CHAPTER 5

DISSCUSSION AND CONCLUSION

5.1 Comparison between the Previous Litho-stratigraphy and Climate-stratigraphy in Formation 2

In Formation 2, Platform B, Arthit Project; has the previous classification using litho-stratigraphy which is discussed in the chapter 2. In this interval, Climate stratigraphy has recognized stratigraphic packages (StratPacs) from the spectral trend, INPEFA-GR curve to 4 lower-order StratPacs and 12 higher-order subdivisions. The lower-order StratPacs comprise of the top part of StratPacs M4000, StratPacs M5000, StratPacs M6000 and StratPacs M7000. The higher-order StratPacs comprise of StratPacs M4400, M4500, M5100, M5200, M5300, M6100, M6200, M6300, M6400, M7100, M7200 and M7300.

The basal boundary of Formation 2 (Top- Formation 1) is between the Negative bounding surface (NBS) 4400 and NBS 4500. The top of Formation 2 (in this study concentrate to Top-2D) has covered by the NBS M8000. The comparison between the previous litho-stratigraphy and climate-stratigraphy has explained to the relationship of the top and marker classified by lithology and negative or positive bounding surface (PBS) indicated by the principle of climate stratigraphy (See in Table 5.1).

Unit 2A has 2 previous major markers, M19-50 and M20-40. The NBS M5200 is near the previous marker M20-40. This NBS is marked under the thick sand bed while the marker M20-40 is picked on a low gamma ray coal. So they are not quite coinciding, but it is not the problem because it can be picked in every study well and

Table 5.1 Comparison between the climate stratigraphy into StratPacs and the litho-stratigraphy of previous top and marker.

STRACT-PAC	NBS	PBS	PREVIOUS TOP&MARKER
M8000	M8100		
			TOP-2D
	M7300		M12-15
	M7200		M12-95
M7000	M7100		TOP-2C
	M6400		
			M14-55
	M6300		
		M6200P	M15-00
		M6000P	M16-00
	M6200		
		M6100P	TOP-2B
			M17-80
M6000	M6100		
	M5400		TOP-2A
			M19-50
	M5300		
	M5200		
			M20-40
M5000	M5100		
	M4500		
	M4400		
			TOP-FM1
		M4300P	
	M4300		
		M4000P	
	M4200		
M4000	M4100		
		M3100P2	
		M3000P	
		M3100P1	
M3000	M3100		
		M2200P	
		M2000P	
	M2200		
		M2100P	
M2000	M2100		
		M1000P	
M1000	M1100		TOP-FM0

shows parallel line of M20-40 and NBS M5200 in correlation. NBS M5400 is adjacent the Top 2A unit. It is marked under a thick coarse-grained fining upward cycle while the Top 2A is defined by a continuous coal section occurring below the lower sand section of the 2B unit (Figure 5.1).

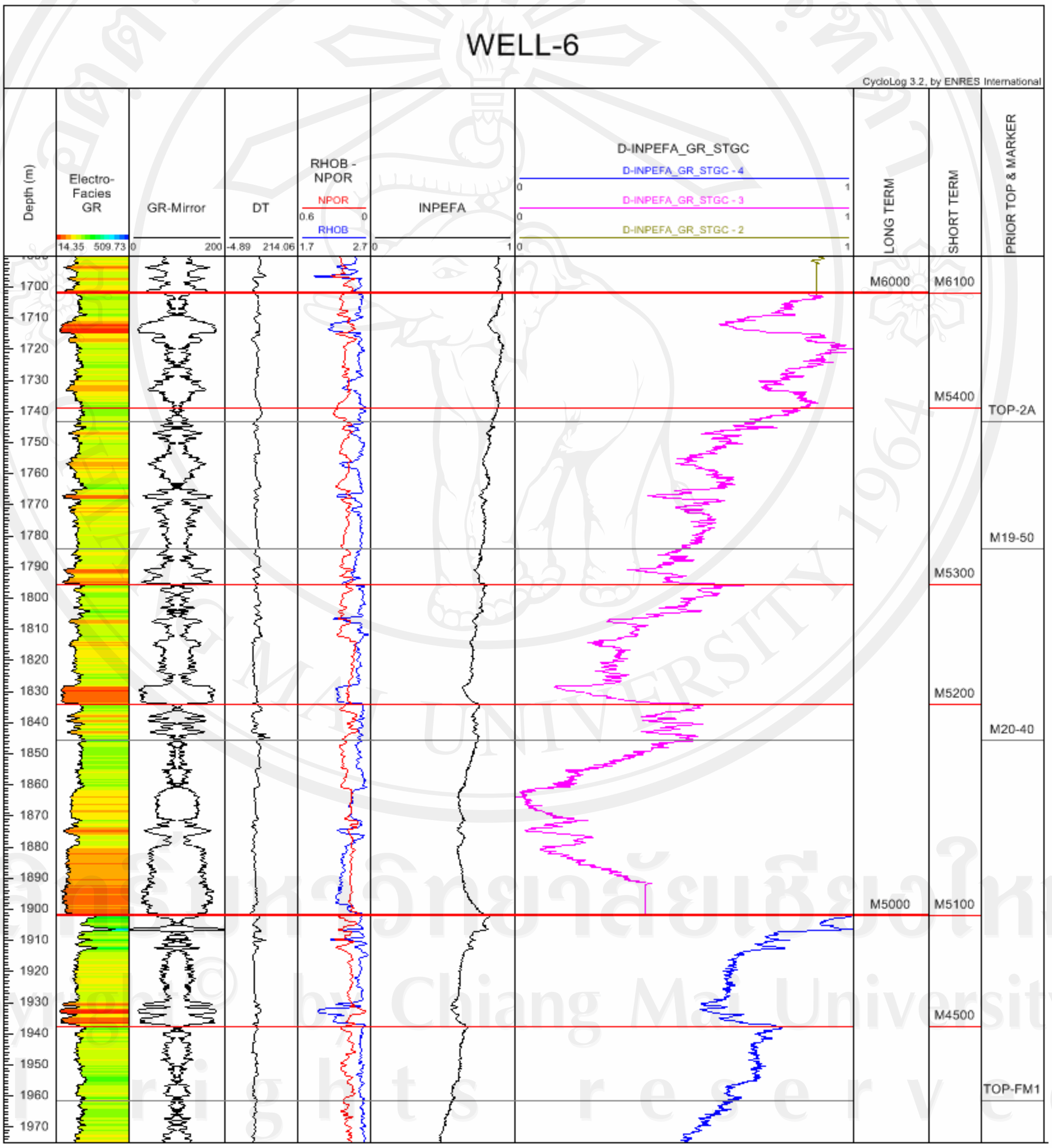

Figure 5.1 show the location of the previous top and marker in 2A unit compare with the negative bounding surface in the top part of StratPacs M4000 and StratPacs M5000 of well 6.

Unit 2B; the positive bounding surface (PBS) M6100P coincides with the Top 2B unit (Figure 5.2). This PBS is marked under a group of shale beds. Top 2B unit is close to H40 seismic marker.

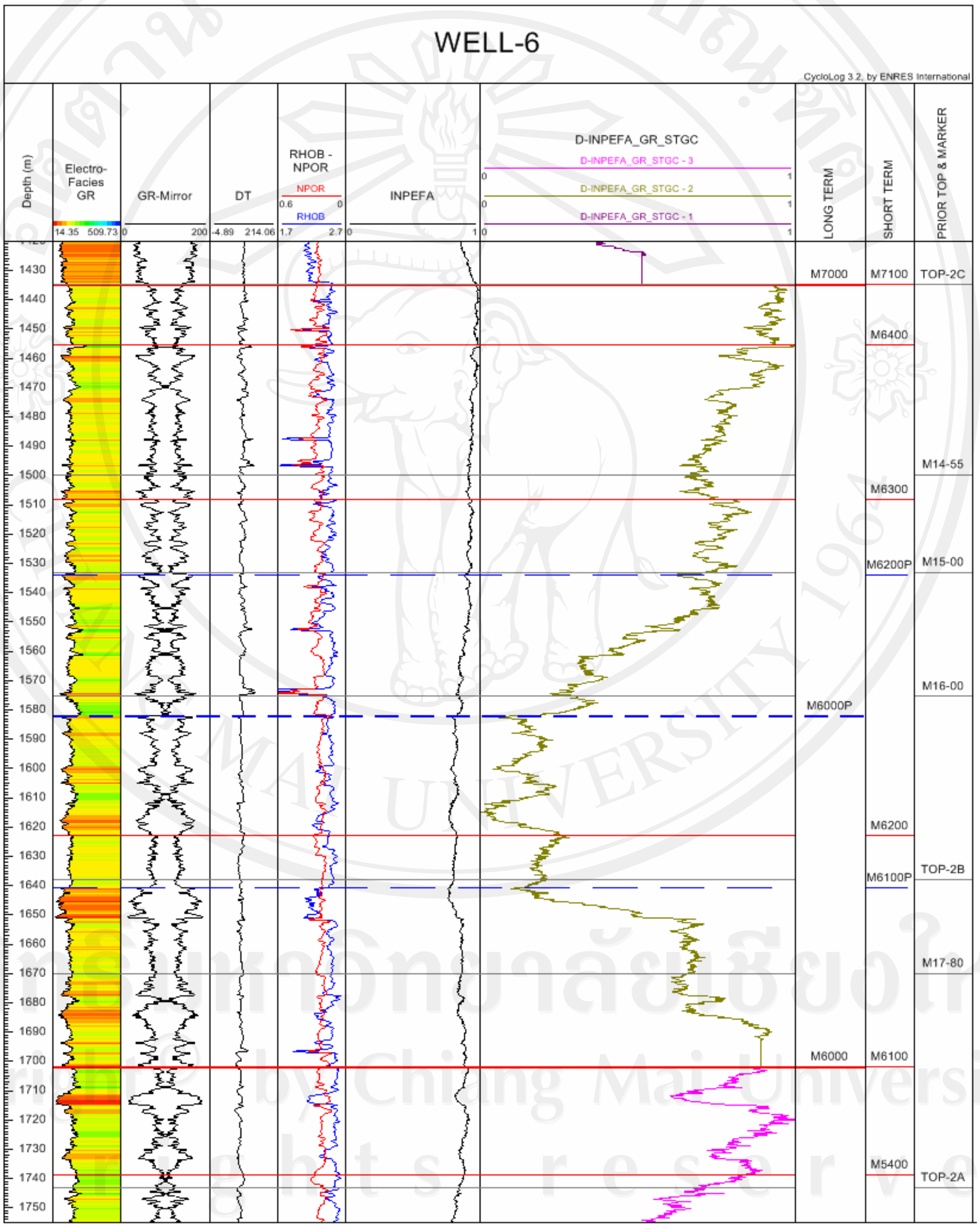

Figure 5.2 Show the location of the previous top and marker in 2B and 2C units compare with the negative bounding surface in top part of StratPacs M5000 and StratPacs M6000 of well 6.

Unit 2C; there are one positive bounding surface and one negative bounding surface coincide with the previous stratigraphy. NBS M7000 or M7100 coincides with the Top 2C which marked under the thick sand bed. PBS M6200P coincides with the previous marker M15-00. The other NBS and PBS do not coincide with the previous markers, but it can correlate from well to well and the correlation line is parallel the previous markers (Figure 5.2).

Unit 2D; the negative bounding surface M7300 coincide with the previous marker M12-15. This NBS is marked under a thick coarse-grained fining upward cycle. NBS M7200 is above the previous marker M12-95. This NBS is marked under a thick coarsening sand bed and it is clearer in the short term INPEFA-GR curve than previous marker M12-95 (Figure 5.3).

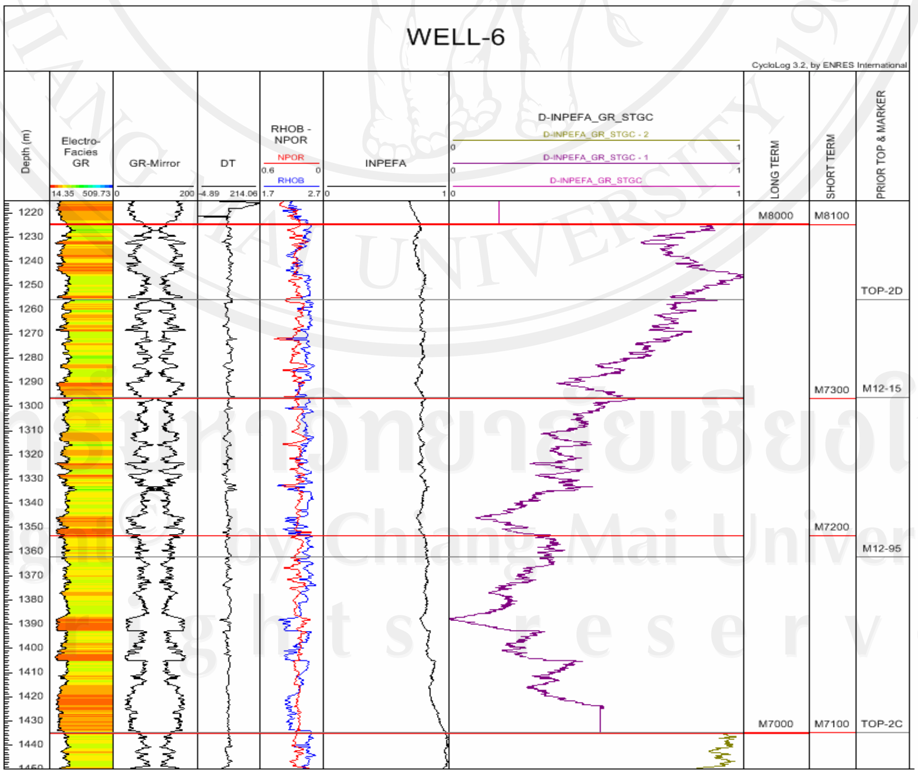

Figure 5.3 Show the location of the previous top and marker in 2D unit compare with the negative and positive bounding surface in StratPacs M7000 of well 6.

In summary, the climate stratigraphic classification into the Stratigraphic Packages and the litho-stratigraphic classification have the relationship. Climate stratigraphy seeks to identify genetically significant stratigraphic packages from the spectral trend facies wireline log data. There are several negative bounding surfaces and positive bounding surface coincide with the previous markers. Although some NBS and PBS do not coincide with the previous markers, it can correlate from well to well and the correlation lines are parallel along the previous markers lines. The comparison process can use for verification the previous formation top and marker, example; all of the study well, except well 2, Top-2C coincide with the NBS M7000 or M7100, but well 2, it do not coincide (see Figure 5.3). In this case, this process can help to improve the top formation correctly. That is to say, the principle of Climate Stratigraphy has been successfully applied to the analysis and correlation of 18 study wells in Formation 2, Platform B, Arthit Project. And it should be use successfully in the Formation 1, because of the one principle of Climate Stratigraphy; lithofacies succession is similar within any one climatic belt. Therefore, if this method can use in the Formation 2, it can use in the Formation 1, also.

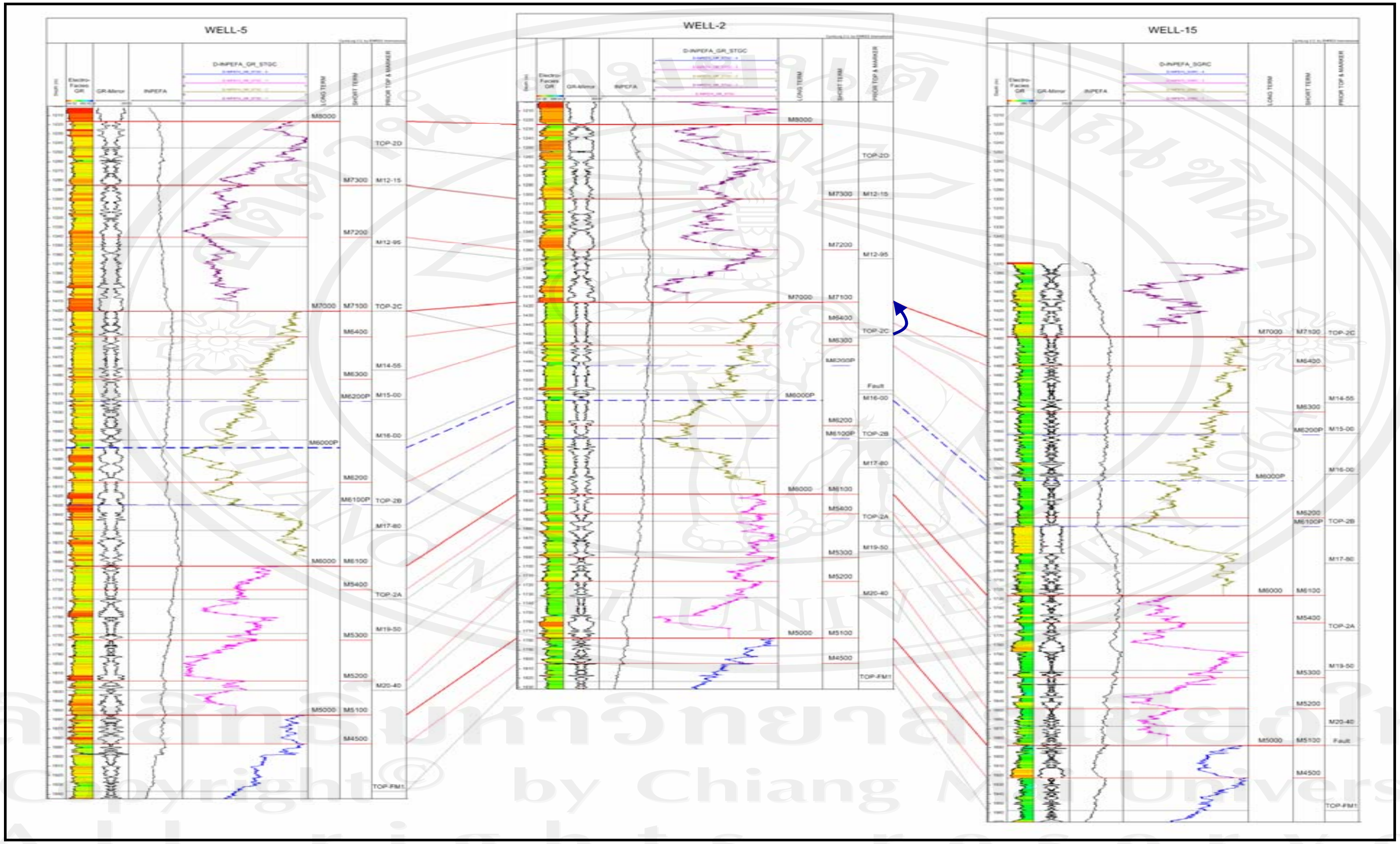

Figure 5.4 shows some mistake of the Top-2C position in well 2 and the StratPacs can be used for the verification. In the correction, Top-2C in well 2 should be coincide with NBS M7000 0r M7100 (above the current position).

5.2 Climate-stratigraphy in Formation 1 (FM1)

In Formation 1, Platform 2, Arthit Project; Climate stratigraphy has recognized stratigraphic packages (StratPacs) from the spectral trend, INPEFA-GR curve to 4 lower-order StratPacs and 7 higher-order subdivisions. The lower-order StratPacs comprise of StratPacs M1000, StratPacs M2000, StratPacs M3000 and the lower-middle part of StratPacs M4000. The higher-order StratPacs comprise of StratPacs M1100, M2100, M2200, M3100, M4100 M4200, and M4300.

Long term INPEFA-GR curve of Formation 1 interval shows C-shape character, represent the alternating fluxes of relatively coarse-grain and fine-grained deposited. The basal boundary of FM1 (NBS M1000), the base of C-shape, corresponds with the base of relatively coarse-grained unit (red-colored GR-log represent low value). It represents the base level minimum (maximum aridity). There are several PBS in FM1 intervals which represent flooding surface and relatively fine-grained deposit. The main PBS in FM1 is M4000P, abrupt change increase in GR-values (green–blue colored GR-log represent high value) correspond with more fine-grained material in the top part of FM 1 (top of C-shape). These PBS are related to a rise in base level or increase in humidity.

There are 8 important turning points of the long term INPEFA-GR curve in Formation 1. The lower one (A in Figure 5.5) marks a trend change form positive to negative trend (NBS M1000), represent renewed sand influx into the area following a period of flooding, shows shale deposit overlie. B marks a negative turning point (NBS M2000) - the base of high sand-shale ratios interval. This section relate to predominant fluvial channel sand deposition. G marks a positive turning point (M4000P). It is the important flooding surface, marking the end of period

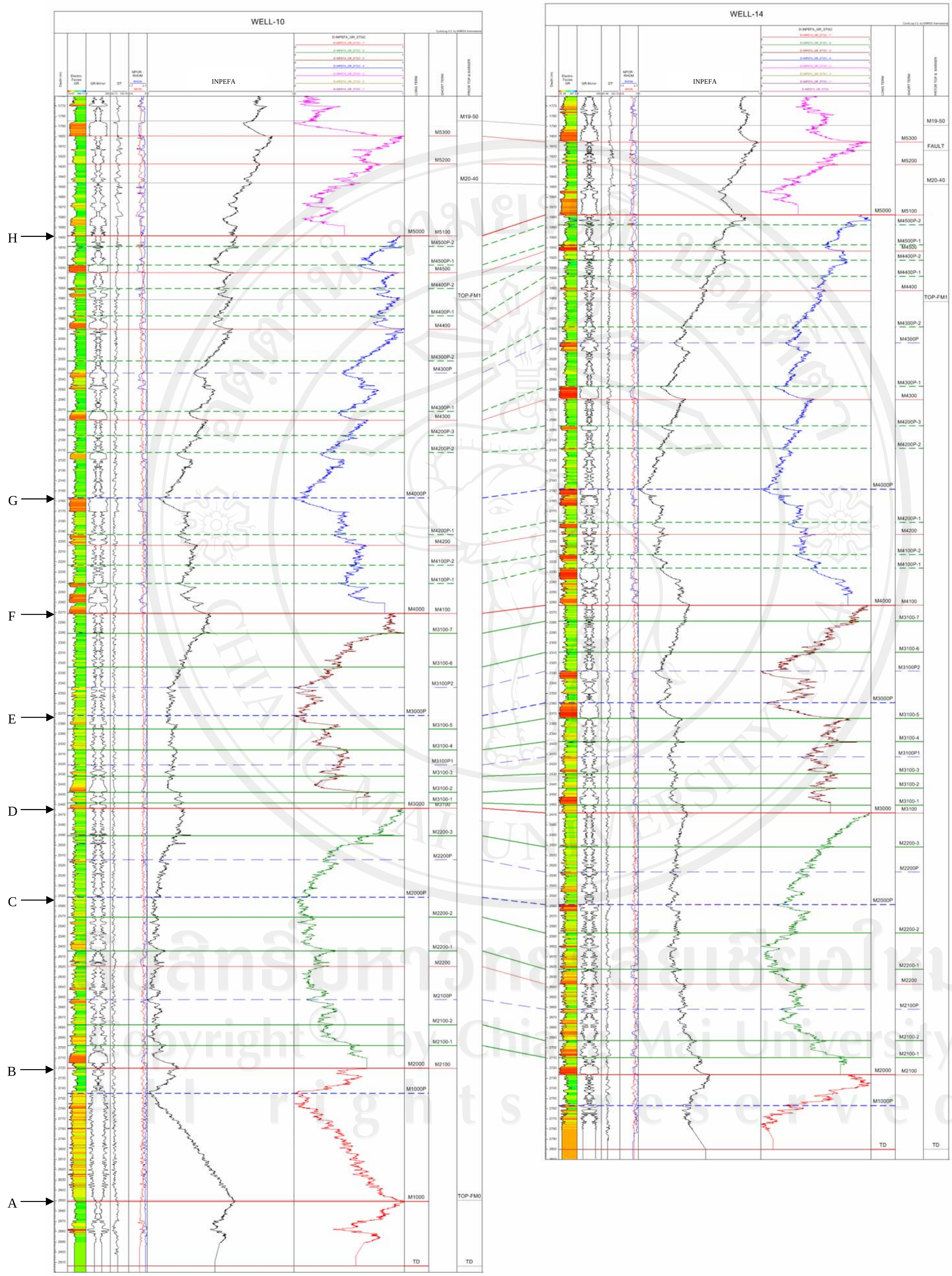

Figure 5.5 Climate stratigraphic correlations of two well (well 10 and well 14) in Formation 1 interval.

predominant sand-shale alternating in fluvial-channel deposition and the beginning of long flood basin deposition. Between G and H (NBS M5000) is the long term flood basin deposition alternate with sand influx into the basin. This section shows very thick shale prone unit alternating with sand beds. In addition, the predominant fluvial channel sand section (between B and G) can divide into two main periods of regression and transgression. The transgression represent by the positive bounding surface or flooding surface (C (M2000P) and E (M3000P)). The regression represent by the negative bounding surface or erosional surface (D (NBS M3000) and F (NBS M4000)).

The higher-order subdivisions in Formation 1 enhance the detail of INPEFA-GR curves and help for stratigraphic framework to narrow down the Stratigraphic package. Its correlation presents a near synchronous framework for understanding the lateral facies variation and offers a “structure” for understanding the facies development. Green line in Figure 5.5 is the additional interpretation of only 2 wells, well 11 and well 16. Solid and dash line represent the negative and positive bounding surfaces, respectively. This additional interpretation is quite breaking down the section to lithofacies development, sandy and shalely lithologies.

In the regional scale, the marker from climate stratigraphy which derives from the positive or negative turning point is quite uniform along the seismic horizon. Negative turning point M4400 is adjacent H65 (Table 5.2) in the seismic section and conform to this seismic line which this line is adjacent the top of Formation 1. The positive turning point M4000P and the negative turning point M4100 is above and under along H80 (Table 5.2) line in the seismic section (Figures 5.6, 5.7, 5.8 and 5.9). That means, the structure in facie development derived from the climate stratigraphic framework is quite uniform the geological structure from the seismic section.

Table 5.2 Relationship of climate stratigraphy into StratPacs, previous top and marker and Seismic Markers.

STRACT-PAC	NBS	PBS	PREVIOUS TOP&MARKER	Seismic Markers
M8000	M8100			
			TOP-2D	
	M7300		M12-15	
	M7200		M12-95	
M7000	M7100		TOP-2C	
	M6400			
			M14-55	
	M6300			
		M6200P	M15-00	
		M6000P	M16-00	H 37
	M6200			
		M6100P	TOP-2B	
			M17-80	
M6000	M6100			
	M5400		TOP-2A	H 44
			M19-50	
	M5300			
	M5200			
			M20-40	
M5000	M5100			
	M4500			H 65
	M4400			
			TOP-FM1	
		M4300P		
	M4300			
		M4000P		
	M4200			H 80
M4000	M4100			
		M3100P2		
		M3000P		
		M3100P1		
M3000	M3100			
		M2200P		
		M2000P		
	M2200			
		M2100P		
M2000	M2100			
		M1000P		
M1000	M1100		TOP-FM0	H 90

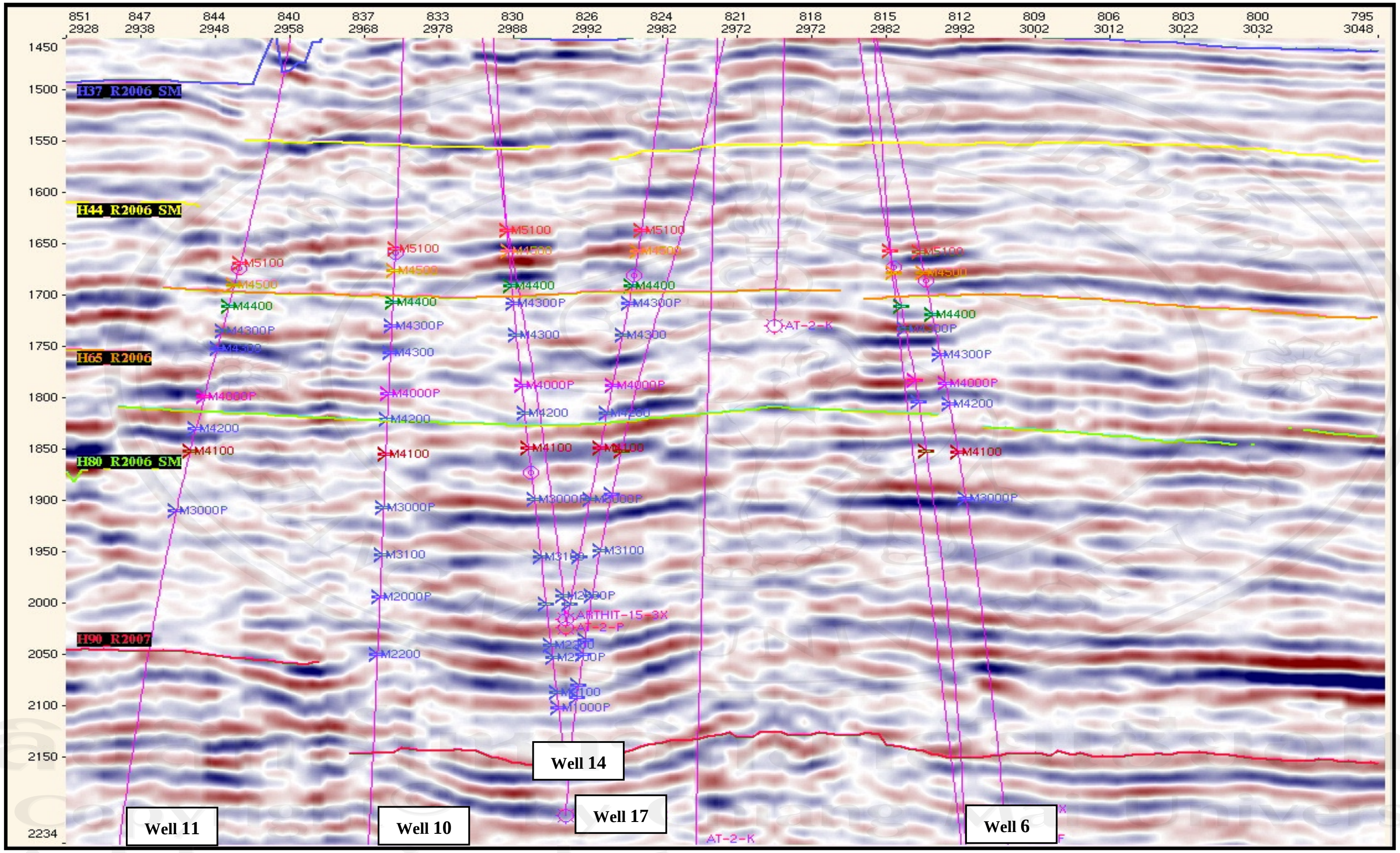

Figure 5.6 Marker from climate stratigraphy derives from the positive or negative turning point, compare with the seismic horizon line, H65, H80 and H90 (wells 11, 10, 14, 17 and 6).

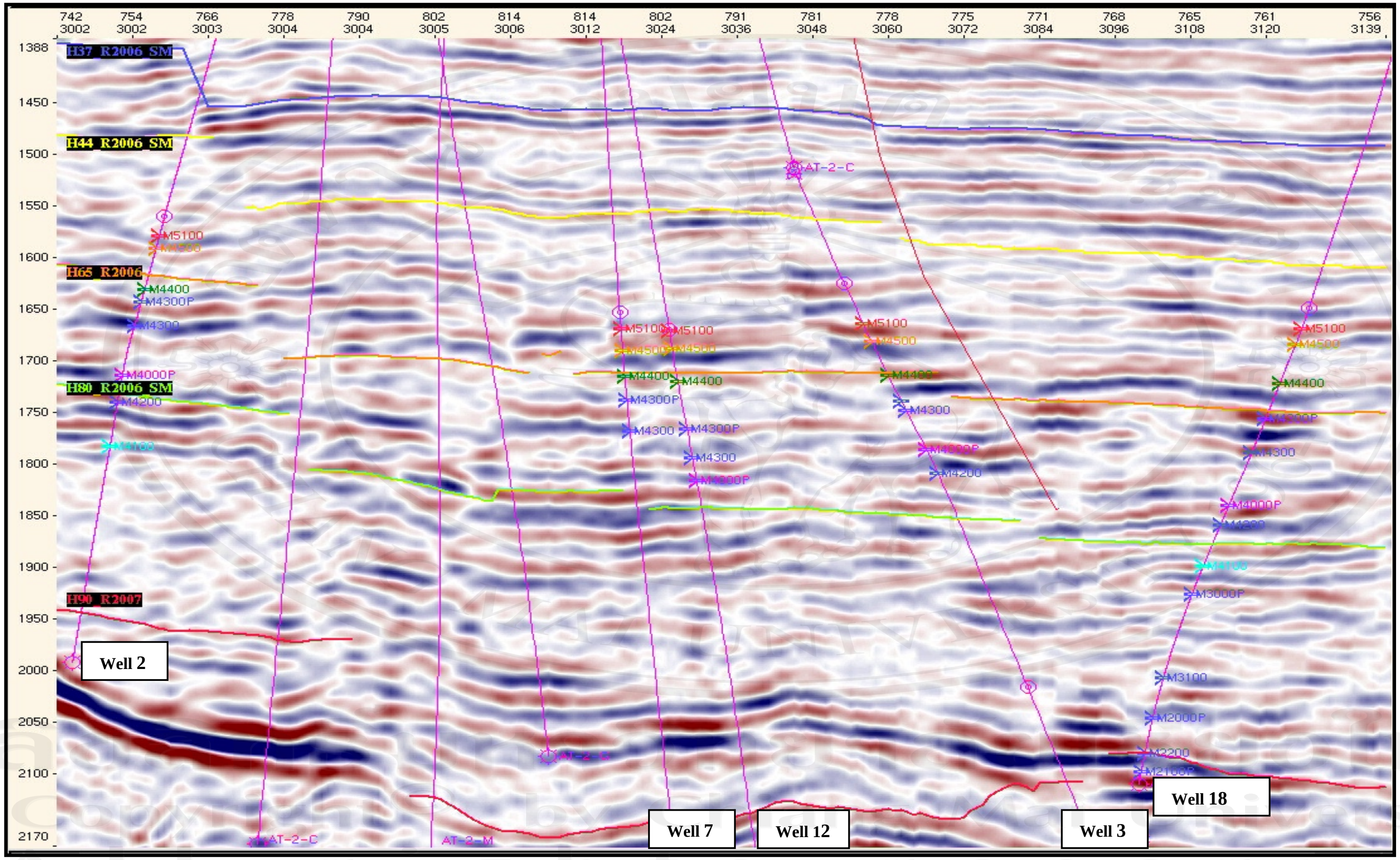

Figure 5.7 Marker from climate stratigraphy derives from the positive or negative turning point, compare with the seismic horizon line, H65, H80 and H90 (wells 2, 7, 12, 3 and18).

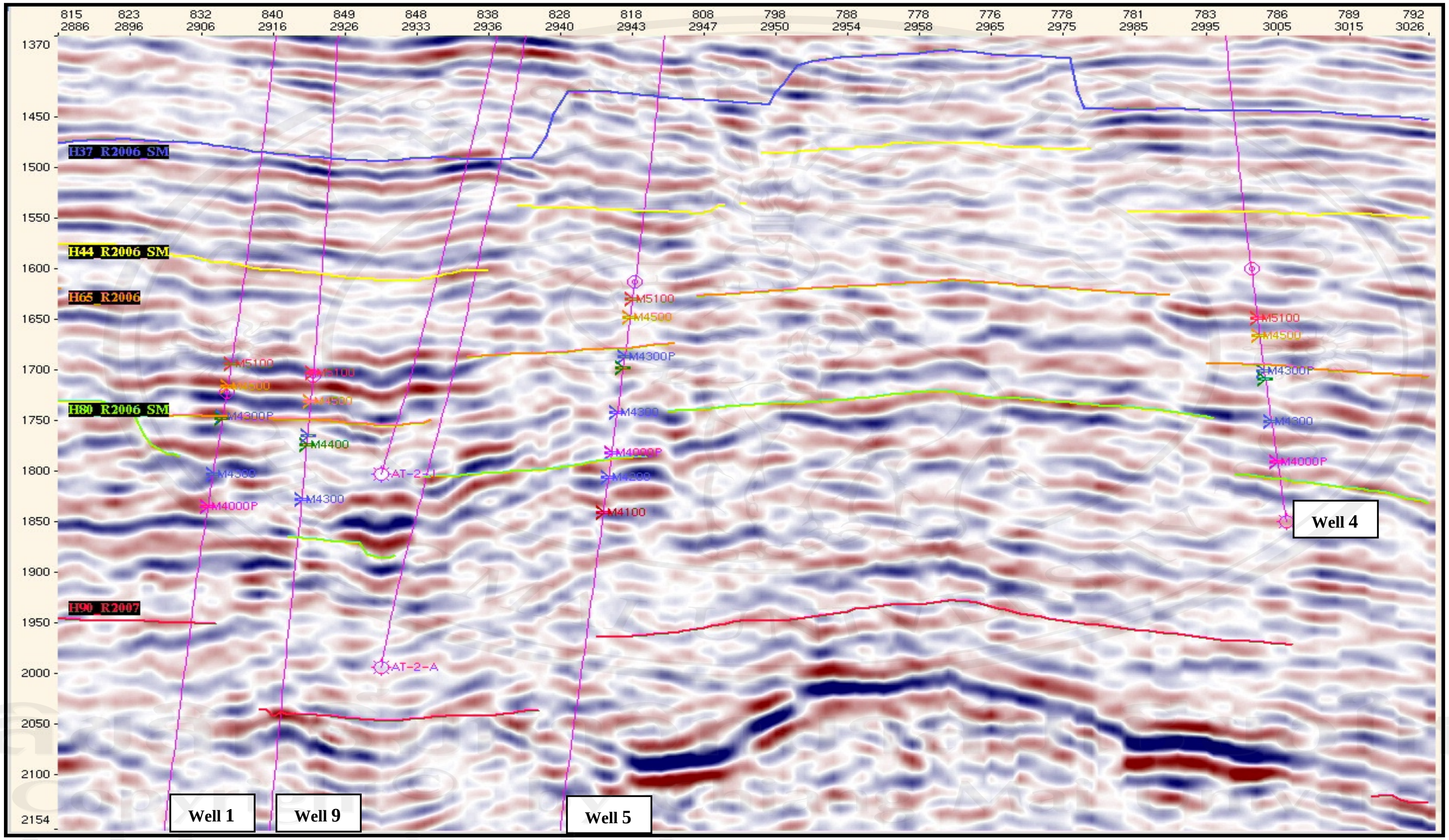

Figure 5.8 Marker from climate stratigraphy derives from the positive or negative turning point, compare with the seismic horizon line, H65 and H80 (wells 1, 9, 5 and 4).

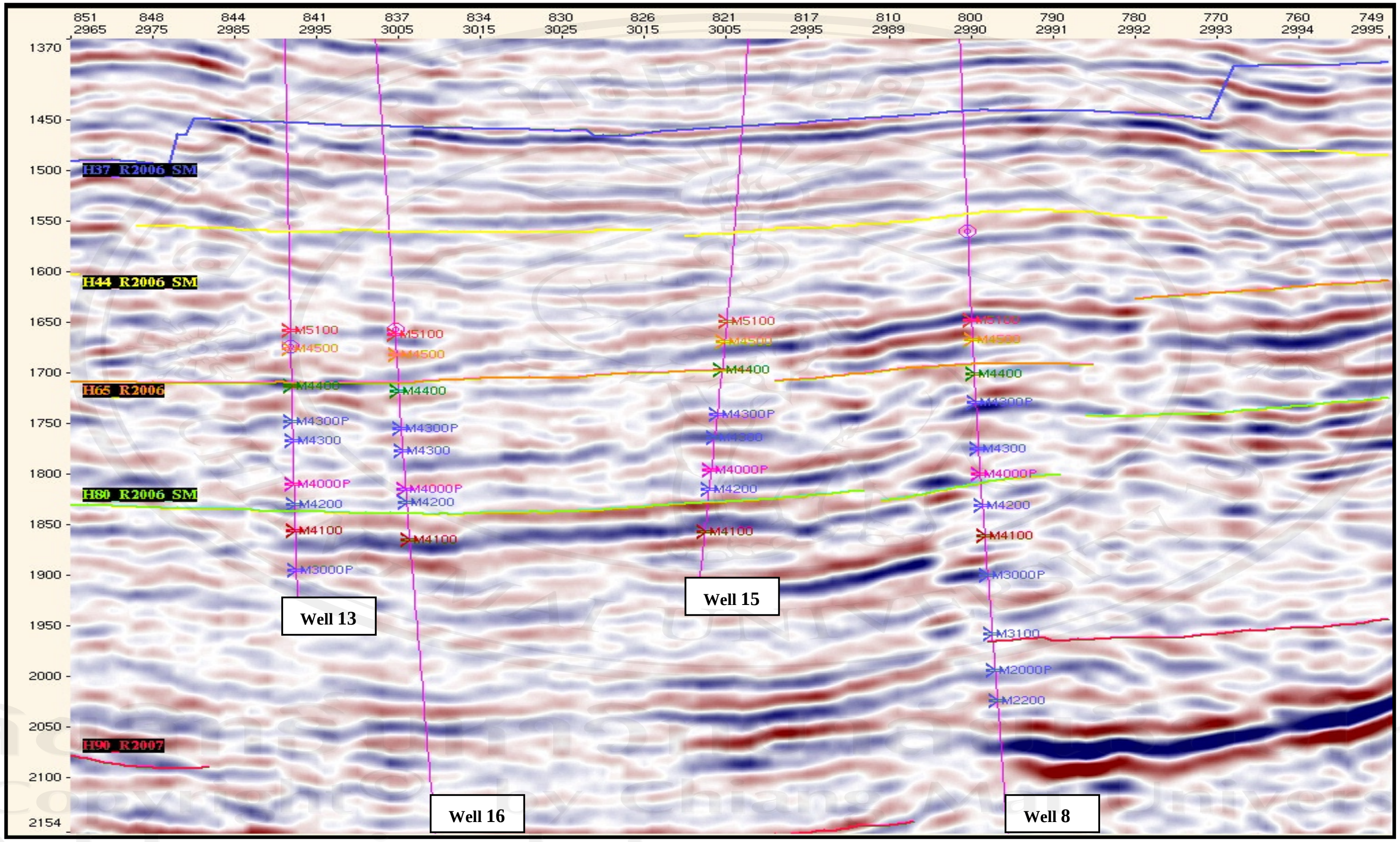

Figure 5.9 Marker from climate stratigraphy derives from the positive or negative turning point, compare with the seismic horizon line, H65, H80 and H90 (wells 13, 16, 15 and 8).

5.3 Relationship of Climate Stratigraphy and Eustatic Sea Level Fluctuation in FM1 and FM2

Climate stratigraphic has related to the eustatic sea level fluctuation. The Long term INPEFA-GR curve in FM1 and FM2 can demonstrate the relationship of Climate stratigraphy and eustatic sea level change related the environment in Arthit area. From the result in this study, Long term INPEFA-GR curve can be divided to 8 lower order StratPacs by the major negative bounding surfaces (NBS) which refer to the major erosional surface and within the StratPacs can be separated by the positive bounding surfaces (PBS) which refer to the major flooding surface.

Figure 5.10, the Long term INPEFA-GR curve of FM 1 show many minor cycles of the negative bounding surfaces and positive bounding surfaces until the major positive turning point at M4000P. This character refer to the lower part of this formation have many minor cycle of sand starved and shale rich, in other word, many cycle of regression and transgression between the NBS M1000 and PBS M4000P . This pattern is conformable with the environment of FM1 which the predominant environment is fluvial-alluvial system. Moreover, after the PBS M4000P, INPEFA-GR curve shows a major positive trend which refer to switching-off of sand supply and shale rich. This interval can be related with the lacustrine environment which is the one of environment in FM1, also.

The Long term INPEFA-GR curve of FM 2 (Figure 5.10) tend to the positive trend until the NPS M7000 (TOP 2C). It refers to the transgressive trend and more marine influent (unit 2A, 2B and 2C). After that trend of the long term INPEFA-GR curve changes to the negative trend. It refer to the regressive trend and less marine influent (unit 2D). It seem likely the previous study, unit 2D and 2E is an overall

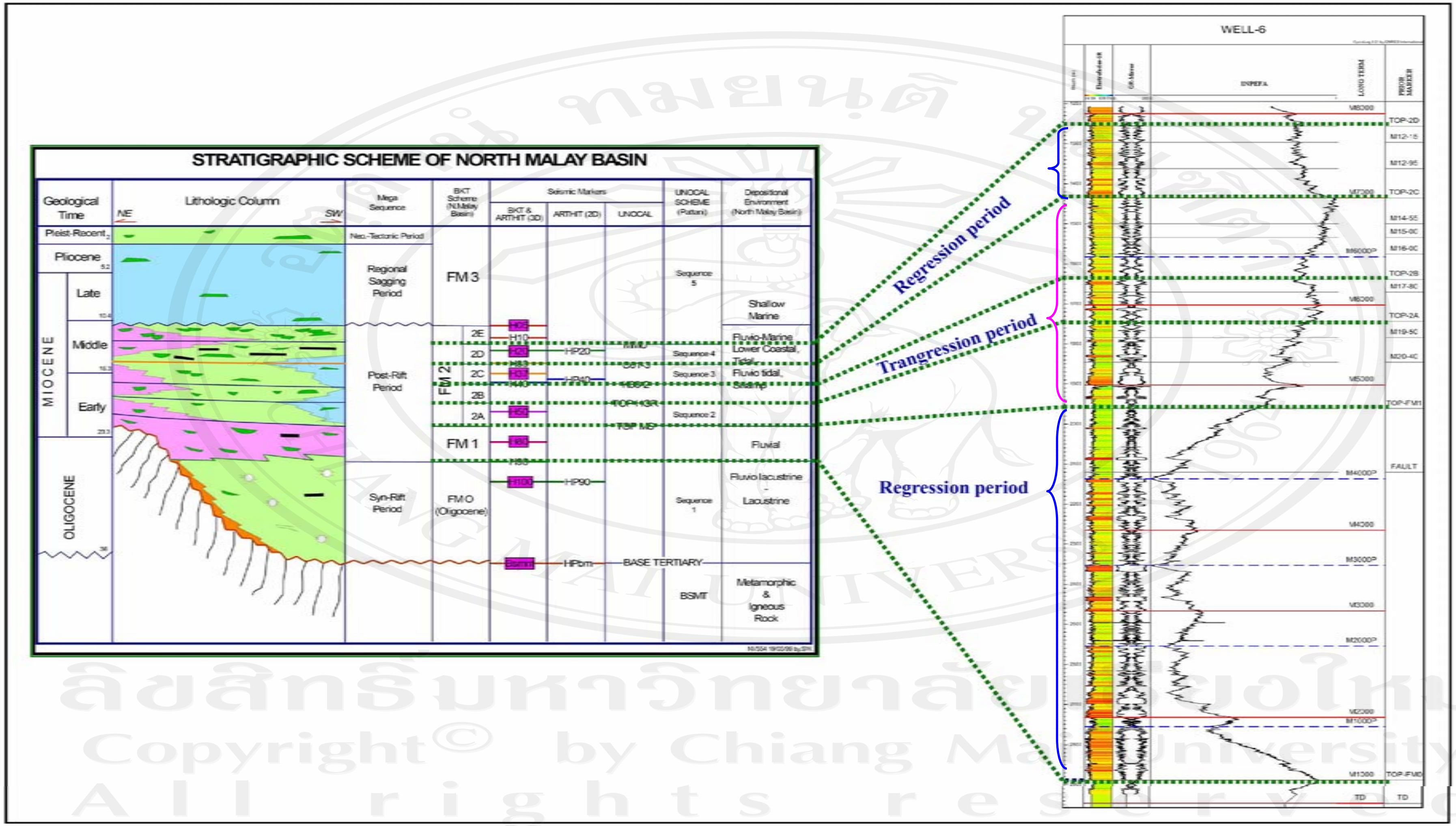

Figure 5.10 The relationship of Climate stratigraphy (represents by Long term INPEFA-GR curve of well 6) and Eustatic Sea Level Fluctuation related to the depositional environment of FM1 and FM2 in Arthit area.

regressive trend, and the lack of low resistivity shale indicates less marine influence than in Units 2A, 2B, and 2C (Turner *et al.*, 2004).

5.4 Application

Climate stratigraphic classification can apply for the reservoir scale in the reservoir correlation. This framework can help to understand sandstone/reservoir deposition in time synchronous which is valuable in the petroleum development plan. The higher-order StratPacs can divide into geologically meaningful unit. Figure 5.11, the identification of marked positive turning-point and negative turning point of INPEFA-GR curve is quite efficient in breaking-down the section into geologically meaningful unit. Positive turning-points represent flooding event characterized by shale lithofacies and their lateral equivalents. Flooding events are likely to have had an impact on a larger than local scale. The negative turning-points represent the erosional surface characterized by sand lithofacies and their lateral equivalent.

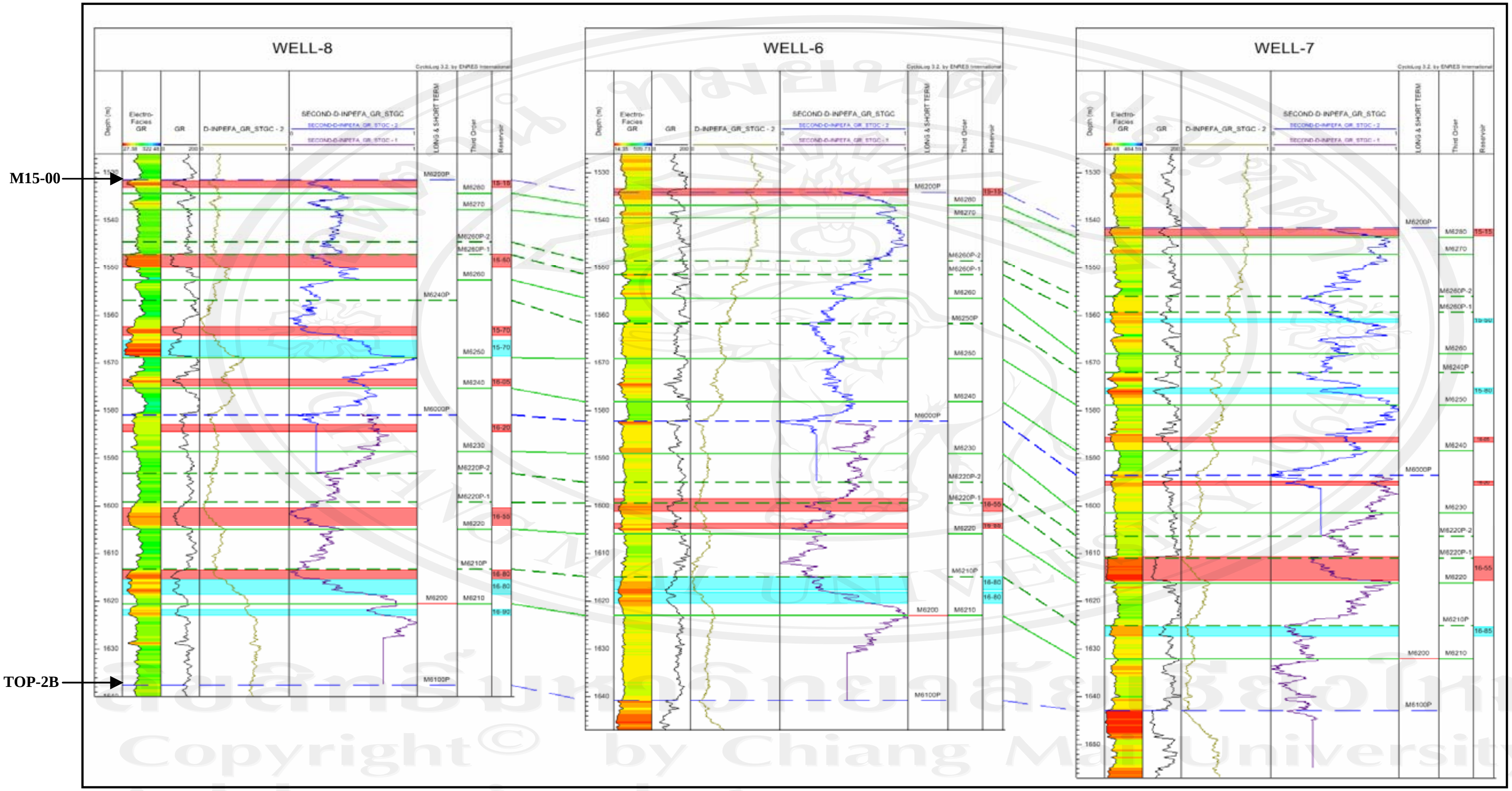

Figure 5.11 Climate stratigraphic correlations in reservoir-scale between Top 2B to-marker M15-00 of well 8, well 6 and well 7. Well separation is approximately 100 m (Blue = Water and Red = Gas).

5.5 Conclusion

Comparison between the Previous Litho-stratigraphy and Climate-stratigraphy in Formation 2 has 2 main points. The first point, Climate-stratigraphy into StratPacs compare with the previous main marker is "good to excellent confidence" due to the StratPacs bounding surface can correlate in all of study well and show the parallel along the previous markers. The second point, Climate-stratigraphy into StratPacs compare with the previous formation top is "fair- good confident", due to either the inconclusiveness of the correlation of the INPEFA-GR curves, or previous top information. However, in some well that high confidence in INPEFA GR curves when correlate with the other well, the INPEFA-GR curves can help to verify and confirm the previous interpretation tops and markers or the previous top and markers also confirm the climate stratigraphy from INPEFA-GR curves.

In the Formation 1, Climate stratigraphy has recognized stratigraphic packages (StratPacs) from the spectral trend, INPEFA-GR curve to 4 lower-order StratPacs and 7 higher-order StratPacs which cannot subdivide by litho-stratigraphy in this formation. That is to say, Climate stratigraphy helps in term of stratigraphic framework to narrow down the range of stratigraphic uncertainty. As well as, the climate stratigraphic correlation presents a near synchronous framework for understanding the lateral facies variation and reservoir correlation. Moreover, it can offers a "structure" for understanding the facies development which is quite uniform the geological structure from the seismic section.