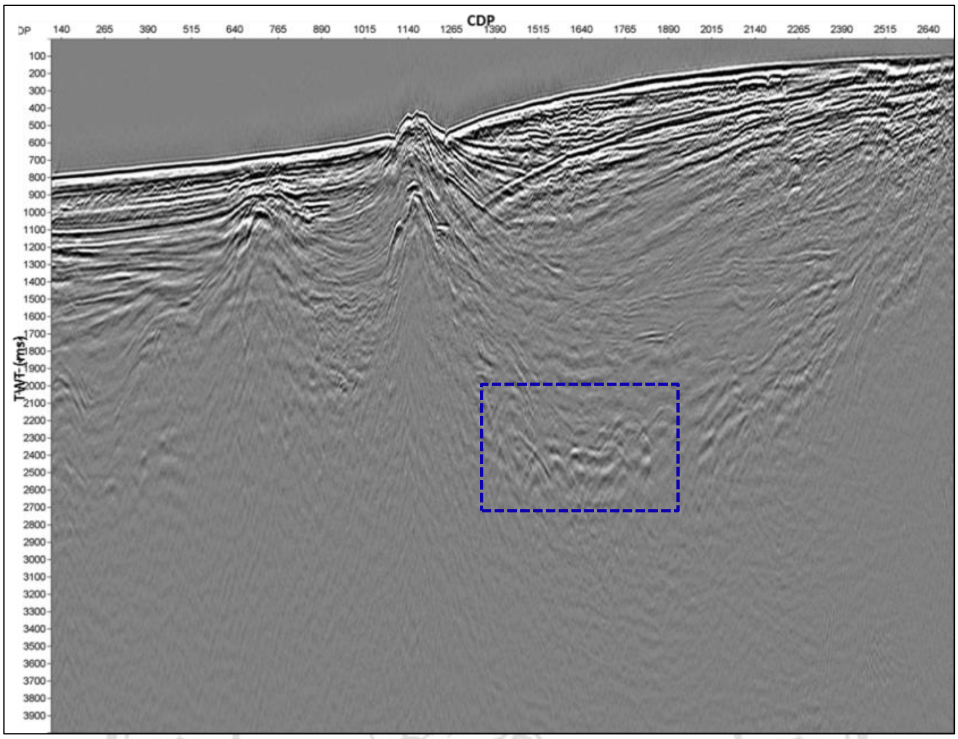

Figure 4.20 WNC82014-coastal of California, 15-degree Finite-difference migrated section in Cartesian coordinate system.

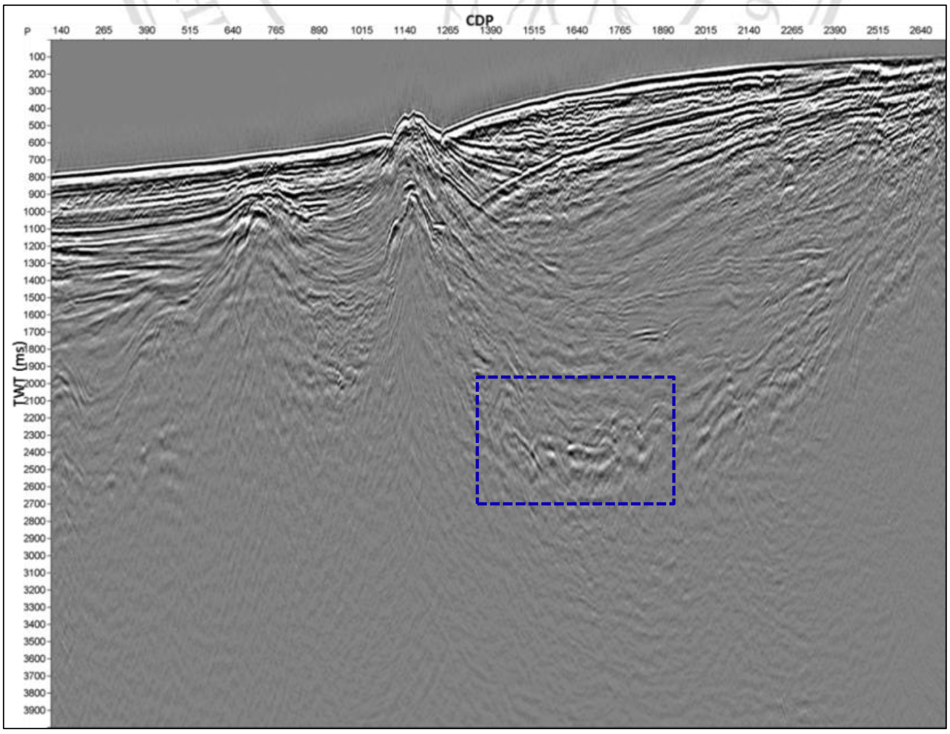

Figure 4.21 WNC82014-coastal of California, 15-degree Finite-difference migrated section in log-polar coordinate system.

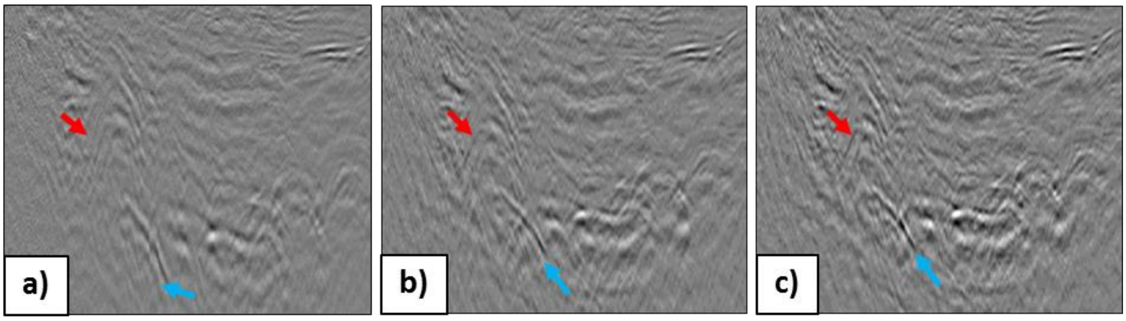

Figure 4.22 Deeper part of WNC82014-coastal of California: a) Gazdag migrated section in Cartesian b) 15-degree Finite-difference migrated section in Cartesian c) 15-degree Finite-difference migrated section in log-polar coordinate systems.

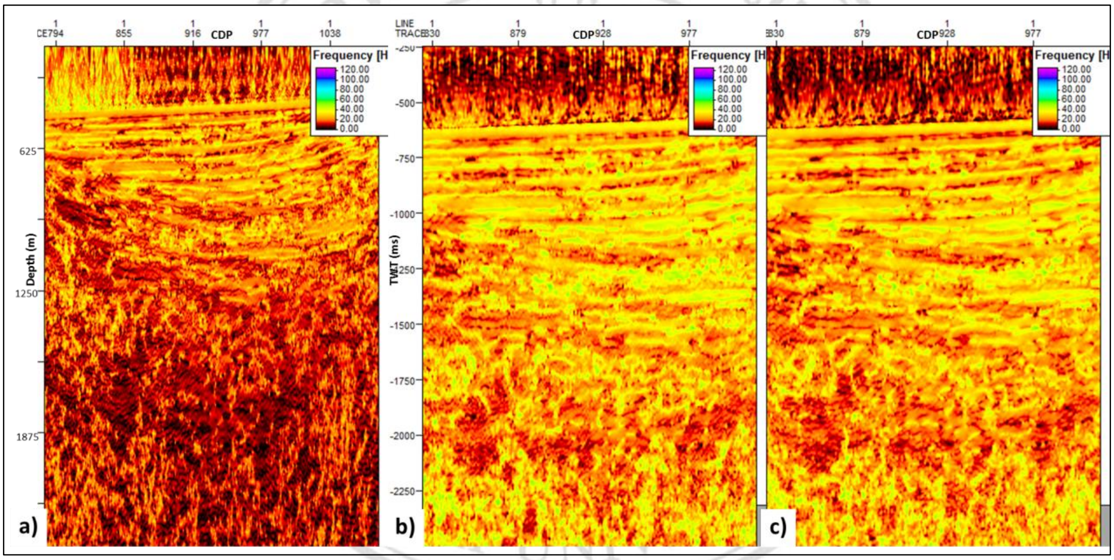

Figure 4.23 Instantaneous frequency of WNC82014-coastal of California: a) Gazdag migrated section in Cartesian b) 15-degree Finite-difference migrated section in Cartesian c) 15-degree Finite-difference migrated section in log-polar coordinate system.

3) Post-stack migration result of WNC82012, coastal of California: The migrated sections highlighted by yellow ellipses in Figure 4.24, Figure 4.25 and Figure 4.26 show there are differences in the imaging of Gazdag migration in Cartesain and 15-degree Finite-difference in two coordinate systems. Zoomed in the highlighted area are shown in Figure 4.27a, Figure 4.27b and Figure 4.27c. This illustrates that the anticline was collapsed to be narrow in Gazdag migration in Cartesain and 15-degree Finite-difference migration in log-polar coordinate system. The diffraction tail collapsed better in log-polar coordinate system. The estimated instantaneous frequency of the sections in both coordinate systems (see Figure 4.28a, Figure 4.28b and Figure 4.28c) show that the migrated section of 15-degree Finite-difference in log-polar coordinates has a bit lower frequency than migrated section in Cartesian coordinate system but higher than the result of Gazdag migration in Cartesian coordinate systems.

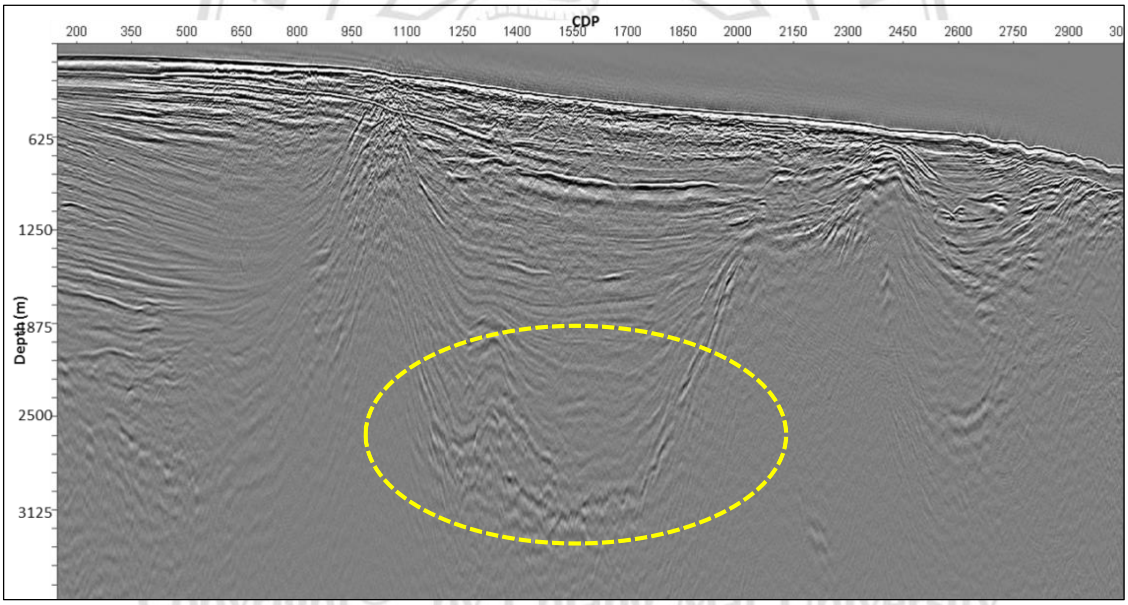

Figure 4.24 WNC82012-coastal of California, Gazdag migrated section in Cartesian coordinate system.

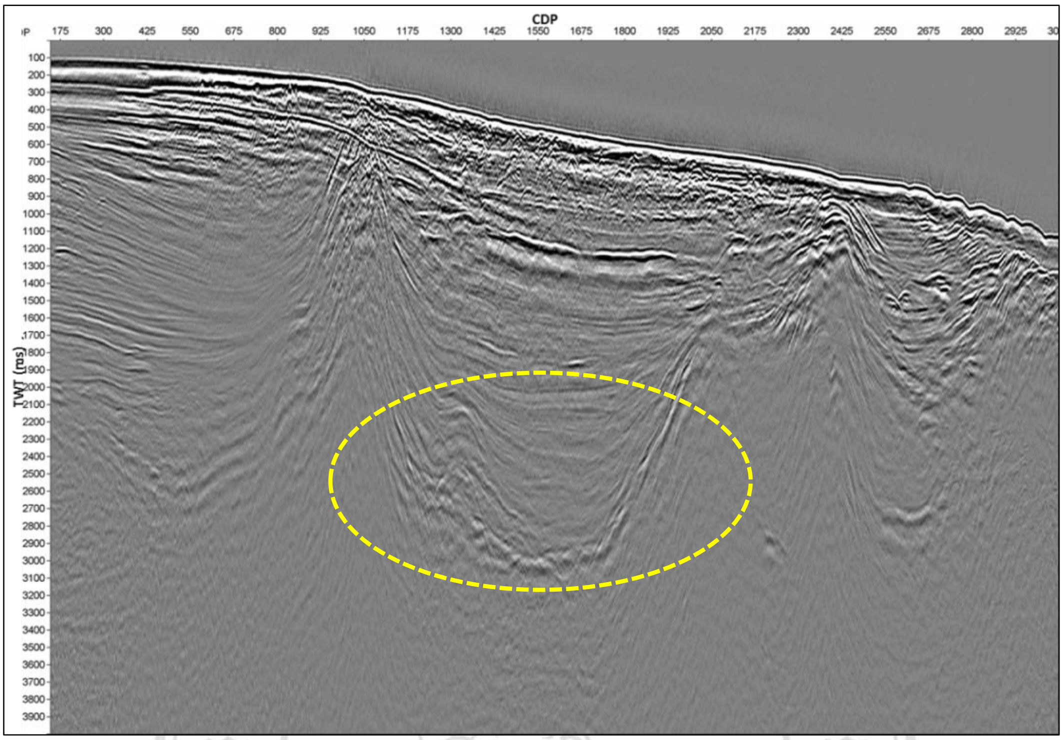

Figure 4.25 WNC82012-coastal of California, 15-degree Finite-difference migrated section in Cartesian coordinate system.

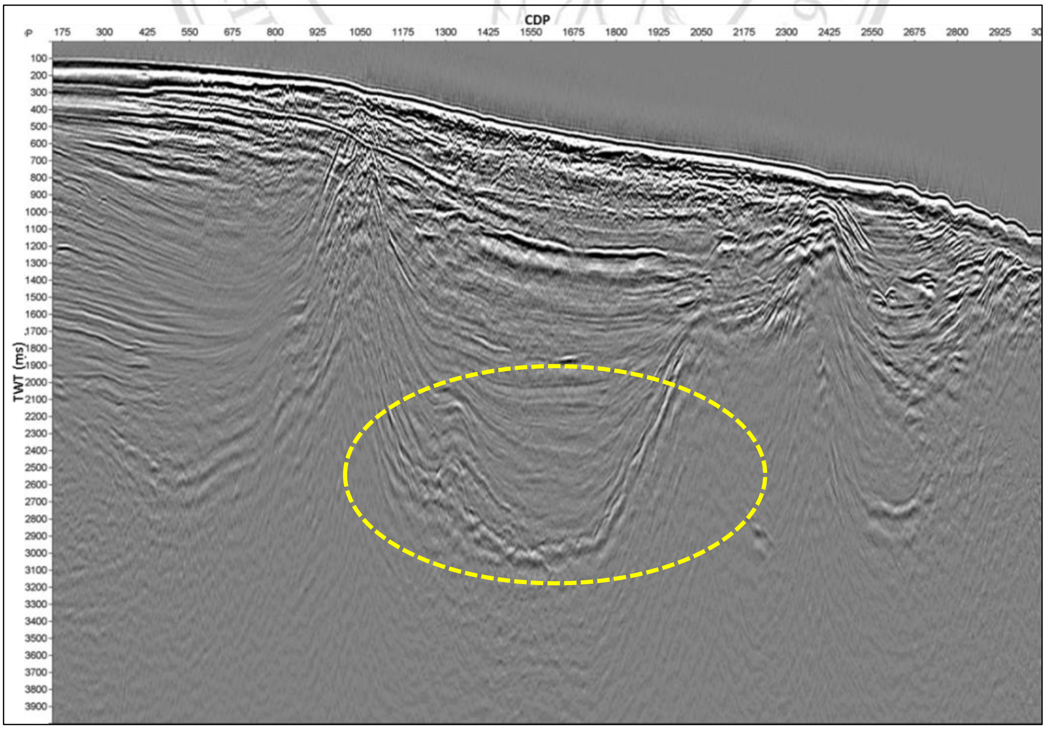

Figure 4.26 WNC82012-coastal of California, 15-degree Finite-difference migrated section in log-polar coordinate system.

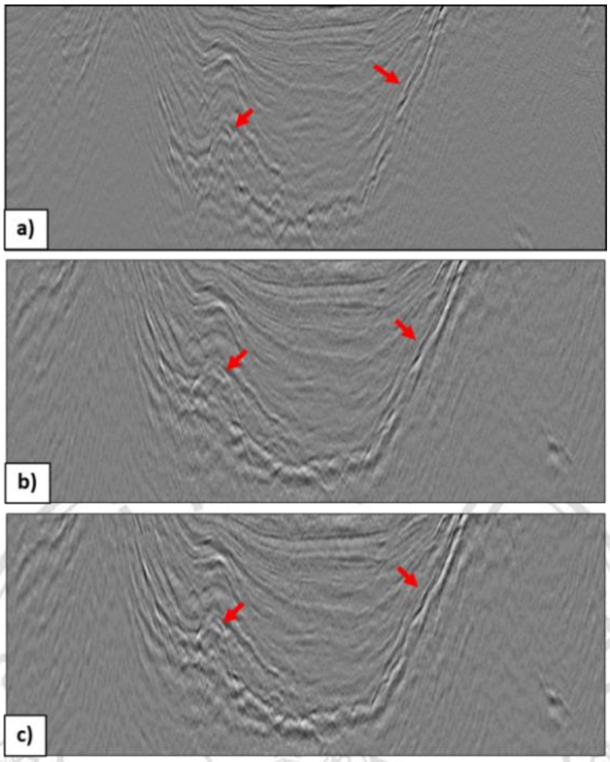

Figure 4.27 Deeper part of WNC82012-coastal of California: a) Gazdag migrated section in Cartesian b) 15-degree Finite-difference migrated section in Cartesian c) 15-degree Finite-difference migrated section in log-polar coordinate systems.

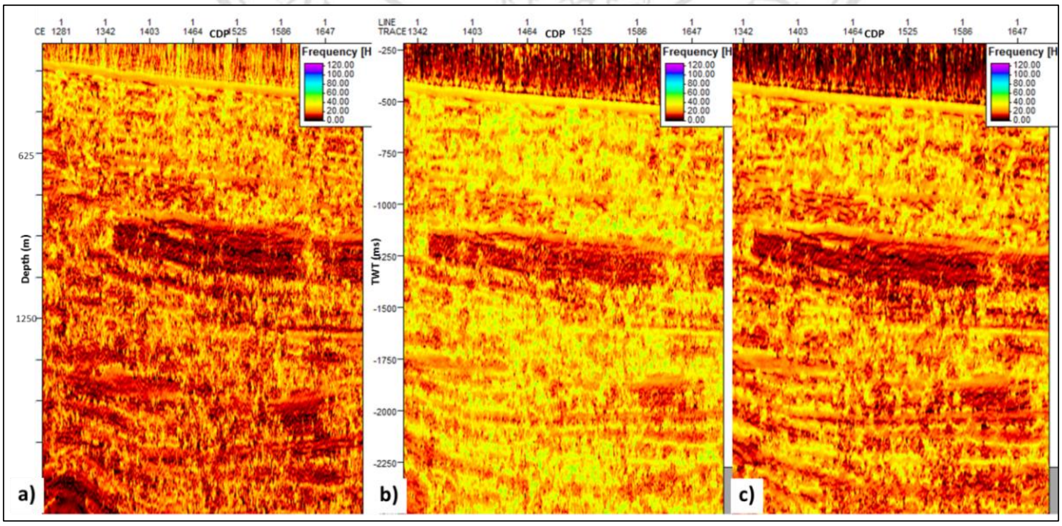

Figure 4.28 Instantaneous frequency of WNC82012-coastal of California: a) Gazdag migrated section in Cartesian b) 15-degree Finite-difference migrated section in Cartesian c) 15-degree Finite-difference migrated section in log-polar coordinate system.

4) Post-stack migration result of W75520, coastal of California: There is a slight difference in the representation of the Gazdag in Cartesian and 15-degree Finite-difference migrated sections of W75520 when using the Cartesian and log-polar coordinate systems, as illustrated by the yellow circles in Figure 4.29, Figure 4.30 and Figure 4.31. This area of distinction is shown at a higher resolution for those images in Figure 4.32a, Figure 4.32b and Figure 4.32c. The steeply dipping reflector, as emphasized in Figure 4.32 by the red arrow, was imaged better in 15-degree Finite-difference in log-polar coordinate system and also shows similarly with Gazdag migration in Cartesian coordinate system. The estimated instantaneous frequency of the migrated sections is shown in Figure 4.33a, Figure 4.33b and Figure 4.33c.

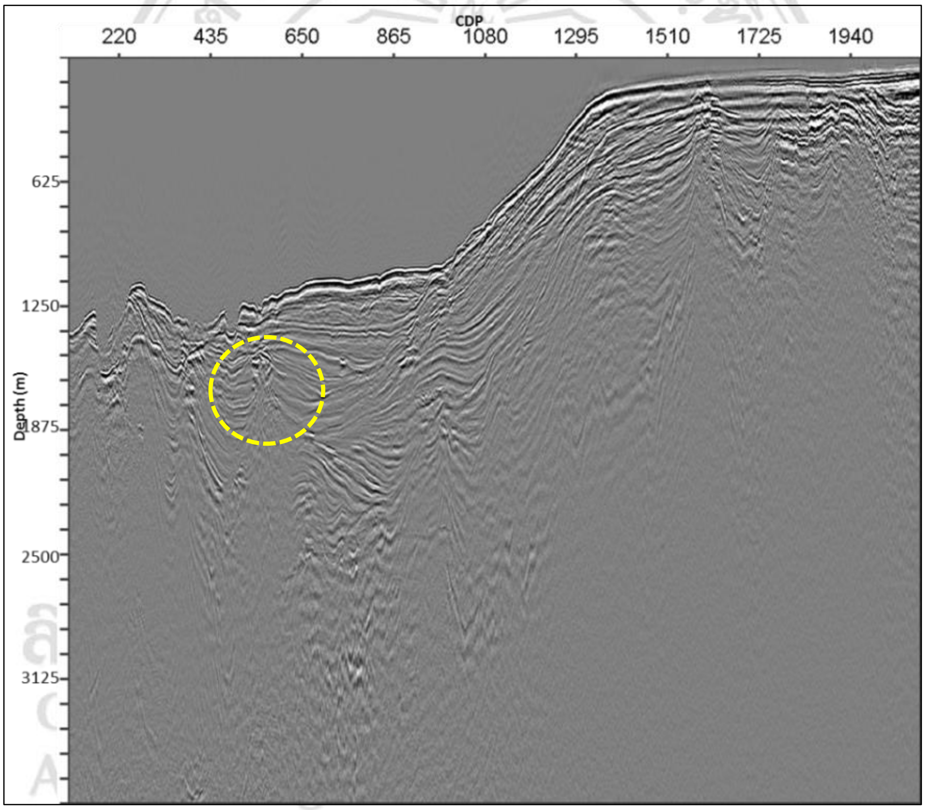

Figure 4.29 W75520-coastal of California, Gazdag migrated section in Cartesian coordinate system.

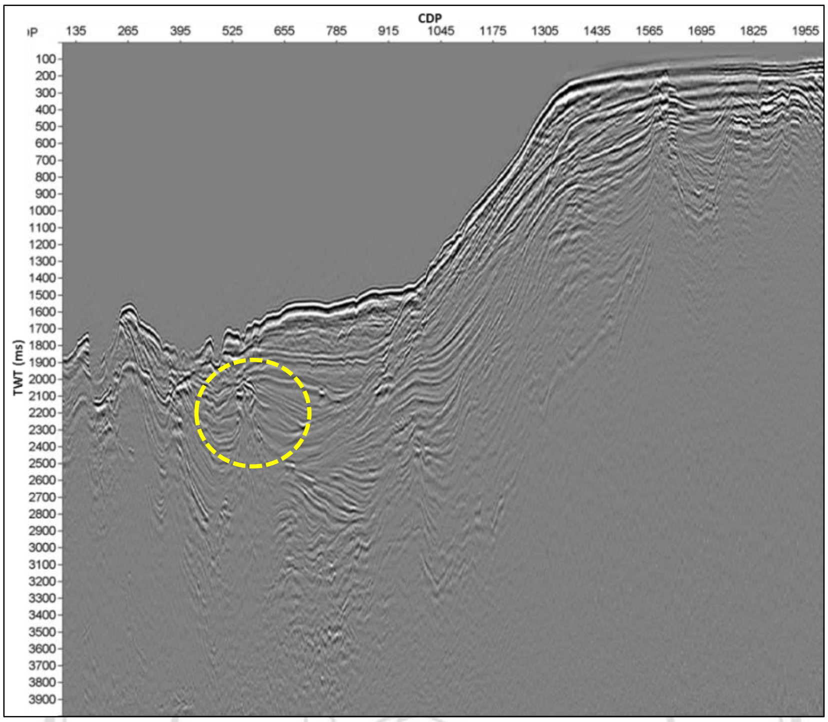

Figure 4.30 W75520-coastal of California, 15-degree Finite-difference migrated section in Cartesian coordinate system.

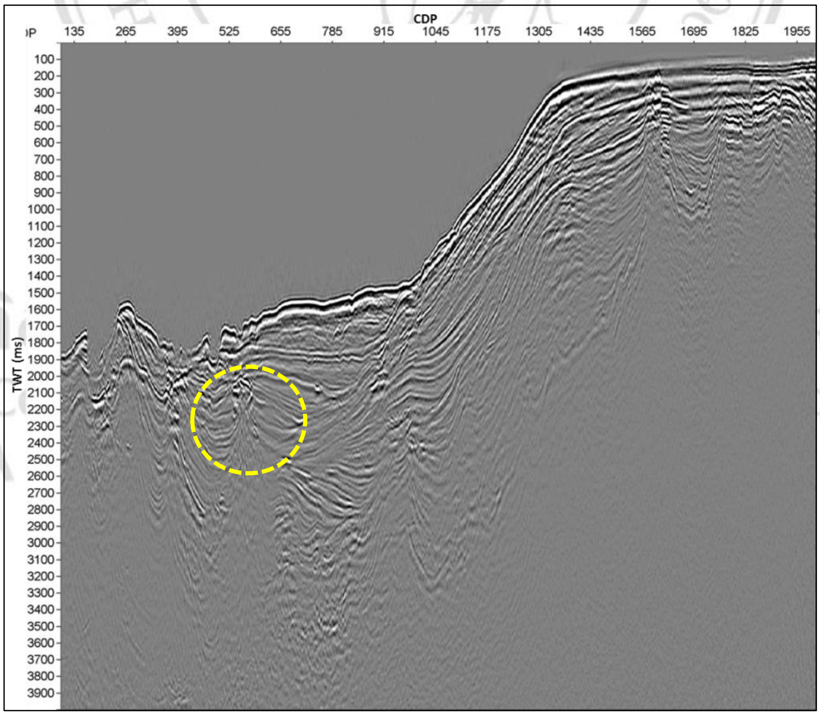

Figure 4.31 W75520-coastal of California, 15-degree Finite-difference migrated section in log-polar coordinate system.

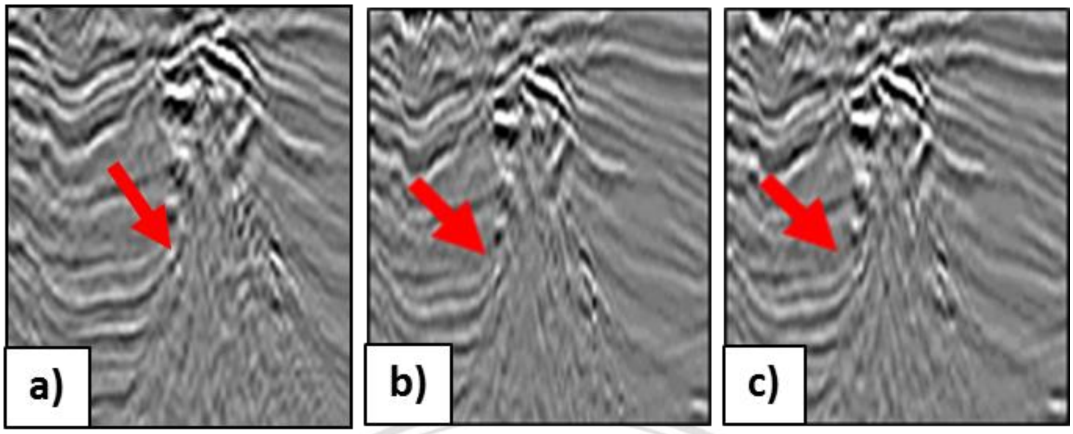

Figure 4.32 Shallow part of W75520-coastal of California: a) Gazdag migrated section in Cartesian b) 15-degree Finite-difference migrated section in Cartesian c) 15-degree Finite-difference migrated section in log-polar coordinate systems.

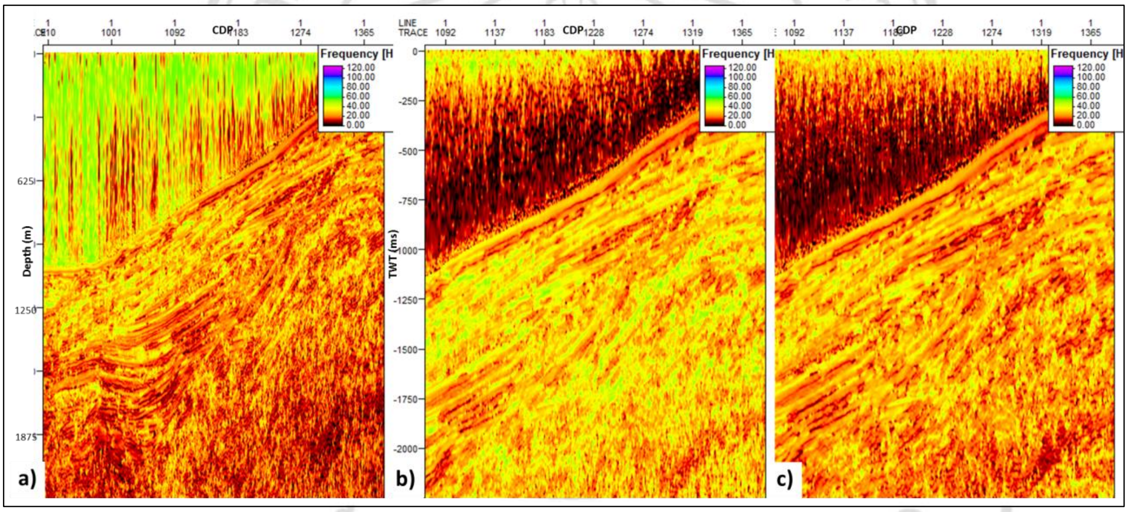

Figure 4.33 Instantaneous frequency of W75520-coastal of California: a) Gazdag migrated section in Cartesian b) 15-degree Finite-difference migrated section in Cartesian c) 15-degree Finite-difference migrated section in log-polar coordinate system.

5) Post-stack migration result of W532A, coastal of California: The Gazdag migration in Cartesian coordinate and 15-degree Finite-difference migrated sections of W532A in Cartesian and log-polar coordinate systems are mostly imaged in a similar fashion as shown in Figure 4.34, Figure 4.35 and Figure 4.36.

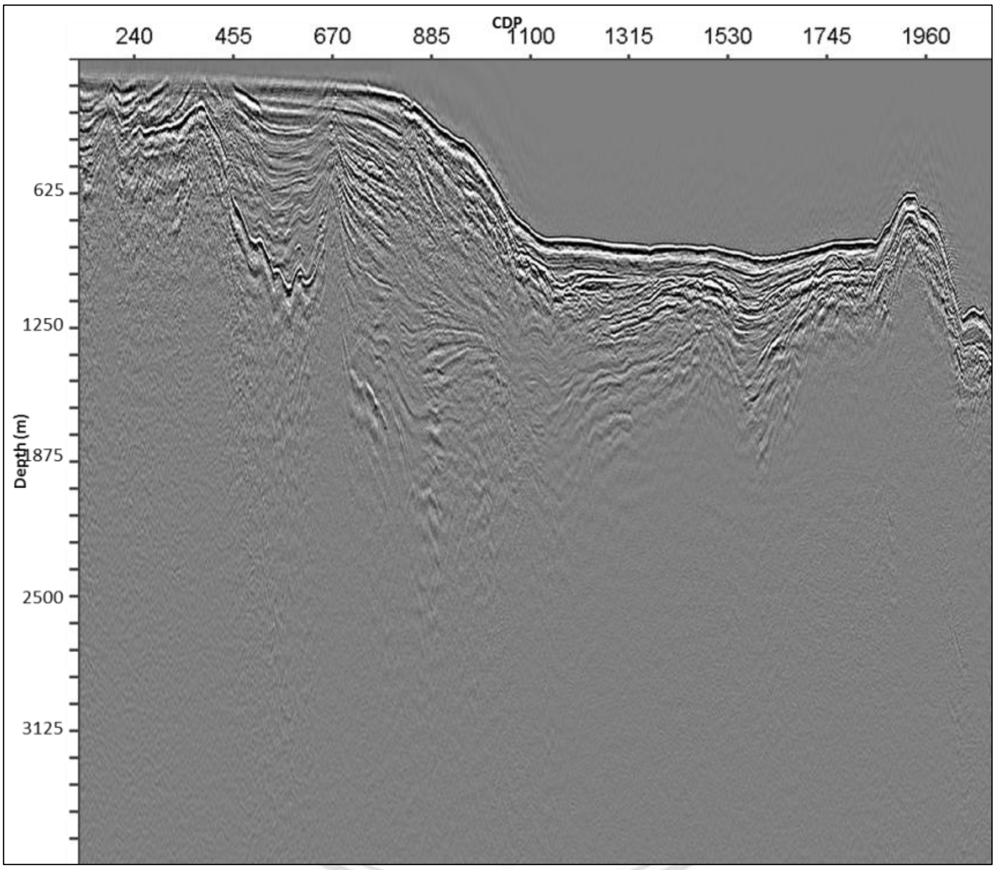

Figure 4.34 W532A-coastal of California, Gazdag migrated section in Cartesian coordinate system.

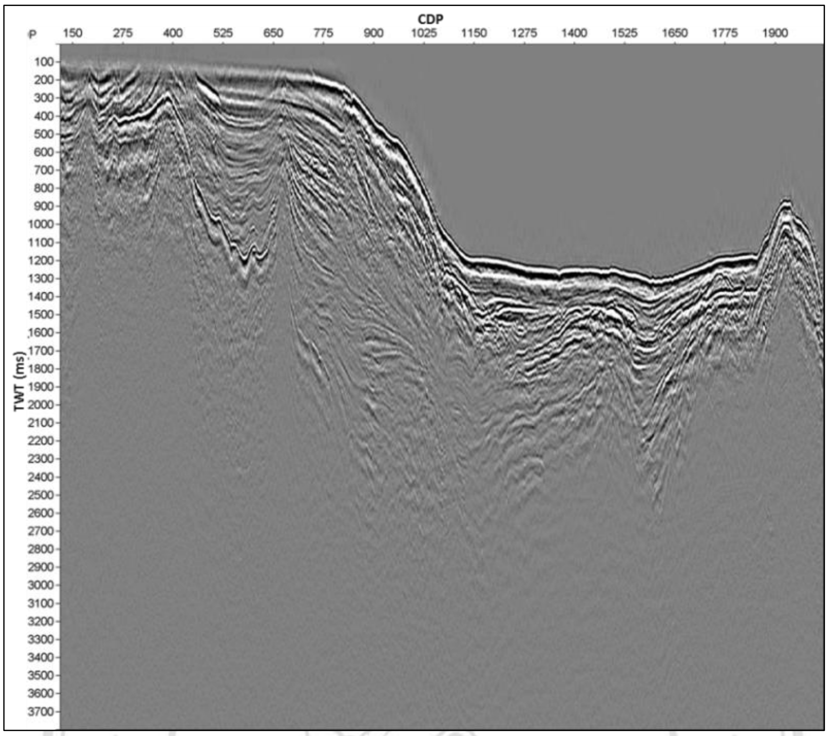

Figure 4.35 W532A-coastal of California, 15-degree Finite-difference migrated section in Cartesian coordinate system.

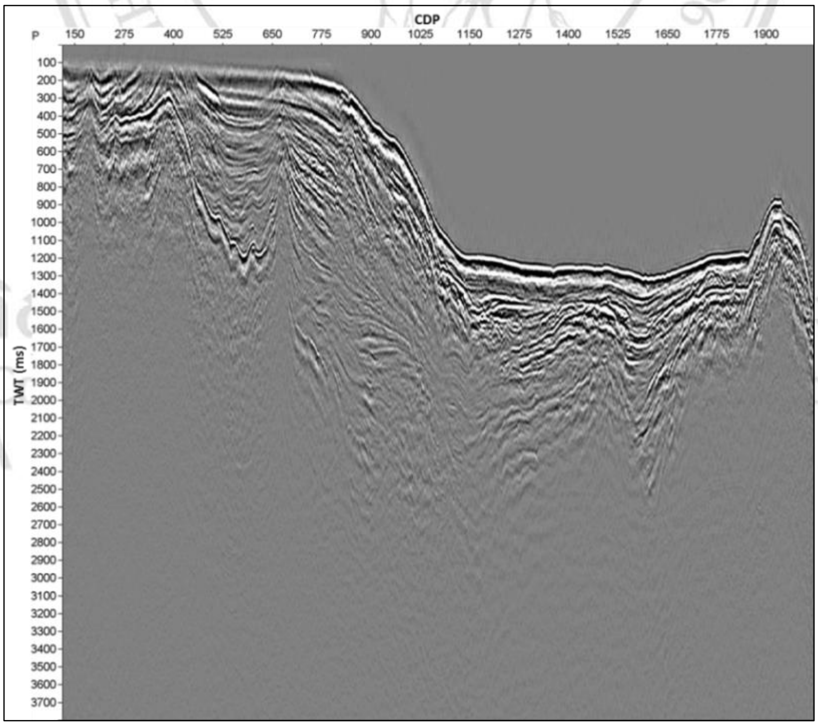

Figure 4.36 W532A-coastal of California, 15-degree Finite-difference migrated section in log-polar coordinate system.

4.2 Conclusion

Seismic migration is the process whereby a reflector is translated to their true subsurface location, and diffractions are collapsed. The result of migration shows that the image has increased its lateral resolution due to the compression of the Fresnel zone. The Cartesian coordinate system is a conventional coordinate method that has been applied in the migration processing. It is limited in vertical direction due to the high angle between wave propagation and extrapolation axis which loses high angle energy. Migration in log-polar coordinate system utilizes the exponential extrapolation axis by changing coordinate system from Cartesian to log-polar domain to image high angle energy. One-way wave equation migration in log-polar coordinates can image steeply reflectors accurately relative to the one-way wave equation in Cartesian coordinate. This is due to the non-vertical extrapolation axis in the Cartesian system that creates small angle between extrapolation axis and wave propagation direction. As a result of the extrapolation step size in log-polar coordinate system changes exponentially, and the origin of log-polar coordinate system can be located to analyze complex geological structures. Therefore, thin layers, faults, synclines, anticlines, channels and intrusions can be imaged with high accuracy when using the log-polar coordinate system. The migration impulse responses show that Gazdag and 15-degree Finite-difference migration in log-polar coordinate can handle high angle energy while migration in Cartesian coordinate cannot be done. In the synthetic dataset, the reflector can be imaged accurately due to high accuracy of velocity seen in the clear imagery of the steeply dipping reflector in log-polar coordinate system outlined in Chapter 3. Specially, Gazdag migration in log-polar coordinate can image the synthetic data correctly more than Cartesian coordinate system while the reflector cannot be imaged by 15-degree Finite-difference in both coordinate systems. Nevertheless, migration methods can image reflectors from real dataset accurately in either coordinate system as illustrated in Chapter 3. Both coordinate systems did not show the high capabilities for the imaging of steeply dip reflectors, which is actually due to the velocity not their accuracy. Finally, the 15-degree finite-difference migration method creates similar results for both coordinate systems did not make high difference between Cartesian and log-polar coordinate