CHAPTER 5

UNDISCOVERED RESOURCES ASSESSMENT IN THE THAI-VIETNAM OVERLAPPING AREA.

5.1 Introduction

Result from investigation of source rock potential indicate that the Thai-Vietnam overlapping area is a potential area for oil and gas accumulation, and probably there is an undiscovered resources in its area. Therefore, there is a need for an assessment of undiscovered petroleum resources in this overlapping area.

The assessment of undiscovered petroleum resources in the Thai-Vietnam overlapping area is performed using FASPU program and play analysis approach. Data used in the assessment were collected from its adjacent areas; the north, the west, and the south of study area. Well name and its location are shown in Table 5.1. Reservoir engineering variables and reservoir fluid properties used in the study are summarized in Table 5.9 and 5.10.

5.2 The consideration for defining the variables and geologic attributes for the Thai-Vietnam overlapping area.

Table 5.1 Well names and their location used in this study.

Well name	Location of well	
	longtitude	latitude
Yala-2	101-26-40	9-59-40
Kaphong-3	101-44-40	9-48-54
Kaphong-1	101-27-25	9-45-34
Platong-5	101-23-20	9-44-05
Platong-1	101-24-16	9-42-36
Platong-8	101-22-47	9-42-13
Surat-1	101-20-33	9-41-07
Ranong-1	101-26-40	9-40-43
Kung-1	101-13-43	9-38-08
S. Platong-1	101-24-05	9-31-51
Pakarang-1	101-17-41	9-26-30
Pladang-3	101-23-43	9-24-38
Insea-1	101-09-00	9-25-08
S. Platong-2	101-25-45	9-23-40
Trat-1	101-32-25	9-21-29
satun-2	101-23-56	9-20-00
satun-1	101-24-29	9-44-40
Erawan 12-9	101-20-22	9-11-40
Dara-1	101-14-09	9-10-22
Satun-3	101-24-16	9-10-56
Erawan 12-1	101-19-39	9-08-43
Erawan 12-8	101-20-44	9-07-25
Erawan 12-7	101-20-22	9-03-43
Krut-1	101-13-09	9-05-45
Erawan K-1	101-20-00	9-04-29

Table 5.1 Well names and their location used in this study (continued)

Well name	Location of well	
	longtitude	latitude
Jakrawan-2	101-32-25	9-02-02
Jakrawan-1	101-32-14	9-54-54
Jakrawan-13	101-30-03	9-56-36
Jakrawan-15	101-29-56	9-01-26
Jakrawan-B-1	101-31-40	9-02-38
Jakrawan-B-3	101-31-41	9-02-37
Jakrawan-B-7	101-33-01	9-03-10
Jakrawan-D-4	101-34-08	9-04-11
Jakrawan-D-9	101-33-39	9-04-46
Funan-1	101-37-07	8-54-34
Funan-A2	101-36-49	8-56-06
Funan-A11	101-36-51	8-54-23
Funan-17	101-34-56	8-52-16
Funan-18	101-36-01	8-53-50
Funan-F8	101-36-43	8-54-02
Baanpot-1	101-24-15	8-53-33
Baanpot B-1	101-25-00	8-52-45
15-B-13X	102-16-21	8-03-52
Ton Koon-1X	102-45-55	9-31-28
Ton Sak-2	102-24-21	8-06-32
Ton Sak-4	102-22-13	8-05-56
Ton Nokyoong-1X	102-53-10	7-41-10
Pilong	103-05-27	7-10-55
17-B-1	102-35-49	7-35-49

As previous mention in Chapter 3, the three geological attributes that concern with the petroleum resources assessment are; 1) play attributes, 2) prospect attributes and 3) hydrocarbon volume parameters.

From the result of the study of geological, geophysical, geochemical and petroleum reservoir engineering, we can defined the attributes and the probability for various cases as showed in Table 5.2 by using these supporting reasons as follows;

5.2.1 Play attributes

Play type of this Thai-Vietnam overlapping area is Miocene Faulted Sand Play and it is the conceptual play because there are not wells have drilled in this area. As an evidence of previous works and the distribution maps of the possible source rock in the Pattani Trough and the north Malay basin area (Figure 4.7-4.14), source rock may extend and cover the Thai-Vietnam overlapping area. Moreover, there are many production fields around the this overlapping, such as in the north, the west and the south of this overlapping area. Therefore, this assessment is defined the probability of there is the existence of a hydrocarbon source and there is the potential reservoir facies in this area are both equal to 1.0.

The probability of there are the favorable timing for migration from source to the reservoir and there is the favorable effective migration path to the reservoir are both defined to equal to 1.0. This is because hydrocarbon usually move from the low

Project Name : Petroleum Assessment on the Thai-Vietnam Overlapping Area
Play Name : Miocene Faulted Sandstone

Play Attributes Probability

Hydrocarbon source	: 1
Timing	: 1
Migration	: 1
Potential Facies	: 1
Lithology	: Sandstone
Trapping mechanism	: 0.80
Hydrocarbon accumulation	: 0.80
Effective porosity	: 0.90
Hydrocarbon type probability for gas	: 0.80

Table 5.2 Play attributes probability and geologic attributes of the Thai-Vietnam overlapping area.

level to higher level, and this overlapping area is located on the high-structure (Figure 2.2).

Therefore, the marginal play probability for this area which is the product of the probability of source rock potential, timing, migration path and the potential of reservoir rock. Then, the marginal play probability in this study is equal to 1.0

5.2.2 Prospect attributes.

The probability of trapping mechanism is good in general because there are thick shales sealed the petroleum in vertical (vertical seal). However, there are some leaking of petroleum along fault planes during trapped structures were found. Therefore, the probability of trapping mechanism should be equal to 0.8.

The probability of the effective porosity is equal to 0.9 because data from drilled-well indicated that the average porosity is normally high.

The probability of hydrocarbon accumulation is equal to 0.9 because the overlapping area closed to the petroleum kitchen area which is located at the center of Pattani Basins and Malay Basins at the depth of 1.7 seconds of seismic data [41, 55]. Therefore, the chance that petroleum will migrate to trapping structures is high too.

5.2.3 Hydrocarbon Volume Parameters.

Type of reservoir rock.

The reservoir rock of this overlapping area is the sandstone of unit III which are deposited in floodplain, channel and deltaic environment. This study set the proportion of hydrocarbon mix as 0.8 of natural gas and as 0.2 of oil by comparing with the 3 wells drilled in Joint Developing Area [JDA], which are 2 wells of natural gas and 1 well of oil. The result from kerogen type analysis indicated that the kerogen type of source rock is type I and type III which accorded with the result of vitrinite reflectance analysis (Table 5.3) and percent TOC and EOM analysis (Table 5.4), indicate that there may be some oil in this area.

Table 5.3 Results of Total Organic Carbon (TOC, percent) and Extractable Organic Matter (EOM, ppm.) of 17-B-1 well.

Depth (ft)	TOC (percent)	EOM (ppm.)
4020	0.35	-
4475	1.04	648
4950	0.54	237
5550	1.41	1444
5775	0.64	386
6000	0.93	0
6375	1.17	839
6800	0.81	0
7300	1.11	162
7800	34.59	0

Table 5.4 Results of Vitrinite reflectance (Ro) analyses of 17-B-1 well.

Depth (ft)	Vitrinit Reflectance (Ro)
4020	0.43
4475	0.43
4950	0.45
5550	0.48
5775	0.49
6000	0.53
6375	0.56
6800	0.62
7300	1.29
7800	1.5

Therefore, the conditional deposit probability which equal to the product of the probability of trapping mechanism x probability of effective porosity x probability of hydrocarbon accumulation is 0.8 x 0.9 x 0.8 = 0.576

For hydrocarbon volume and the number of prospect can consider and calculate from the plot of data and observe its distribution and predict the favorable value on the basis of;

: The distribution of area of closure is lognormal distribution because the big or large prospects usually have the distribution and number less than the small prospects (Figure 5.1 and Table 5.5). Next, enter the value at the fractile of 95^{th}, 7^{th}, 50^{th}, 25^{th}, 25^{th} and 5^{th} to FASPU program. For the value at fractile of 100^{th}, the smallest prospect is used. On the other hand, size of the largest prospect is used as the value at fractile of 0^{th}.

Table 5.5 Statistics of area of closure (thousand acre) of the adjacents areas of the Thai-Vietnam overlapping area.

Size Class (Thousand Acre)	Frequency	Cumulative Greater Than %
1	11	100.00
2	11	67.65
3	4	35.29
4	2	23.53
5	1	17.65
6	1	14.71
7	2	11.76
8	0	5.88
9	2	5.88

: The thickness of reservoir/vertical closure can be taken from the data distribution which is the normal distribution type (Figure 5.2 and Table 5.6).

Table 5.6 Statistics of reservoir thickness (ft) of the adjacent areas of the Thai-Vietnam overlapping area.

Thickness Class (ft)	Frequency	Cumulative Greater Than Percent
5	79	100.00
10	78	68.65
15	30	37.70
20	21	25.79
25	13	17.46
30	11	12.30
35	7	7.94
40	6	5.16
45	4	2.78
50	1	1.19
55	1	0.79
60	0	0.40
65	0	0.40
70	1	0.40

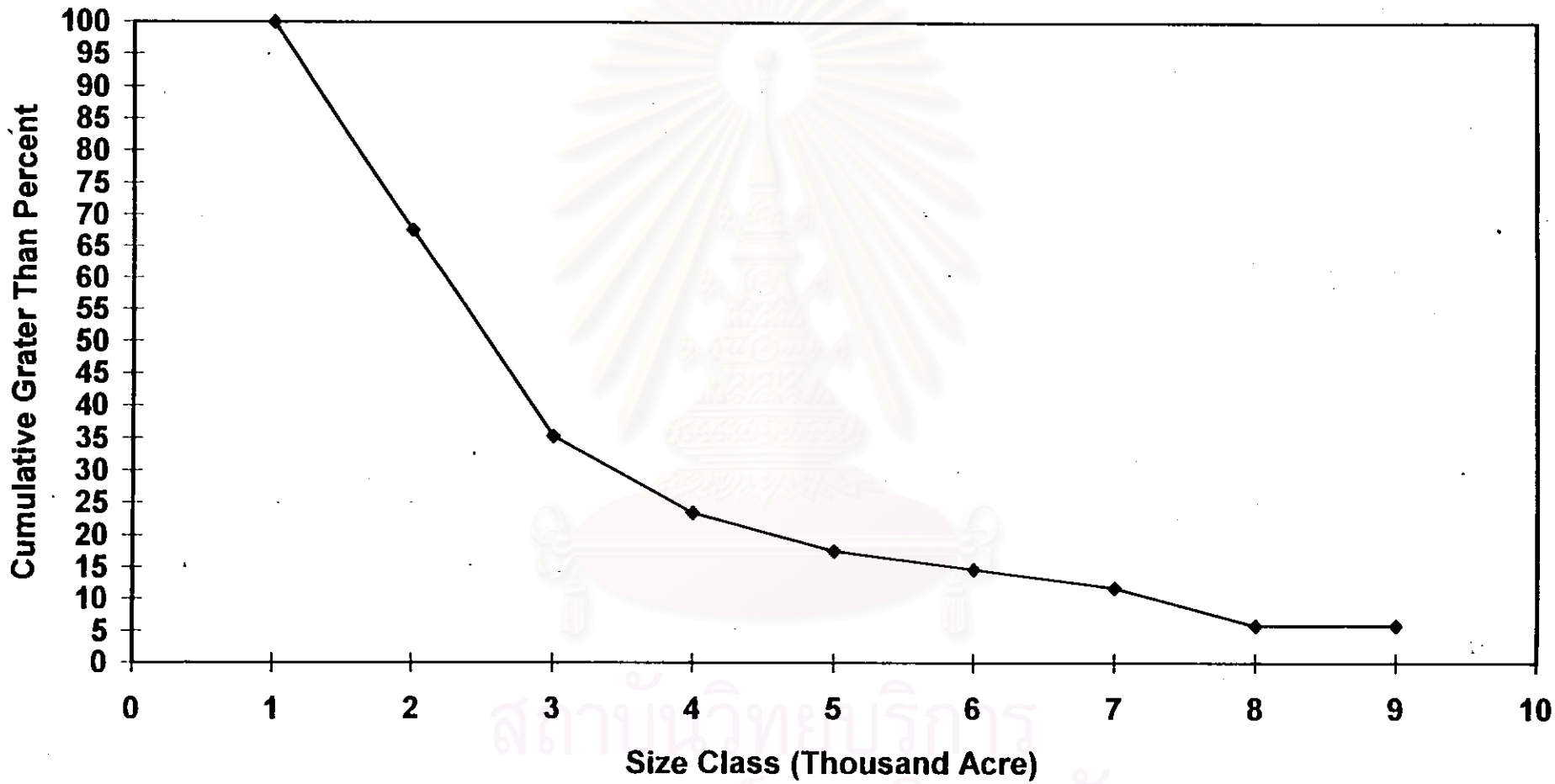


Figure 5.1 Cumulative greater than percent of the area of closure of the adjacent ares of the Thai-Vietnam overlapping area

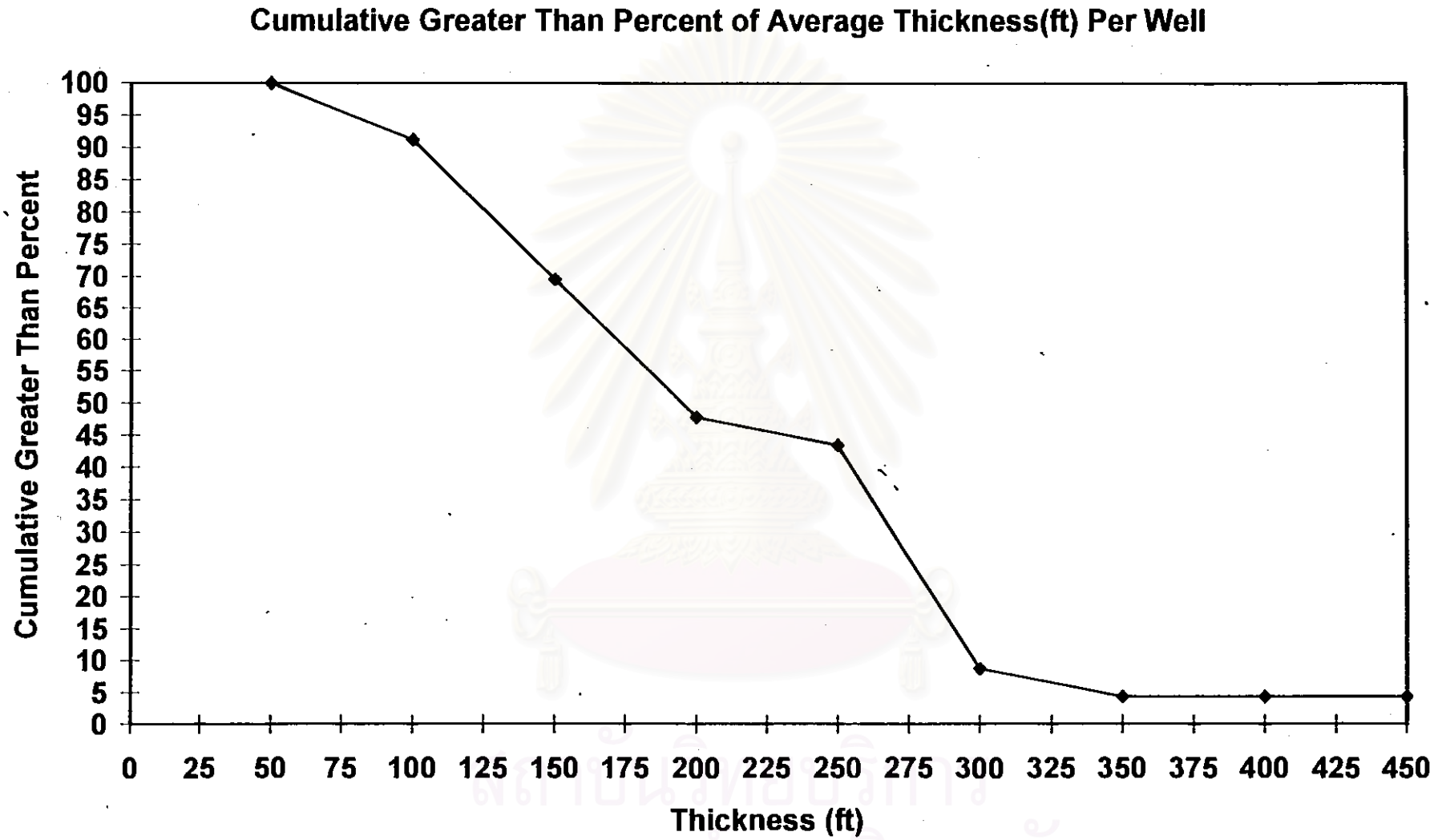


Figure 5.2 Cumulative greater than percent of average reservoir thickness (ft) of the adjacent areas of the Thai-Vietnam overlapping area.

: Apply the processes as used in area of closure to the effective porosity (Figure 5.3 and Table 5.7) and hydrocarbon saturation (Figure 5.4 and Table 5.8).

Table 5.7 Statistics of porosity (percent) of the adjacent areas of the Thai-Vietnam overlapping area.

Porosity (%) Class	Frequency	Cumulative Greater Than Percent
8	2	100.00
10	7	99.34
12	13	97.04
14	28	92.76
16	42	83.55
18	52	69.74
20	58	52.63
22	41	33.55
24	40	20.07
26	11	6.91
28	8	3.29
30	2	0.66

: The percent of trap fill can be considered from size of large (big) prospect which is expected to have not been filled in those structures. Sattayarak [30] suggested that the number of drillable prospects for this area should not be over 12 prospects including the area that lack seismic data

: Oil floor depth is given to be 7,500 ft, considered from temperature that oil will crack and yield gas at above 150°c (1,200 degree Rankine) .

: Recovery factor is determined to be 30 percent for oil and 70 percent for gas by comparing with JDA ,Pattani Trough and Bongkot field.

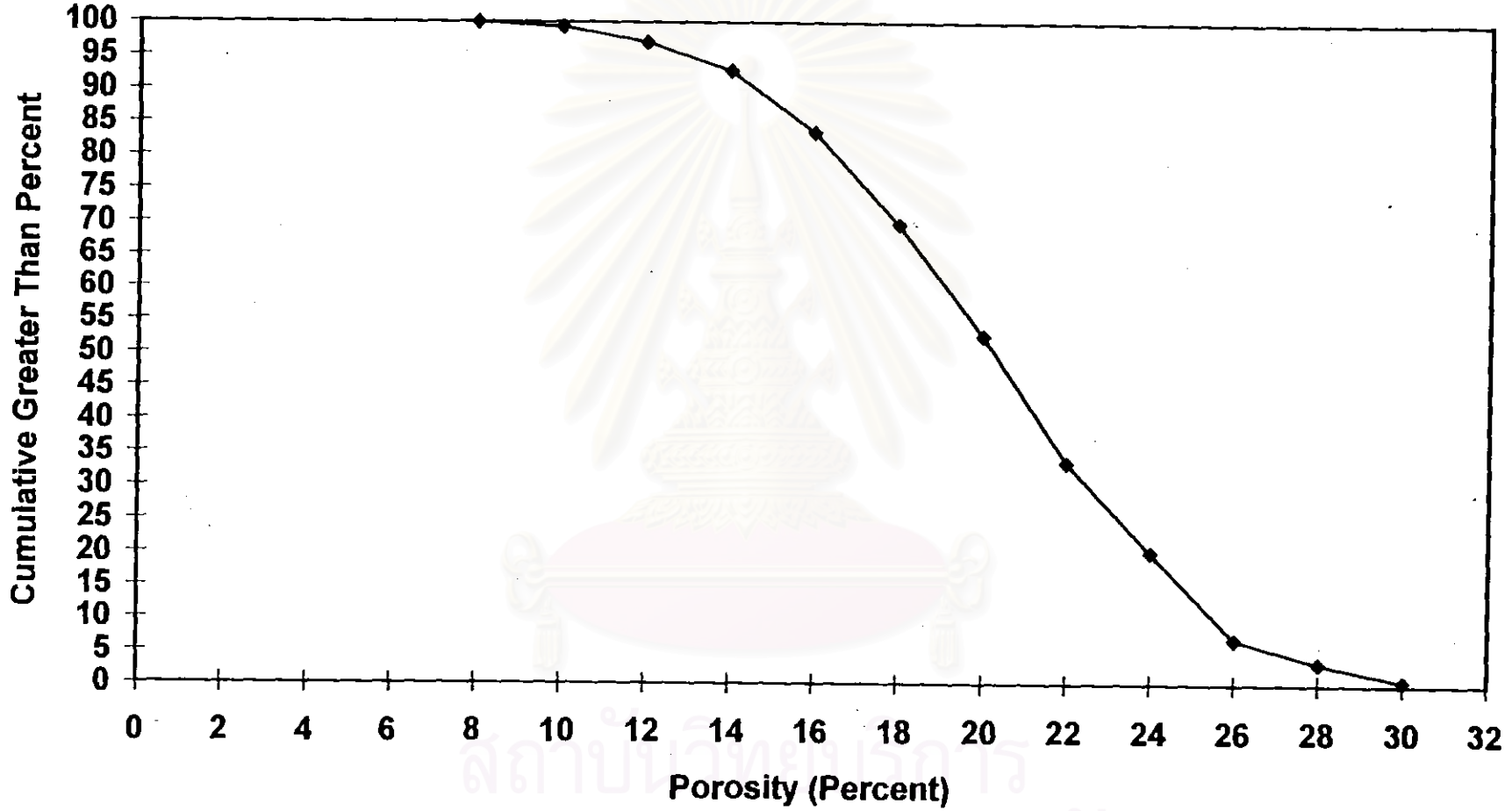


Figure 5.3 Cumulative greater than percent of porosity (percent) of the adjacent areas of the Thai-Vietnam overlapping area.

Table 5.8 Statistics of the hydrocarbon saturation (percent) of adjacent area of the Thai-Vietnam overlapping area.

Shc (%) Class	Frequency	Cumulative Greater Than Percent
10	1	100.00
15	2	99.67
20	3	99.01
25	3	98.03
30	5	97.04
35	25	95.39
40	40	87.17
45	41	74.01
50	46	60.53
55	44	45.39
60	37	30.92
65	22	18.75
70	22	11.51
75	9	4.28
80	3	1.32
85	0	0.33
90	1	0.33

5.3 Petroleum Reservoir Engineering Variables.

This section will study about the reservoir engineering of the Thai-Vietnam overlapping area, including ; initial pressure, reservoir temperature, gas-oil ratio, oil/gas formation volume factor, gas compressibility factor and the petroleum potential of this overlapping area. Methodology still used the probability theory as in the hydrocarbon approaching.

5.3.1 Initial Pressure (reservoir pressure, psi)

The relationship between the pressure and the depth of reservoir (Figure 5.5) can generate an exponential equation as follow;

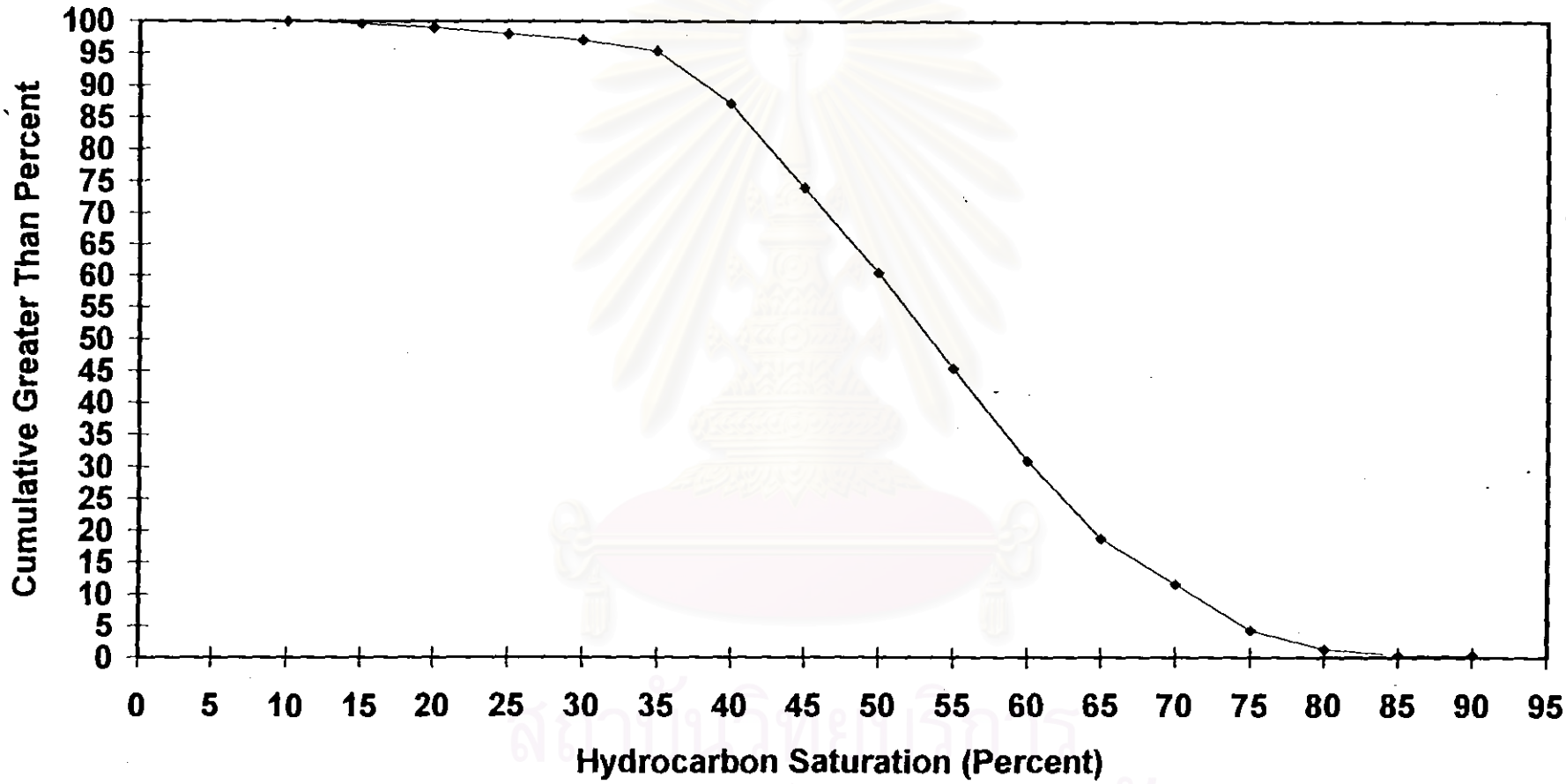


Figure 5.4 Cumulative greater than percent of hydrocarbon saturation (percent) of adjacent areas the Thai-Vietnam overlapping area.

$$Pe = 726.91e^{0.000225(Depth)} \quad \text{(psi)}$$

5.3.2 Reservoir Temperature (Rankine)

The relationship between the temperature and depth which is correlated from the temperature history of its adjacent areas (Figure 5.6) can generate a linear equation as ;

$$T = 0.3065(Depth) - 360.7 \quad \text{(Rankine)}$$

5.3.3 Gas-oil Ratio (Rs: MCF/BBL)

Due to it has no any well has drilled in this overlapping area, therefore, this study will use and refer to the Rs study of Sattayarak *et al.* [26] in Joint Developing Area between Thailand and Malaysia where adjacent to this overlapping area. The study indicated that the relationship between Rs and Depth is linear equation with two sections.

$Rs = 0.017(Depth) + 1$ (MCF/BBL) D = depth from 0-7,000 ft

$Rs = 120$ (and will be constant for depth below 7,000 ft)

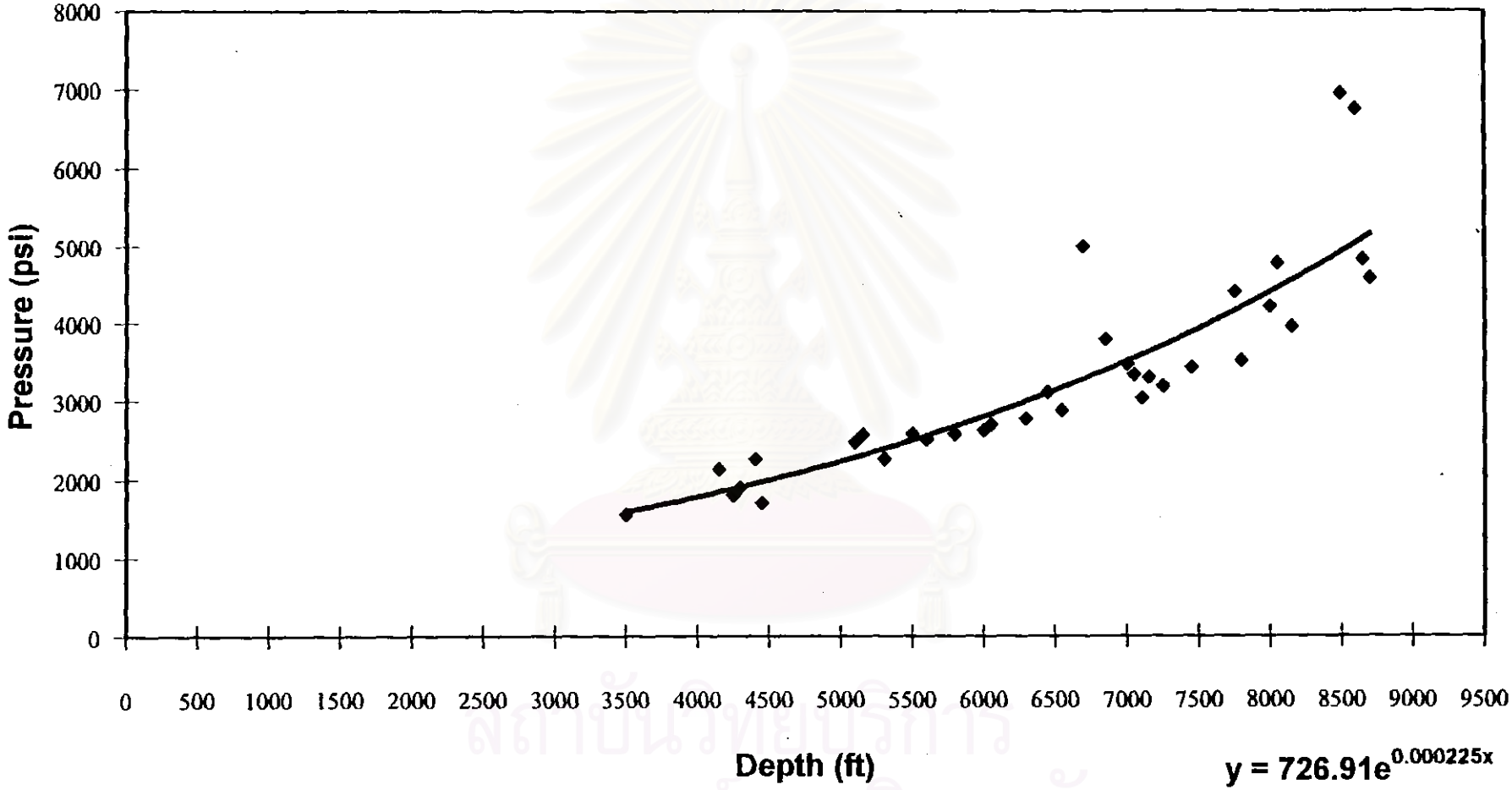


Figure 5.5 The relationship between reservoir pressure (psi) and depth(ft) of the adjacent areas of the Thai-Vietnam overlapping area.

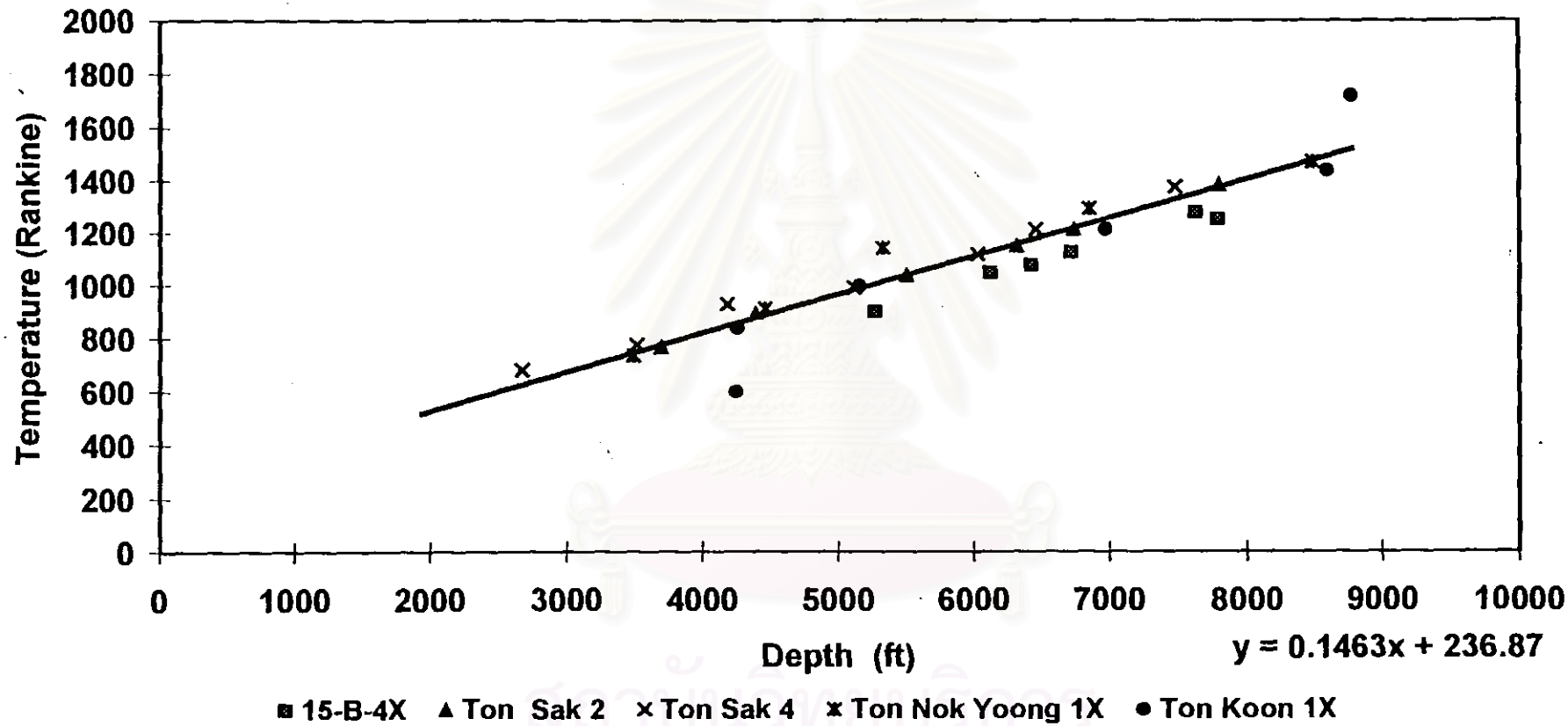


Figure 5.6 The relationship between reservoir temperature (Rankine) and Depth (ft) of the adjacent areas of the Thai-Vietnam overlapping area.

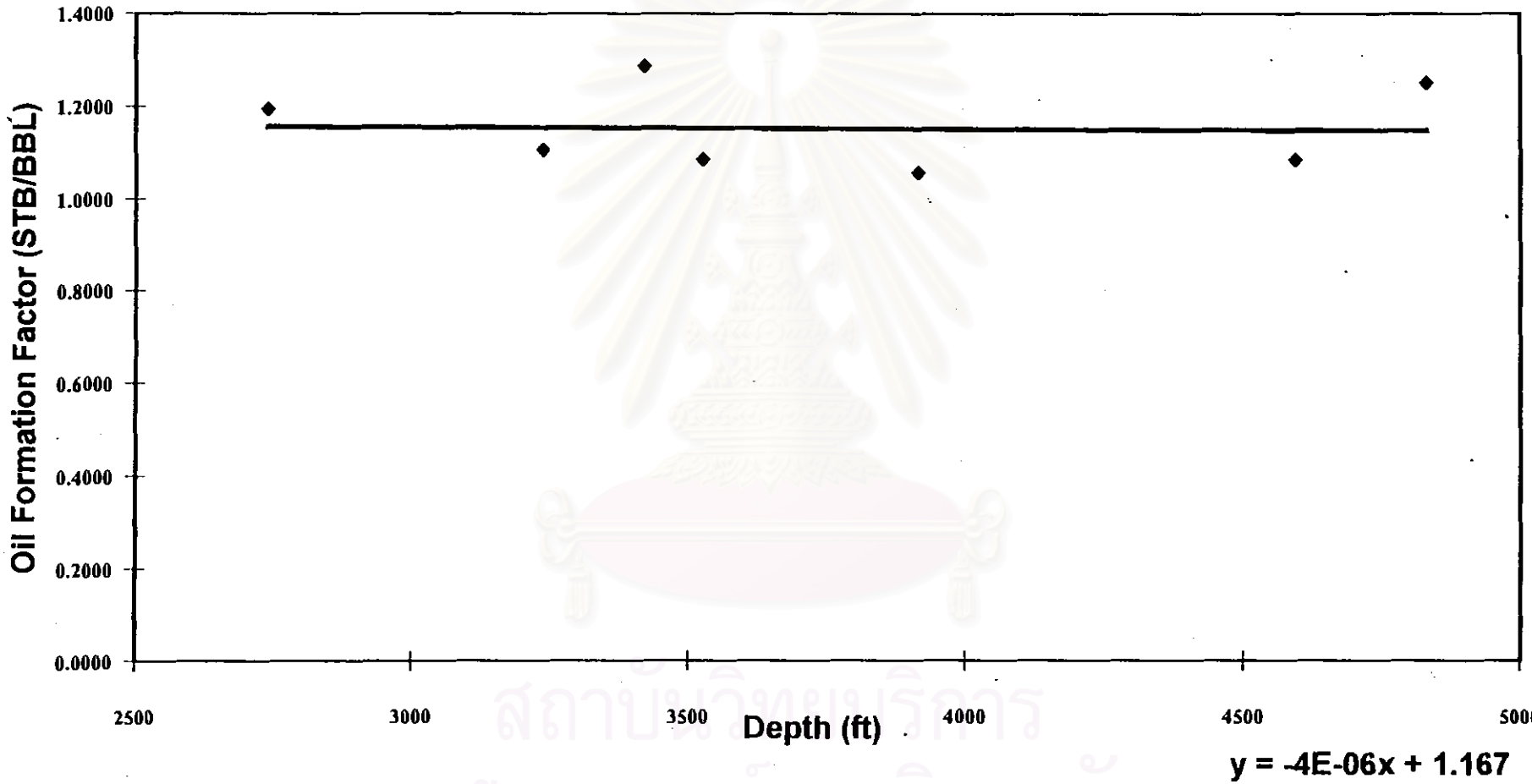


Figure 5.7 The relationship between oil formation volume factor (stb/bbl) and depth (ft) of the adjacent areas of the Thai-Vietnam overlapping area.

5.3.4 Oil formation Volume Factor (Bo)

Oil formation volume factor analysis from Erawan 12-9, Erawan 12-8, Baanpot-4, North Pladang, Ppladang-2 and Kraphong-3 plot with depth (Figure 5.7), it can generate a linear equation as;

$$Bo = -0.000004(Depth) + 1.167$$

5.3.5 Gas Compressibility Factor (Z)

Plot gas compressibility factor (Z) and depth of Pilong-1, Baanpot-4, North Pladang-2, Pladang-2, Erawan 12-6, and Kaphong-3, it will generate the 2 alteration zone of linear equations (Figure 5.8) as follows;

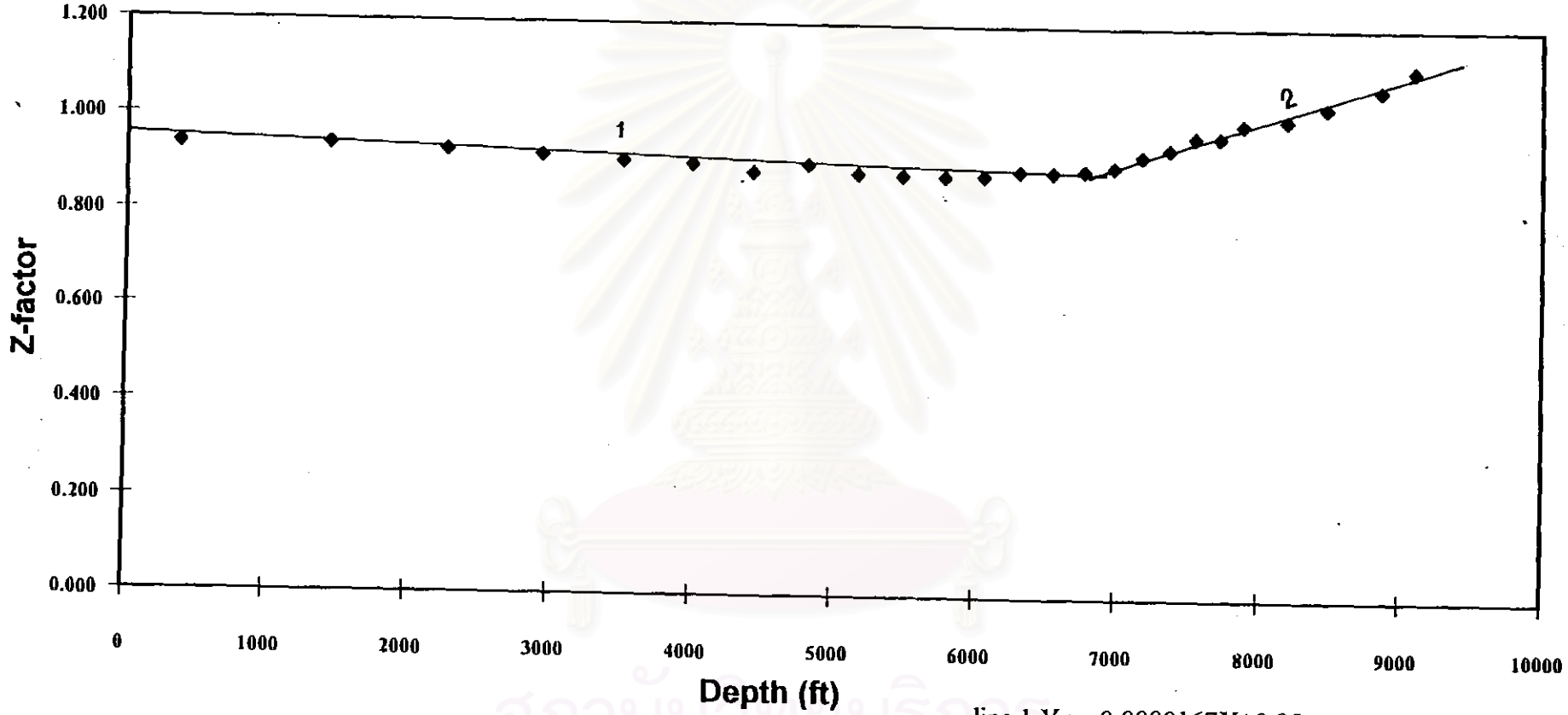
Zone 1) $Z = -0.0000167(depth) + 0.95$ D = depth from 0- 6,600 ft

Zone 2) $Z = 0.0001(Depth) + 0.34$ D = depth from 6,600 -9,000 ft.

5.4 Petroleum Potential of Thai-Vietnam Overlapping Area.

From the result of calculation of FUSPU program (Figure 5.9), the petroleum potential of the Thai-Vietnam overlapping area is considered to be oil potential and gas potential. This assessment will category level of confidence to 3 levels.

1. High confidence at fractile of 95 (F95)
2. Medium confidence (expectation) at fractile of 50 (F50)



line 1 Y = -0.0000167X+0.95
line 2 Y = 0.0001X+0.34

Figure 5.8 The relationship between Z factor and depth (ft) of the adjacent areas of the Thai-Vietnam overlapping area.

3. Low confidence at fractile of 25 (F25) and 5 (F05)

Oil potential

There is a probability of 25 percent to discover 1 oil field in this overlapping area and 5 percent to discover 2 oil fields. The expected field vary in size from 118.052 MMBBL to 272.551 MMBLL. However, at the high confidence, it is expected that there is no oil field in Miocene Faulted Sand Play Type in this overlapping area.

Natural Gas Potential.

Sattayarak et al. [26] suggested that gas fields in this overlapping area may be non-associated gas as in Joint Developing Area. The quantity of this natural gas would be subtracted by CO_2 content, assuming that CO_2 dissolved in natural gas is 30 percent of total gas volume. Therefore, at high confidence (fractile of 75^{th}) there is 1 field of natural gas with its size of 36.659 BFC, at medium confidence (fractile of 50^{th}) there is 1 gas accumulation with its size 65.606 BCF, at low confidence (fractile of 25^{th}) there is 3 gas accumulations with their size 117.409 BCF, and at very low confidence (fractile of 5^{th}) there is 6 gas accumulations with their size 271.256 BCF respectively.

5.5 Conclusion and Discussion

The undiscovered petroleum resources in the Thai-Vietnam overlapping area is can be concluded as;

Oil Potential: Although the result from FASPU indicates a very large amount of oil accumulation, 118.052-272.551 MMBBL, the level of confidence is quiet low, 5 percent to 25 percent of confidence respectively. Therefore, there is a low or no chance to hit an oil field in this overlapping area.

Gas Potential: The result from FASPU indicates non-associated gas potential as follows;

- at the fractile of 75^{th}, high confidence, there is 1 gas accumulation with its size 36.659 BCF.
- at the fractile of 50^{th}, medium confidence, there is 1 gas accumulation with its size 65.606 BCF.
- at the fractile of 25^{th}, low confidence, there is 3 gas accumulations with their size 117.409 BCF.
- at the fractile of 5^{th}, very low confidence, there is 6 gas accumulations with their size 271.256 BCF.

The methodology problems

The play assessment method which FASPU is based on, is well suited for the areas where the geology if fairly well known from an extensive grid of seismic data and from many exploration wells. These data allows a fair distribution for such input attributes as the number of prospects, prospect size, reservoir thickness, etc. to be estimated from an actual data base. In frontier areas where little or no seismic data or well/surface data are available, the input distribution must be subjectively estimated and therefor are primarily based on analogs and on the experience of the geologists making the assessment. The resulting resource assessment can only be as good as the geological analogs selected by the geologist, which may or may not match the frontier basin.

The distributions for prospect size, number of prospects, marginal play probability and conditional deposit probability were the most difficult to estimate where a good set of analog data for this methodology was not available. However, the estimates serve to document current thinking in a way that can be scale and compared with other assessments and known field populations. A better understanding of the relationship between tectonic setting and size / number of trap is also critical. The goal should be a set of guidelines for parameters like number of prospects, area of closure and play / deposit probabilities. It is particular difficult to see the relationship between the various parameters and to avoid the double-risking. It is also important for updating of the last play assessment when new data becomes available.

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PLAY : Miocene Faulted Sand PROJECT : Petroleum Assessment on the Thai- Vietnam Overlapping Area

INPUT SUMMARY

Play Attribute Probabilities				Prospect Attribute Probabilities		
Hydrocarbon Source	Timing	Migration	Potential Res. Facies	Trapping Mechanism	Effective Porosity	Hydrocarbon Accumulation
1.000	1.000	1.000	1.000	0.800	0.900	0.800

Marginal Play Probability	Conditional Deposit Probability	Reservoir Lithology	Hydrocarbon Prob. Gas	Oil	Recovery Factors % Oil	Free Gas
1.000	0.576	sandstone	0.800	0.200	30.00	70.00

Geologic Variables	F100	95	F75	F50	F25	F05	F0
Closure (thousand acres)	1.00000	1.10000	1.75000	2.50000	3.85000	8.00000	9.00000
Thickness (feet)	50.0000	80.0000	140.000	195.000	275.000	350.000	400.000
Porosity (percent)	8.00000	13.0000	17.0000	20.5000	23.0000	28.0000	30.0000
Trap Fill (percent)	30.0000	40.0000	50.0000	60.0000	70.0000	80.0000	90.0000
Depth (thousand feet)	3.50000	4.00000	4.50000	5.50000	6.00000	8.00000	9.00000
HC Saturation (percent)	10.0000	35.0000	45.0000	53.0000	63.0000	75.0000	90.0000
Number of Prospects	1	1	2	4	6	11	13

Figure 5.9 Results of petroleum resources assessment of the Thai-Vietnam overlapping area.

GEOLOGIC VARIABLES and PROBABILITIES OF OCCURRENCE

	Mean	Std. Dev.
Closure	3.27250	2.09348
Thickness	207.125	86.4729
Porosity	20.2000	4.68170
Trap Fill	60.0000	13.1656
Depth	5.55000	1.24231
HC Saturation	53.8000	13.9879
Prospects	4.17500	3.06502
Accumulations	2.40480	2.03383

"Dry Hole" Risk = 0.4240

Prob. (Depth <= 7500 feet) = 0.9000

	RESOURCE			
	Oil	NA Gas	AD Gas	Gas
Cond. Prob. Prospect has	0.1037	0.4723	0.1037	0.5760
Cond. Play Prob.	0.3340	0.7983	0.3340	0.8558
Uncond. Play Prob.	0.3340	0.7983	0.3340	0.8558

Variable	Function	A	B	D(feet)	A	B
Pe (PSI)	Expon	726.91000	0.0002250			
T (Deg Rankine)	Linear	0.1463000	236.87000			
Rs (Thousand CuFt/BBL)	Linear	0.0170000	1.0000000	7000.0000	0.000	120.00000
Bo (no units)	Linear	-0.000004	1.1670000			
Z (no units)	Linear	-0.000017	0.9500000	6600.0000	0.0001000	0.3400000

Depth Floor (feet) = 7500.00

Figure 5.9 Results of petroleum resources assessment of the Thai-Vietnam overlapping area (continued).

Miocene Faulted Sand ESTIMATED RESOURCES

	Mean	Std. Dev.	F95	F75	F50	F25	F05
OIL (Millions of BBLs)							
Number of Accumulations	0.43286	0.69926	0	0	0	1	2
Accumulation Size	95.7035	100.502	15.9813	36.8964	65.9978	118.052	272.551
Cond. Prospect Potential	9.92254	43.5707	0.0	0.0	0.0	0.0	68.6475
Cond. (B) Play Potential	124.050	127.490	21.4038	48.7921	86.5090	153.382	349.648
Cond. (A) Play Potential	41.4266	94.0786	0.0	0.0	0.0	48.9765	209.201
Uncond. Play Potential	41.4266	94.0786	0.0	0.0	0.0	48.9765	209.201
NON-ASSOCIATED GAS (Billions of CuFt)							
Number of Accumulations	1.97194	1.77096	0	1	1	3	6
Accumulation Size	135.993	142.981	22.6679	52.3708	93.7230	167.727	387.508
Cond. Prospect Potential	64.2321	119.437	0.0	0.0	0.0	88.0188	275.962
Cond. (B) Play Potential	335.919	316.854	65.7813	142.674	244.363	418.529	907.757
Cond. (A) Play Potential	268.169	313.555	0.0	70.8854	189.041	360.536	831.921
Uncond. Play Potential	268.169	313.555	0.0	70.8854	189.041	360.536	831.921
ASSOCIATED-DISSOLVED GAS (Billions of CuFt)							
Number of Accumulations	0.43286	0.69926	0	0	0	1	2
Accumulation Size	8597.26	9263.50	1380.08	3235.13	5848.34	10572.4	24783.4
Cond. Prospect Potential	891.363	3970.62	0.0	0.0	0.0	0. 0	6087.61
Cond. (B) Play Potential	11143.7	11693.6	1863.00	4299.24	7687.81	13747.2	31724.4
Cond. (A) Play Potential	3721.44	8560.74	0.0	0.0	0.0	4315.78	18837.1
Uncond. Play Potential	3721.44	560.74	0.0	0.0	0.0	4315.78	18837.1

Figure 5.9 Results of petroleum resources assessment of the Thai-Vietnam overlapping area (continued).

GAS

(Billions of CuFt)

Number of Accumulations	2.40480	2.03383	0	1	2	3	7
Accumulation Size	1659.02	5101.97	41.2657	182.533	513.026	1441.91	6378.07
Cond. Prospect Potential	955.596	3957.97	0. 0	0.0	92.6459	663.566	4148.35
Cond. (B) Play Potential	4661.60	9127.48	268.921	909.262	2120.26	4944.13	16716.8
Cond. (A) Play Potential	3989.61	8601.29	0.0	496.298	1624.74	4226.15	15236.3
Uncond. Play Potential	3989.61	8601.29	0.0	496.298	1624.74	4226.15	15236.3

YIELD FACTORS

OIL							
(Thousand BBL / Acre-Ft)	0.78441	0.36143	0.34616	0.52992	0.71242	0.95778	1.46623
NON-ASSOCIATED GAS							
(Million CuFt / Acre-Ft)	0.47770	0.22089	0.21018	0.32220	0.43359	0.58348	0.89445
DISSOLVED GAS							
(Million CuFt / Acre-Ft)	70.4653	34.9393	29.1936	46.0151	63.1308	86.6130	136.520

Figure 5.9 Results of petroleum resources assessment of the Thai-Vietnam overlapping area (continued).

Table 5.9 Petroleum reservoir engineering variables summary.

Pattani Trough (Thai Basins)

Well	Reservoir	Longitude	Latitude	Depth (ft)	Net Pay (ft)	Porosity (%)	Sw (%)	Shc (%)	TOC (%)	EOM (ppm)	Ro (%)	Temp (C)	Pressure (psi)	CO2 (%)	N2 (%)
[redacted]	[redacted]	101-37-07	8-54-34	4739	25	31	33	67							
				4758	7	29	53	47					2014	4.7	
				5510	13	29	23	77					2486		
				5620	17	31	32	68					2513		
				5700	2	23	58	42							
				6010	32	25	39	61					2663		
				6050	7	28	47	53					2771	10.2	
				6159	14	22	43	57							
				6300	3	20	49	51							
				6350	11	23	36	64					3003		
				6500	68	23	30	70					3186	11.8	2.9
				6801	18	25	49	51					3288	18	
				6870	2	20	46	54							
				7000	9	20	53	47							
				7100	24	20	37	63							
				7450	11	20	60	40							
				7500	5	21	58	42							
	276 ft			7876	8	23	65	35							
	[redacted]	101-36-49	8-56-06	5053	22	24	40	60							
				5200	4	20	60	40							
				5212	22	22	44	56							
				5500	13	24	36	64							
				5800	3	20	57	43							
				5850	8	19	58	42							
				5970	7	23	52	48							
				6050	5	25	41	59							
				6550	5	20	40	60							
				6570	7	22	39	61							
				6780	5	18	58	42							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth	Nphay(%)	Bvpay(%)	Sw (%)	Shc (%)	TOC (%)	EOM (ppm)	Bo	Temp(C)	Pressure (psi)	%CO2	%N2
				7210	9	18	38	62							
				7290	38	18	62	38							
	167 ft			7556	19	18	62	38							
	[redacted]	101-36-51	8-54-23	5607	8	23	51	49							
				5700	7	25	60	40							
				5850	14	22	34	66							
				5870	3	25	58	42							
				5950	4	25	49	51							
				6010	5	20	51	49							
				6070	8	17	53	47							
				6180	1	17	58	42							
				6200	16	24	46	54							
				6280	6	20	49	51							
				6300	4	18	60	40							
				6500	55	23	38	62							
				6550	5	22	53	47							
				6600	14	21	36	64							
				6800	10	23	43	57							
				6870	4	26	51	49							
				6900	9	27	33	67							
				6950	2	24	61	39							
				7000	8	20	46	54							
				7080	2	17	45	55							
				7100	13	19	41	59							
				7350	21	17	40	60							
				7370	25	19	44	56							
				7750	10	19	54	46							
	264 ft			8074	5	15	52	48							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth	Netpay(ft)	Porosity(%)	Sw(%)	Shc(%)	TOC(%)	EOM(ppm)	Ro	Temp(C)	Pressure(psi)	Sw,Co2	Sw,N2
	[redacted]	101-34-56	8-52-16	5114	13	25	45	55							
				5400	7	25	46	54							
				5600	4	20	61	39							
				5900	12	26	39	61							
				6000	14	26	55	45					2591		
				6100	7	21	60	40							
				6200	4	24	48	52							
				6265	14	23	49	51					2804		
				6350	6	25	43	57							
				6623	12	23	35	65					3021	11.4	
				6740	12	21	49	51							
				6850	18	24	50	50					3055	17	
				6900	13	21	40	60							
	142 ft			7430	6	19	51	49					3790	15	
	[redacted]	101-36-01	8-53-50	5223	9	26	37	63							
				5520	4	24	57	43							
				5527	3	18	59	41							
				5653	3	19	59	41							
				5670	3	21	56	44							
				5920	5	20	50	50							
				5971	4	25	47	53							
				6000	4	23	51	49							
				6080	5	26	57	43							
				6140	21	21	41	59							
				6450	26	25	30	70							16
				6500	13	24	40	60							
				7000	28	20	43	57							
	133 ft			7229	5	21	46	54							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth	Netpay(ft)	Porosity(%)	Sw (%)	Shc%	TOC (%)	EOM (ppm)	HI	Temp(C)	Pressure (psi)	Ro (%)	Sw(%)
		101-36-43	8-54-02	4885	19	22	43	57							
				5000	4	21	44	56							
				5010	19	22	46	54							
				5100	17	26	56	44							
				5140	17	21	36	64							
				5200	12	25	46	54							
				5250	18	22	39	61							
				2564	4	28	45	55							
				5300	8	25	44	56							
				5320	3	19	58	42							
				5500	16	24	35	65							
				5700	9	22	42	58							
				5850	8	25	48	52							
				5900	44	23	37	63							
				5990	7	22	41	59							
				6010	4	18	42	58							
				6170	9	16	56	44							
				6200	9	22	56	44							
				6500	6	17	44	56							
				6750	6	19	49	51							
				6742	3	17	57	43							
				6790	3	17	55	45							
				6800	5	22	47	53							
				6820	12	20	40	60							
				6852	3	20	42	58							
	271 ft			6894	6	18	16	84							
		101-31-40	9-02-38	6273	13	24	48	52							
				6483	28	23	35	65						12.62	0.37
				6756	6	24	35	65						14.61	0.17
				7181	13	19	35	65							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	longitude	latitude	Depth	Netpay(ft)	Porosity(%)	Sw (%)	Shc %	TOC (%)	EOM (ppm)	Ro	Temp C	Pressure (psi)	%CO2	%N2
				7360	2	19	57	43							
				7491	41	17	51	49						18.8	3.41
	121 ft			7536	18	21	41	59						18.75	1.54
	[redacted]	101-31-41	9-02-37	6057	28	22	59	41							
				6291	6	26	35	65							
				6503	26	21	30	70							
				6555	11	20	29	71							
				6588	4	20	52	48							
				6718	42	19	30	70							
				6955	3	20	49	51							
				7117	5	18	61	39							
				7404	6	25	40	60							
				7615	5	17	48	52							
				7879	20	15	55	45							
				7941	5	19	56	44							
	173 ft			8053	12	18	48	52							
	[redacted]	101-33-01	9-03-10	5881	23	24	33	67							
				6117	6	20	62	38							
				6221	50	21	30	70							
				6492	8	22	35	65							
				6676	7	21	49	51							
				6720	28	18	44	56							
				6777	8	22	47	53							
				7004	25	25	30	70							
				7070	3	19	51	49							
				7111	6	16	45	55							
				7173	15	15	44	56							
				7218	18	21	36	64							
				7335	4	17	48	52							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

[redacted]	[redacted] Well name	Longitude	Latitude	Depth	Net pay (ft)	Porosity (%)	Sw (%)	Shc (%)	TOC (%)	EOM (ppm)	Ro (%)	Temp (C)	Pressure (psi)	%CO2	%CH4
				7381	7	17	50	50							
				7497	10	16	28	72							
				7732	14	15	44	56							
				7811	5	14	45	55							
				7821	7	13	62	38							
	252 ft			7844	8	13	39	61							
	[redacted]	101-30-03	9-56-36	6440	6	22	53	47							
				6908	33	20	27	73						14.92	4.15
				7172	34	21	31	69							
				7398	16	21	45	55							
				7953	22	18	39	61						19.6	0.35
	115 ft			8000	4	16	60	40							
	[redacted]	101-29-56	9-01-26	7079	14	20	36	64							
				7276	4	16	42	58							
				7360	27	18	42	58							
				7456	3	15	59	41							
				7565	17	22	26	74						18.4	0.18
				7603	28	19	36	64							
				7670	39	18	46	54							
				7845	6	21	29	71							
				7884	25	15	43	57							
				7934	31	17	43	57						21.1	0
				8069	9	16	27	73							
				8104	6	16	27	73							
				8120	4	17	30	70							
				8487	18	15	55	45							
				8525	4	15	53	47							
				8563	7	16	51	49							
				8599	33	14	55	45							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	longitude	latitude	Depth	Netpay(ft)	Porosity(%)	Sw(%)	Sho(%)	TOC(%)	EOM(ppm)	Ro	Temp(C)	Pressure(psi)	%CO2	%N2
	296 ft			8685	21	19	35	65						19.06	0.04
	[redacted]			6736	4	24	52	48							
				7097	13	16	51	49							
				7126	42	19	38	62							
				7814	4	21	63	37							
				7861	12	19	42	58							
				7918	27	26	29	71							
				8219	2	18	56	44							
				8889	4	11	58	42							
				9200	3	23	47	53							
	124 ft			9228	13	19	46	54							
	[redacted]	101-34-08	9-04-11	5413	12	28	34	66							
	15 ZONES			5480	37	29	21	79							
				5583	36	27	23	77							
				5623	4	24	61	39							
				6072	12	23	39	61							
				6109	3	21	55	45							
				6585	8	20	34	66							
				6664	4	25	40	60							
				6982	5	17	29	71							
				7004	12	20	43	57							
				7168	5	18	51	49							
				7204	4	15	51	49							
				7407	3	20	46	54							
				7779	6	16	47	53							
	168 ft			8003	17	17	55	45							
	[redacted]	101-34-7.7	9-04-11	5336	10	18	56	44							
				6237	16	25	36	64							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth	Netpay(ft)	Porosity(%)	Sw(%)	Shc(%)	TOC(%)	EOM(ppm)	HI	Tem(C)	Pressure(psi)	%CO2	%N2
				7043	6	20	57	43							
				7096	8	18	41	59							
				7508	8	21	41	59							
	55 ft			8228	7	15	59	41							
[redacted]				6037	18	22	38	62							
				6524	6	22	46	54							
				6726	6	17	55	45							
				6759	12	19	66	34							
				6870	6	22	57	43							
				7009	6	15	61	39							
				7240	31	13	36	64							
				7272	29	13	40	60							
				7301	11	12	54	46							
				7372	7	13	54	46							
				7380	10	16	50	50							
				8070	35	14	63	37							
				8833	10	13	80	20							
				8870	7	14	61	39							
	199 ft			8892	5	8	52	48							
	[redacted]			5410	9	21	44	56							
				5419	7	24	47	53							
				5788	5	20	51	49							
				5873	5	18	44	56							
				5881	3	23	72	28							
				6760	6	13	61	39							
				6862	6	15	64	36							
				6955	11	14	62	38							
				7253	40	15	49	51							
				7311	6	16	49	51							
				7344	5	11	52	48							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth (ft)	Netpay (ft)	Porosity (%)	Sw (%)	Shc (%)	TOC (%)	EOM (ppm)	Ro	Temp (C)	Pressure (psi)	Xe-CO2	Xe-N2
				8251	6	14	57	43							
				8729	22	14	63	37							
				8767	6	11	67	33							
				8861	7	11	62	38							
				8889	29	12	75	25							
	211 ft			8987	38	9	66	34							
	[redacted]			4707	6	24	47	53							
				5039	10	23	43	57							
				5061	5	15	52	48							
				5125	3	20	75	25							
				5274	4	26	70	30							
				5335	17	18	33	67							
				5439	7	25	51	49							
				5562	9	20	48	52							
				5647	18	16	56	44							
				5664	5	24	44	56							
				5713	12	24	46	54							
				5902	3	20	64	36							
				5933	9	25	46	54							
				6329	11	17	47	53							
				6993	7	18	38	62							
				7314	7	15	62	38							
				7428	4	15	83	17							
				8542	3	11	90	10							
				8613	3	11	80	20							
				8659	9	11	81	19							
	157 ft			8724	5	13	58	42							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth	Npay(ft)	Porosity(%)	Sw (%)	Cw/%	TDS (K)	FOM (ppm)	Ro%	Temp(C)	Pressure(psi)	H2S(%)	CO2(%)
Pladang	N-Pladang-1	101-23-47	9-31-57	7810								303	4328		
				8652								317	4328		
	Pladang-2	101-21-57	9-29-31	7240								285	2776		
				7534								294	3193		
Pakarang	Pakarang-2	101-18-06	9-30-48	8263	16	21	51					295	3713		
				9220	5	17	54					307	4183		
				11307	17	17	45					326	4926		
				11664	32	17	52					330	4950		
				11225	13	15	46					330	4889		
	91 ft			10432	8	13	58					322	4596		
	Pakarang-1	101-17-41	9-26-30	7643								260	2515		
Yala	Yala-2	101-26-40	9-59-40	5410									2289		
				6589									2799		
				6596									2804		
				6969									2963		
				7564									3292		
				7993									3584		

Table 5.9 Petroleum reservoir engineering variables summary (continued)

North Malay Basins

Field	Well name	Longitude	Latitude	Depth	Thick(ft)	Porosity(%)	Sw(%)	Shr%	TOC(%)	EOM(ppm)	Ro	Tmax(C)	Pressure(psi)	%CO2	%N2
JDA	17-B-1	102-35-49	7-35-49			19	45	55							
						23	30	70							
						17	63	37							
						21	58	42							
						14	44	56							
						15	50	50							
						16	41	59							
				4020					0.35	0	0.43				
				4475					1.04	648	0.43				
				4950					0.54	237	0.45				
				5550					1.41	1444	0.48				
				5775					0.64	386	0.49				
				6000					0.93	0	0.53				
				6375					1.17	839	0.56				
				6800					0.81	0	0.62				
				7300					1.11	162	1.29				
				7800					34.59	0	1.5				
	PILONG	103-05-27	7-10-55			28	29	71							
						29	25	75							
						18	34	66							
						18	34	66							
						18	41	59							
						20	58	42							
						18	51	49							
						17	54	46							
[redacted]		102-16-21	8-03-52	5027	10	21	61	39				135.73		13	
				5944	62	21	69	31				160.49			
				6216	8	15	63	37				167.83			
				6315	11	19	39	61				170.51			
				6412	8	24	19	81				173.12		18.6	

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth	Net pay (ft)	Porosity (%)	Sw (%)	Shc (%)	TOC (%)	EOM (ppm)	Ro (%)	Temp (C)	Pressure (psi)	%CO2	%N2
				6423	11	21	23	77				173.42			
				6538	15	23	41	59				176.53		22.3	
				6700	44	22	62	38				180.90			
				7124	46	18	37	63				192.35		22.6	
				7175	11	19	21	79				330.05		16	
				7628	13	17	59	41				350.89			
				7641	13	17	88	12				351.49			
				7683	13	16	51	49				353.42			
				7693	10	13	76	24				353.88			
				7785	10	13	100	0				358.11			
	298 ft			7937	13	14	60	40				365.10		40	
	[redacted]	102-19-05	8-01-00	3120	30	-	-	-	0.73	444	0.38				
				4000	30	-	-	-	12.23	7345	0.38				
				4500	10	-	-	-	8.04	-	0.39				
				5000	10	-	-	-	0.98	1931	0.42				
				5265	6	21.9	54.2	45.8	12.33			112.78		16	
				5500	10	-	-	-	1.07	822					
				6116	26	23	64	36	0.83	648		131.11		18	
				6500	10	-	-	-	1.69	646					
				6660	10	16.9	37	63				135.00		19	
				6670	16	19.5	30.6	69.4						19	
				6716	20	21	26.3	73.7		1330		141.11		19	
				6739	4	17.6	45.1	54.9							
				6934	6	16.9	33	67	1.63		0.42				
				7179	19	17.5	36.5	63.5	0.22		0.43				
				7482	15	16.5	24.7	75.3		220					
				7542	9	15	25.9	74.1	0.43						
				7621	22	19.1	10	90				160.00		48	
				7705	28	16.6	31	69							
				7777	10	18.8	24.1	75.9							

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth	Npay(ft)	Poros(%)	Sw(%)	Sh(%)	TOC(%)	EOM(ppm)	Ro(%)	Temp(C)	Pressure(psi)	Kv/Kh	Sw/Sh
				7787	19	16.5	17.9	82.1				156.67		44	
				7806	8	15.8	25.9	74.1							
				7816	10	16.3	24.2	75.8							
				7965	5				0.07		0.53				
	343 ft			8000	10				0.22						
	[redacted]	102-24-21	8-06-32	3691								96	-		
				4392								112	2269		
				5501	42							130	2679	13	
				6313	13							144	2783	-	
				6733	162							152	3323	35/81/84	
	254 ft			7794	37							173	3751	76/45/74	
	[redacted]	102-22-13	8-06-56	2672								85	-		
				3514								97	-		
				4182								116	2136		
				5114	27							124	2483	7.4	
				6025								140	2653		
				6453	20							152	3121	12/14/7.6	
	85 ft			7477	38							172	3440	43/56	
	[redacted]	102-53-10	7-41-10	3490	38							78-92.3	1561	3	
				3464	162							114-128.3	1703	22-35	
				5324	200							143-162	2270	60	
				6850	27							162-174	4540	65	
				8484	20							184-191.5	6952	65	
	477 ft			9172	30							-	7661	70-80	
	[redacted]	102-45-55	9-31-28	4248	7							75	1807	4	
				4255	50							105	1906	8	
				5152	112							125	2579	18-81	
				6971	27							152	6692	83	
				8589								180	6752	85	

Table 5.9 Petroleum reservoir engineering variables summary (continued)

Field	Well name	Longitude	Latitude	Depth	(Nahey)(L	Porosity(%)	Sw(%)	Shc%	TOC (%)	FOM (ppm)	Ro%	Temp(C)	Pressure (psi)	%CO2	%N2
				8773	62							215	7313	90	
				10124								245	7801	94	
	[redacted]	102-15-00	8-03-12	2900								178			
		102-14-36	7-58-14	2510								162			
		102-12-40	7-58-00	900								72			
				950								62			
				975								78			
				1210								84			
				1770								140			
				1900								144			
				1960								125			
				2140								140			
				2390								172			
	[redacted]	102-14-42	7-57-20	2515								158			
		102-20-30	7-56-06	2430								166			
		102-15-42	7-55-18	2410								164			
		102-18-30	-7-51-30	2630								172			
				3280								194			
	[redacted]	102-20-42	7-50-36	2470								174			
		102-22-48	7-50-16	2670								178			
		102-21-24	7-48-42	2900								198			
		102-27-30	7-31-30	1750								136			
				2000								164			
				2580								194			

Table 5.10 Reservoir fluid properties

Well name	Pressure (PSI)	Remark	Compressibility Factor (Z factor)	Temperature (F)	GOR (scf/bbl)	Remark
Bannpot-4	1020		0.922	295		
	1200		0.909			
	1500		0.895			
	1650		0.888			
	1900		0.883			
	2200		0.874			
	2300		0.873			
	2550		0.874			
	2632	dew point pressure	0.875			
	2886	reservoir pressure	0.881			
	3000		0.883			
	3500		0.902			
	4000		0.929			
	4500		0.960			
	5000		0.996			
	5500		1.038			
North Pladang	1006		0.957	317		
DST-1B	1039		0.951			
	1215		0.942			
	1372		0.943			
	1546		0.928			
	1808		0.917			
	2200		0.908			
	2600		0.905			
	3000		0.910			
	3400		0.923			
	3800		0.942			
	3900		0.948			
	4025	dew point pressure	0.955			
	4100		0.960			
	4200		0.967			
	430		0.974			
	4400		0.982			
	4500		0.989			
	5000		1.029			

Table 5.10 Reservoir fluid properties (continued)

Well name	Pressure (PSI)	Remark	Compressibility Factor (Z factor)	Temperature (F)	GOR (scf/bbl)	Remark
North Pladan	2733	dew point pressure	0.875			
DST-2	2776	reservoir pressure	0.876			
	2800		0.877			
	2900		0.880			
	3000		0.883			
	3200		0.891			
	3600		0.910			
	4000		0.934			
	4500		0.965			
	5000		1.005			
	830		0.952	294		
	911		0.948			
	995		0.944			
	1115		0.938			
	1265		0.930			
	1433		0.922			
	1699		0.911			
	2100		0.901			
	2500		0.899			
	2900		0.905			
	3000		0.908			
	3100		0.911			
	3193	reservoir pressure	0.914			
	3262		0.918			
	3300		0.919			
	3400		0.924			
	3500		0.930			
	3600		0.936			
	4000		0.960			
	4500		0.997			
	5000		1.038			
North pladan	600				465	
	1000				636	
	1400				802	
	1900				1026	
	2300				1241	
	2700				1498	
	3291				2166	

Reservoir fluid properties (continued)

Pressure (PSI)	Remark	Compressibility Factor (Z factor)	Temperature (F)	GOR (scf/bbl)	Remark
2465			281	45000	
2628				40119	producing ratio
3210				35000	
2512			266	29000	
2715				24311	producing ratio
2815				19000	
3322			283	49000	
3448				43882	producing ratio
3550				39000	
893		0.921	270		
1020		0.912			
1258		0.901			
1369		0.893			
1594		0.882			
1900		0.871			
2200		0.865			
2600		0.863			
3000		0.869			
3250		0.876			
350		0.880			
3401		0.882			
3450		0.884			
3474	dew point pressure	0.885			
3500		0.890			
3600		0.894			
3700		0.890			
4000		0.894			
4500		0.911			
5000		0.942			
5500		0.979			
6000		1.017			
3260			295		
3728					
3803					
3728	dew point pressure	0.915	295		
3750		0.916			
3800		0.919			
3900		0.924			
4000		0.930			
4500	reservoir pressure	0.963			

Table 5.10 Reservoir fluid properties (continued)

Well name	Pressure (PSI)	Remark	Compressibility Factor (Z factor)	Temperature (F)	GOR (scf/bbl)	Remark
	5000		1.000			
	5500		1.040			
	6000		1.082			
Kaphong-3	4060	dew point pressure	0.968	305		
	4100		0.970			
	4200		0.974			
	4220	reservoir pressure	0.975			
	4400		0.984			
	4700		1.000			
	5100		1.024			
	5500		1.049			
	6000		1.081			
	6500		1.115			
DST-4A	58		0.989	60	56	
	110		0.983		80	
	250		0.973		127	
	550		0.959		211	
	850		0.940		279	
	1150		0.929		347	
	1450		0.919		415	
	1750		0.913		485	
	2050		0.910		556	
	2350		0.908		630	
	2650		0.908		708	
	3047				321	