CHAPTER V

PETROLEUM POTENTIAL ASSESSMENTS IN THE HUA HIN BASIN

Petroleum is the major contributors of the world energy supply. The petroleum industry has directly and indirectly initiated, supported, and incorporated much of the accumulated research on sedimentary basins and their contained deposits because of petroleum commonly occurs in sedimentary basin and is absent from intervening areas of igneous and metamorphic rocks. All in all, a sedimentary basin is an area of the earth's crust that is underlain by the thick sequence of sedimentary rocks.

Petroleum are generated by time and thermal maturation of organic matter incorporated within the basin fill. Initial diagenesis of plant and animal debris produces kerogen and further increase in temperature, with time-intergrate thermal flux, kerogen, in time, yields hydrocarbon liquids and the gas. Following generation, the petroleum moves from fine-grained source rocks into adjacent, permeable stratigraphic or structural conduits. Due to the fact that, the long-recognized critical elements for formation of hydrocarbon accumulations include a source, reservoir, trap and seal. Besides, more recent recognition of the important dynamic aspects of oil and gas occurrence has added burial history and migration pathway- to the original list. Depositional system analysis answers questions about reservoir volume and distribution, and probably nature and extent of source and sealing facies. Trap may be produced by structural flexures or discontinuities by facies distribution patterns, or by a

combination of both.

Therefore, the recognition of the dynamic component of petroleum generation and subsurface fluid migration commonly used application of genetic facies studies with the tectonic studies.

In the Upper Gulf of Thailand , the discussion will be focusing upon the Hua Hin basin which is summarized by characteristics of sedimentary facies of source, reservoir trap, seal and proposed model for petroleum generation and maturation and lastly the petroleum potential.

5.1 Source and Reservoir rocks

From the exploration of petroleum company in this area, as no commercial hydrocarbon is present in the Hua Hin basin. However, the result of the study from well-logs of the Phetchaburi-1 well shows that the sedimentary facies are possibly to be the good source rock.

The potential source rocks contain adequate quantities of organic matter to generate significant volume of petroleum. The relatively simple measurement of total organic carbon content (TOC) is widely applied to screen for potential source rocks (Ronov, 1959; Dow, 1978). A commonly accepted minimal TOC content for a potential source rock is 0.4%, values of 1% or more are preferable. Burial and diagenesis of deposited organic matter produces kerogen, the precursor of oil and gas. Kerogen is classified on the basis of chemical composition into 3 types, namely, I, II and III. Type I is an oil-prone kerogen that consists of algal amorphous organic material. Type II kerogen contains a mix of amorphous and herbaceous

organic material and is also and oil-rich precursor. Type III kerogen consists of woody and coaly material, and it yields largely gas upon thermal maturation.

The result of the geochemical analysis of the samples from many ranges of depth of side wall cores of the Phetchaburi-1 well is summarized in Table 5.1.

In summary, the potential source rock of the Hua Hin basin with particular emphasis on the facies A and facies B. These facies are the lacustrine and fluvio-lacustrine facies which deposited in deep part of the basin. Then the petroleum potential of source rocks of the Hua Hin basin are as follow:

(a) Facies A is considered to be of relatively potential petroleum source rock with the average TOD of 4 % varying in the rang off 0.73 to 43.30 % in the coal and grey shale of lacustrine origin. The upper part of the facies A is lacustrine rocks where the analytical data are available is considered to be the potential source rock whereas the lower part is considered to be latent source rock (Barker,1980). Beside, the total thickness of the facies A within the Hua Hin basin is exceeds 2,000 metres.

(b) Facies B is considered to be the limited source rock (Barker,1980) with the TOC of 0.48% in the shale of lacustrine origin. Despite the fact that at least 6 cycles of lacustrine facies of varying thicknesses ranging from 100 to 500 metres are associated with fluvialtile facies, the total volume of the source beds is limited to generate substantial amount of petroleum.

Table 5.1 a The Geochemical analysis data of rocks from the Phetchaburi-1 well.
(after Pradidtan,1987)

Sedimentary Facies			Depth (ft)	(TOC)%	Rock type	Kerogen			Source rock type (Barker, 1980)	Potential Petrolum Source Rock
Symbol	Total of thickness	Depositional Environment				I	II	III		
B	~ 3000′	Fluvio - lacustrine	3086	0.48	shale	no analisis			Limited Source Rock	poor
A	~ 7000′	Lacustrine	9390-9420	4.33	grey shale				Latent Source Rock	good
			9570 9600	43.30	coal					very good
			9690-9720	5.06	grey shale					good
			9960-9990	3.49	grey shale					good
			10885	0.73	grey shale					poor
			10890-10920	1.49	grey shale	9	0	91		fair
			10934	3.35	grey shale	27	0	73		good
			10959.5	1.60	grey shale	34	0	66		fair
			10980-11007	4.00	grey shale	26	0	74		good

5.2 The Petroleum Generation Potential

In general, the principles for the assessment of a sedimentary basin being prospective for petroleum are; the sedimentary depositional environment suitable for quality and quantity of organic matter accumulated in the source-rock facies, the nature of sedimentary deposition with respects to the reservoir rock facies and seals, the sufficient burial and thermal history of the source rock to enable convection of kerogen into hydrocarbons followed by the effective migrating, and primary sedimentary features to provide stratigraphic trap and/ or tectonic event to provide structural trap timely for migrating hydrocarbons.

On the whole, sedimentary basins with about 3 kilometres or more in thickness and an average normal temperature gradient of 3 °C/100 metres can generally be judged as oil prospective. The Hua Hin basin with about 5 kilometres thick of sediments covering 1,000 square kilometres area can generally be considered to be the petroleum-bearing potential. In addition, the heat flow value of the Hua Hin basin is 3.5°C/100 metres. The potential source rock facies in the Hua Hin basin is lacustrine facies of Oligocene to Early Miocene in age. However, the state of maturity of purposed active source-rock facies has to be determined using the methods of Lopatin and Waples.

Lopatin's method has developed for tacking both time and temperature into account as factors in thermal maturation of kerogen (Waples,1980). The time-temperature index of maturity (TTI) values correlate with the thermal regimes corresponding to generation and

preservation of hydrocarbons. The conceptual framework can be summarized as follows:

a. The rate of the chemical reaction involved in thermal maturation of organic material appears to double with every 10 degree °C rise in temperature.

b. Threshold values of Lopatin's time-temperature index of maturity (TTI) are:

15	Onset of oil generation
75	Peak oil generation
160	End of oil generation
500	Upper TTI limit for occurrence of oil with API gravity <40
1,000	Upper TTI limit for occurrence of oil with API gravity <50
1,500	Upper TTI limit for occurrence of wet gas
65,000	Last known occurrence of dry gas

c. TTI values calculated from Lopatin reconstruction consistently agree with other maturation parameters commonly used by petroleum geologists.

The geological models were constructed using the information of the seismic section line T-81-26 A (Fig. 5.2 a) which lies W to E and cross-cut the Phetchaburi-1 well. The geological models for every horizon which is equivalent to the specific rock formation of the Hua Hin basin have been constructed using subsurface temperature, depth, and geological time. The geothermal gradient of the Hua Hin basin measured from the Phetchaburi-1 well is about 3.45°C/100 metres, and the average surface themperature is 21°C. The three geological models are presented in Figures 5.2 b, c & d. The calculated results from

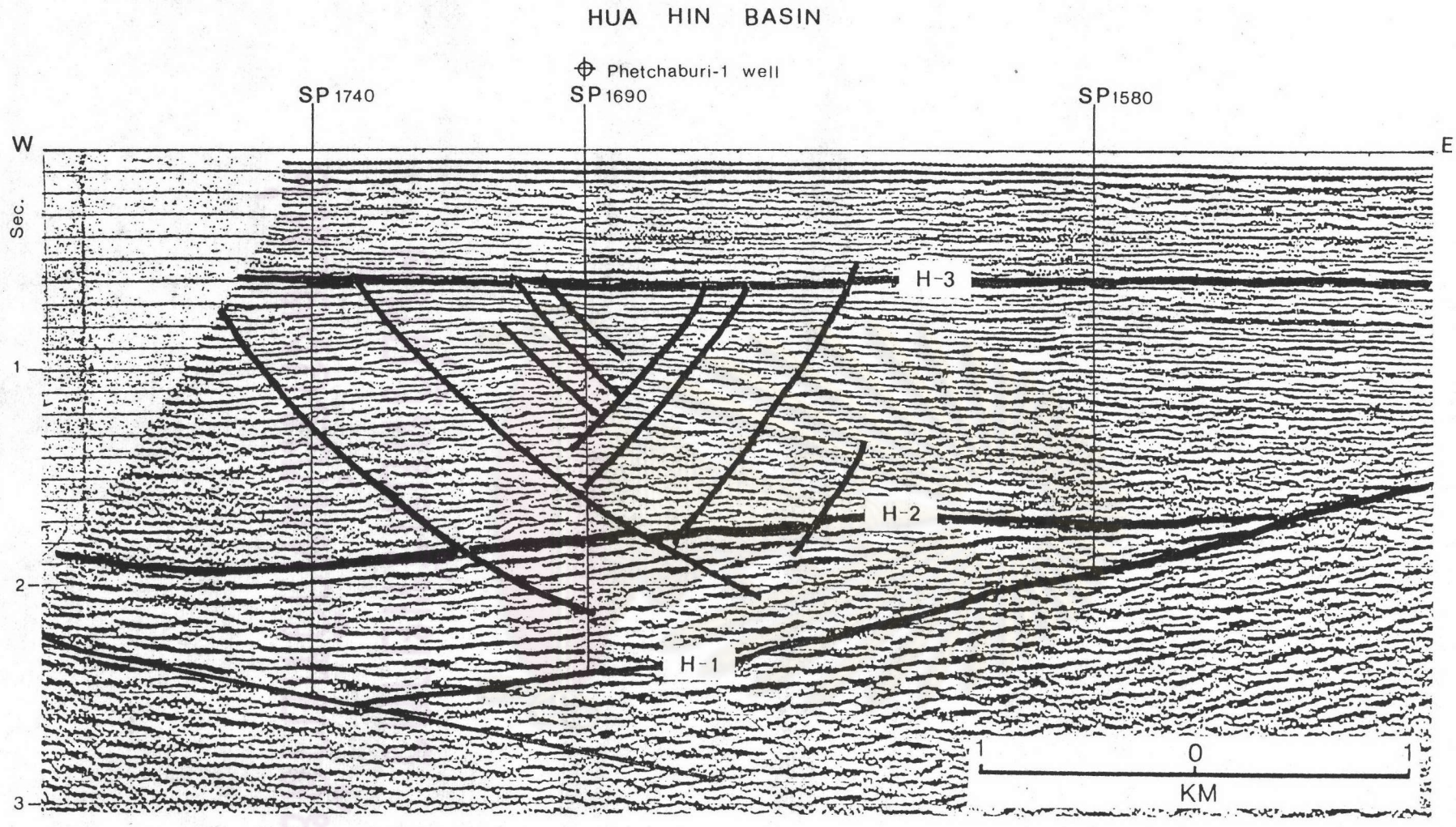

Figure 5.2 a Seismic section line no.26A showing the locations of few shot-points were selected to study.

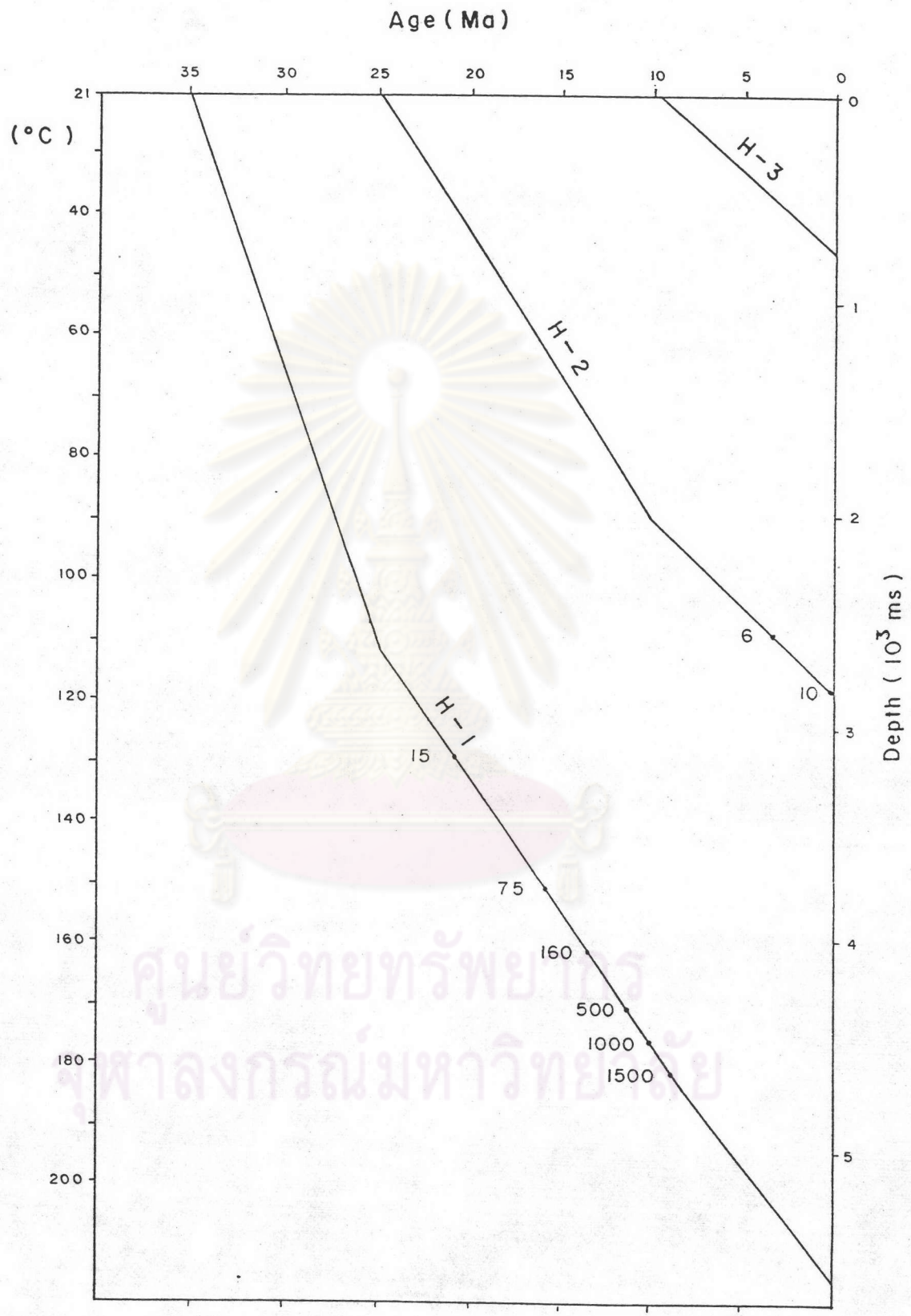

Figure 5.2 b Burial History graph of the Hua Hin basin of short-point 1630.

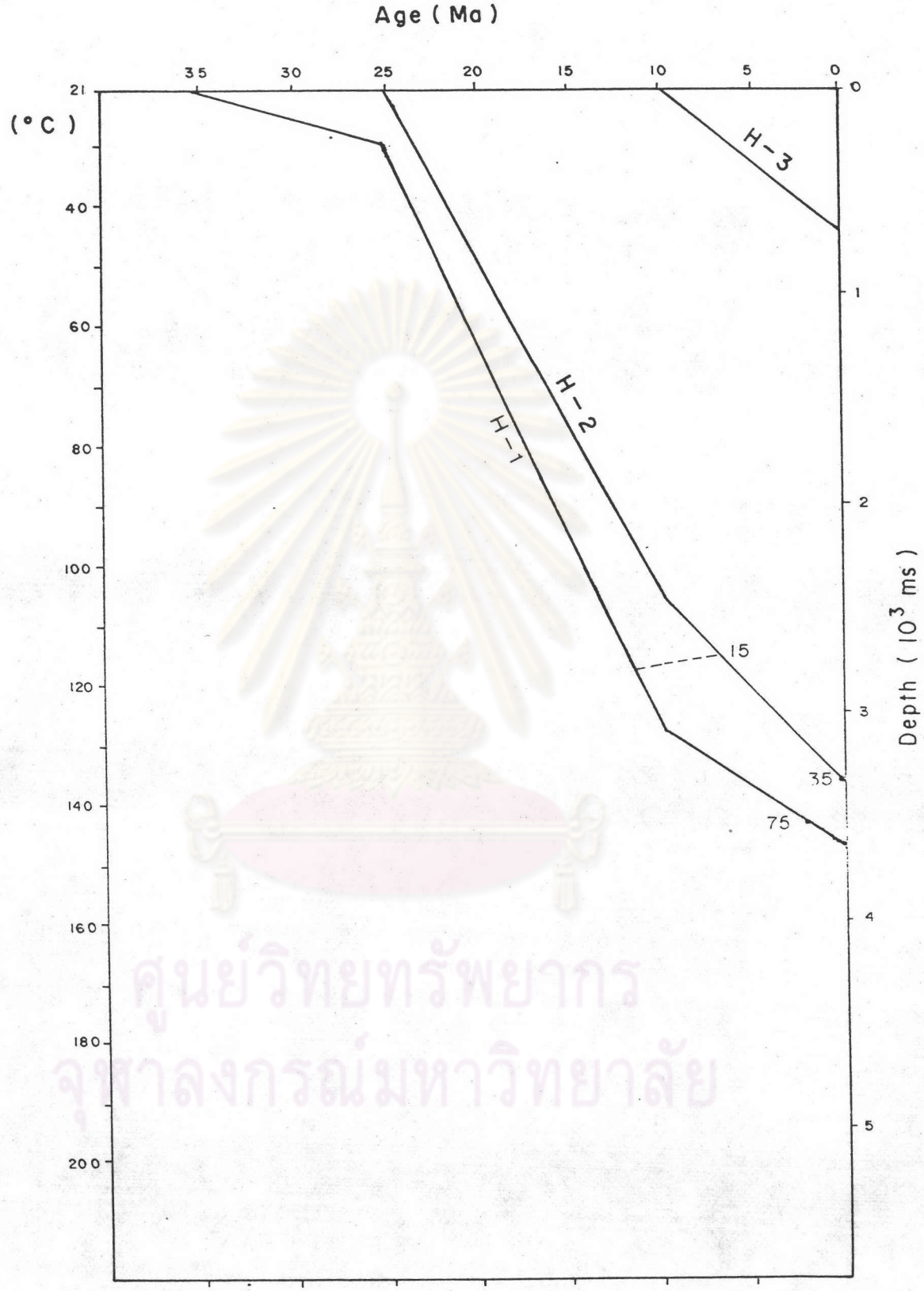

Figure 5.2 c Burial History graph of the Hua Hin basin of short-point 1580.

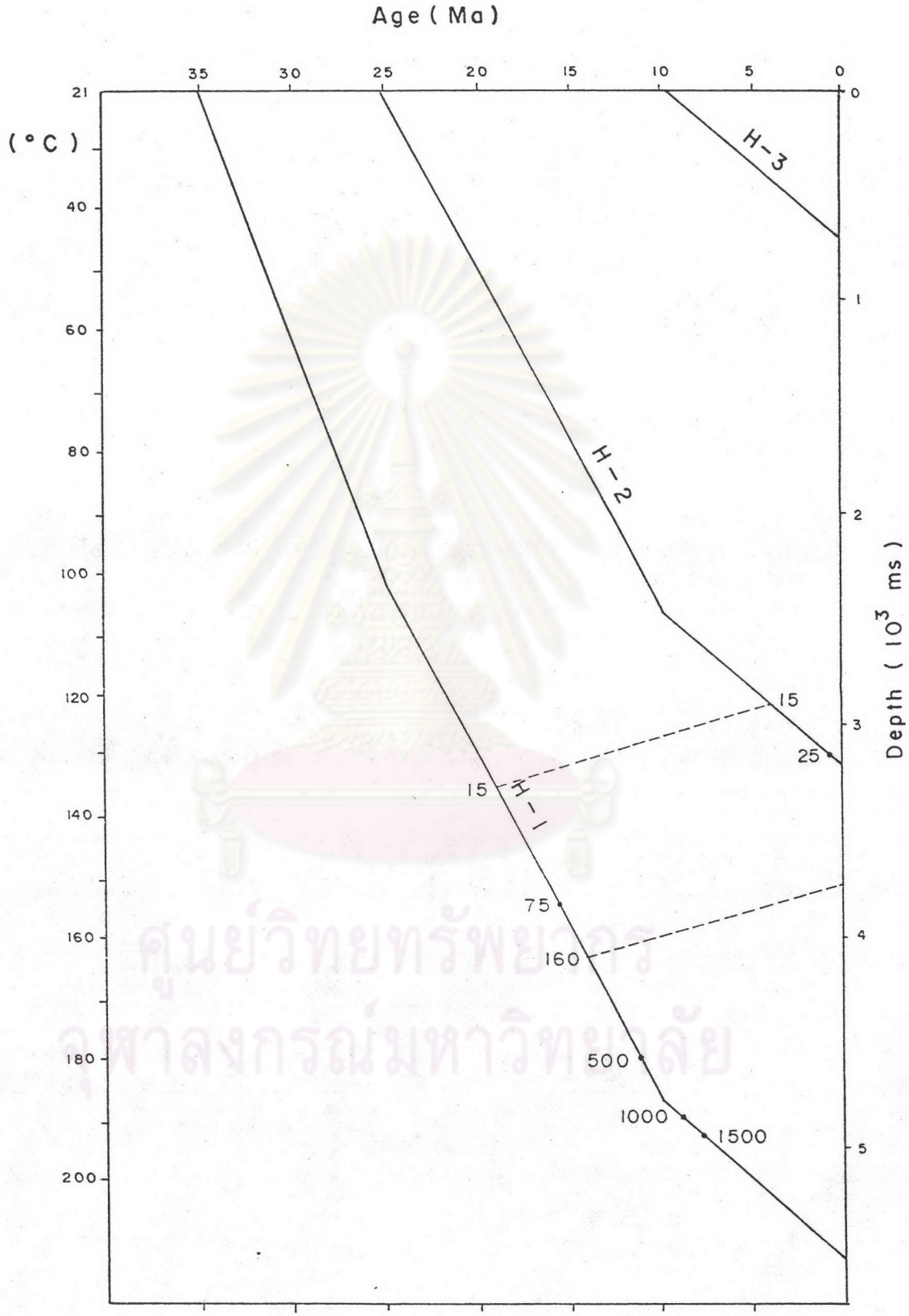

Figure 5.2 d Burial History graph of the Hua Hin basin of short- point 1740.

these three geological models are summarized in Tables 5.2 a, b & c.

The TTI value indicates that the petroleum can be generated between the depth of about 2,900 to 3,700 metres. The oil can be generated between the Early Miocene to the Middle Miocene from the lacustrine facies of Nong Kae Formation, and the Lacustrine facies of the lower part of the Phetchaburi Formation. The source rock facies is the lacustrine sediments which are likely to be present in the lower part of the basin.

5.3 The Petroleum Potential of the Hua Hin Basin

Considering the sedimentary facies and sedimentary volume of the Tertiary sediments in the Hua Hin basin, the availability and quality of suitable source rock is the lacustrine facies of the Nong Kae and Phetchaburi Formations. The study of maturity of source rock defines the oil window between the depth of 2,900 to 3,700 metres beneath the sea-bed. Therefore, the kitchen area is confined only to the lower part of the basin. The absence of petroleum in the exploration wells drilled at the basement-high areas in the Upper Gulf is possibly due to fact that the petroleum generated in the lower part of basin may not be migrated to these areas.

The preliminary evaluation of potential reservoir of the Cenozoic succession within the Hua Hin basin reveals that the fluvio-lacustrine facies of the Phetchaburi Formation with porosity of 10-15% and the fluviatile facies of the Krabang Formation with porosity of 17-30% are promising. However, the geometry of the fluviatile sand body is of shoe-string type which are likely to be discontinuous, and limited in extent. The absence of petroleum in the fluvialtile

Table 5.2 a TTI values of Phetchaburi-1 well of Hua Hin basin of short point 1630 on seismic section line no 26A. (see Fig.4.4.2 for location)

Temperature interval (°C)	Time interval	Temperature factor	Interval TTI	Total TTI
Horizon-1				
20-30	1.0	0.003906	0.003906	
30-40	1.0	0.007813	0.007813	0.011719
40-50	1.4	0.015625	0.021875	0.033594
50-60	1.0	0.03125	0.03125	0.064844
60-70	1.1	0.0628	0.06875	0.133594
70-80	1.2	0.125	0.15	0.283594
80-90	1.1	0.25	0.275	0.558594
90-100	1.2	0.5	0.6	1.158594
100-110	1.0	1	1	2.158594
110-120	2.0	2	4	6.158594
120-130	2.4	4	9.6	10.758594
130-140	2.3	8	18.4	29.158594
140-150	2.3	16	36.8	65.958594
150-160	2.0	32	64.0	129.958594
160-170	2.4	64	153.6	283.558594
170-180	2.3	128	294.4	577.958594
180-190	2.7	256	691.1	1269.158594
190-200	2.6	512	1331.2	2600.358594
200-210	2.4	1024	2457.6	5057.958594
210-220	1.6	2048	3276.8	8334.758594
Horizon-2				
20-30	2.0	0.003906	0.007812	
30-40	2.0	0.007813	0.015626	0.023438
40-50	1.7	0.015625	0.026562	0.050000
50-60	2.7	0.03125	0.084375	0.134375
60-70	2.0	0.0625	0.125	0.259375
70-80	2.3	0.125	0.2875	0.546875
80-90	2.3	0.25	0.575	1.121875
90-100	3.4	0.5	1.7	2.821875
100-110	3.3	1	3.3	6.121875
110-120	3.3	2	6.6	12.721875
Horizon-3				
20-30	3.6	0.003906	0.0148	
30-40	3.8	0.007813	0.0297	0.0445
40-50	2.6	0.015625	0.0406	0.0851

Table 5.2 b TTI values of short point 1580 on seismic section line no. 26A of the Hua Hin basin. (see Fig.4.4.2 for location)

Temperature interval (°C)	Time interval	Temperature factor	Interval TTI	Total TTI
Horizon-1				
20-30	2.0	0.003906	0.007812	
30-40	1.7	0.007813	0.013282	0.021094
40-50	1.7	0.015625	0.026562	0.047657
50-60	1.6	0.03125	0.05000	0.097657
60-70	1.7	0.0625	0.1062	0.203857
70-80	1.7	0.125	0.2125	0.416357
80-90	1.6	0.25	0.400	0.816357
90-100	2.0	0.5	1.0	1.816357
100-110	2.4	1	2.4	4.216357
110-120	1.6	2	3.2	7.416357
120-130	2.7	4	10.8	18.216357
130-140	4.0	8	32.0	50.216357
140-150	3.3	16	52.8	103.016357
Horizon-2				
20-30	1.7	0.003906	0.006640	
30-40	2.7	0.007813	0.02109	0.02773
40-50	1.6	0.015625	0.0250	0.05273
50-60	2.0	0.03125	0.0625	0.11523
60-70	2.0	0.0625	0.125	0.24023
70-80	1.7	0.125	0.21	0.45023
80-90	2.0	0.25	0.50	0.95023
90-100	1.3	0.5	0.65	1.60023
100-110	2.7	1	2.7	4.30023
110-120	3.3	2	6.6	10.90023
120-130	3.0	4	12.0	22.90023
130-140	2.0	8	16.0	38.90023
Horizon-3				
20-30	4	0.003906	0.0156	
30-40	4	0.007813	0.0313	0.0469
40-50	2	0.015625	0.0313	0.0782

Table 5.2 c TTI values of short point 1740 on seismic section line no. 26A of the Hua Hin basin. (see Fig.4.4.2 for location)

Temperature interval (°C)	Time interval	Temperature factor	Interval TTI	Total TTI
Horizon-1				
20-30	1.0	0.003906	0.003906	
30-40	1.7	0.007813	0.013282	0.017188
40-50	1.0	0.015625	0.01562	0.032813
50-60	1.3	0.03125	0.040625	0.073438
60-70	1.4	0.0628	0.08792	0.161385
70-80	1.0	0.125	0.125	0.286358
80-90	1.6	0.25	0.4	0.686358
90-100	1.0	0.5	0.5	1.186358
100-110	1.7	1	1.7	2.886358
110-120	1.7	2	2.4	5.286358
120-130	1.6	4	6.4	11.686358
130-140	1.7	8	13.6	25.286358
140-150	1.7	16	27.2	52.486358
150-160	2.0	32	64.0	116.486358
160-170	2.0	64	128.0	244.486358
170-180	1.6	128	204.8	449.286358
180-190	2.4	256	614.4	1063.686358
190-200	1.5	512	768.0	1831.686358
200-210	4.0	1024	4096.0	5927.686358
210-220	1.0	2048	2048.0	7975.686358
Horizon-2				
20-30	1.7	0.003906	0.0066402	
30-40	1.7	0.007813	0.0132821	0.0199223
40-50	1.6	0.015625	0.0250	0.0449223
50-60	2.0	0.03125	0.0625	0.1074223
60-70	2.0	0.0628	0.1256	0.2330223
70-80	1.4	0.125	0.175	0.4080223
80-90	2.0	0.25	0.5	0.9080223
90-100	1.6	0.5	0.8	1.7080223
100-110	2.7	1	2.7	4.4080223
110-120	4.0	2	8.0	12.4080223
120-130	3.3	4	13.2	25.6080223
130-140	1.0	8	8.0	33.6080223
Horizon-3				
20-30	3.8	0.003926	0.0148	
30-40	3.8	0.007813	0.0297	0.0445
40-50	2.4	0.015625	0.0375	0.8020

sediments in both formations of the Phectchaburi-1 well might be explained by the selective petroleum-barren shoe-string sand bodies. It is concluded that there might be some petroleum-bearing shoe-string sand bodies in the basin where petroleum was migrated from the underneath sources rocks of the Nong Kae Formation and lower part of Phetchaburi Formation.

It is noted that, the possibility of petroleum potential in the pre-Cenozoic limestone basement rocks where both source rocks and reservoir rocks of different geological setting from those of Cenozoic deposits of the Hua Hin basin is also promising. However, there is no concrete evidence to support this hypothesis.

The Hua Hin basin is the structural control basin developed by the listric normal faults. The petroleum, which was generated and accumulated in the basin, may be trapped by the listric normal faults. Besides, structural configurations within the listric normal faults in this basin including roll-over anticlines and antithetic faults may form hydrocarbon traps. The listric normal faults developed during the sedimentation of the Nong Kae Formation and the Phetchaburi Formation, and was ceased at the Late Miocene time. Therefore, structural hydrocarbon traps in the Hua Hin basin are possibly present in the Nong Kae Formation and Phetchaburi Formations.

Although, no commercial hydrocarbon was found in the Hua Hin basin from the exploration of Pecten Company ,but the information of the quality of source rocks, the maturity of sources rocks, the potential of reservoir rocks including structural and stratigraphic

traps suggest that the possibility to discover petroleum in the Hua Hin basin is still open. Besides, the petroleum potential in the pre-Cenozoic basement rocks at relatively greater depths is also promising.