CHAPTER 4
RESULTS AND INTERPRETATION

4.1 Screening data

Many geochemical exploration, development, and production projects are complex because of large numbers of samples. Therefore screening analysis should be rapid and cheap. Large numbers of oil, rocks and/or sediments can be screened using geochemical tools such as total organic carbon (TOC), Rock-Eval pyrolysis, Use of these practical and less expensive methods allows non-source rocks to be identified and oils and source rocks to be provisionally grouped into genetic families.

Screening analysis of this study is a determination of the sample in term of total organic carbon (TOC) content, total carbon (TC) content, and total sulphur (TS) content. Rock-Eval analysis provided S_1, S_2, T_{max}, hydrogen index (HI) and production index (PI) (Appendix II). Together they provide general appraisal of sample characteristic.

Total organic carbon (TOC) content

Total organic carbon (TOC), also called organic carbon (C_{org}), is the amount of organic carbon in a rock, expressed as weight percent, used to describe the quantity of organic carbon in the rock sample and includes both kerogen and bitumen. In general, TOC values more than 2 wt% in shale are regarded as good source rock. In contrast, TOC values lower than 0.5 wt% have no petroleum generating potential (Bordenave *et al*., 1993).

Total carbon (TC) content and total sulphur (TS) content

Total carbon is an amount of carbon in the rock, including both inorganic (carbonate minerals) and organic carbon (aliphatic and aromatic compounds).

Total sulphur is a bulk of organic sulphur in the rock. Understanding the origin of sulphur in petroleum and kerogen is necessary in order to make reliable interpretation of source input and depositional environment. High- and low-sulphur crude oils analysed by LECO CS-200 induction furnace are derived from high- and low- sulphur kerogens respectively (Gransch and Posthuma, 1974). High-sulphur kerogen and oils originate from marine rocks deposited under highly reducing to anoxic condion.

TOC/TS ratio

The weight ratio of total organic carbon (TOC) and total sulphur (TS) (TOC/TS ratio, =C/S ratio) is an indicator for distinguishing the whether original environment of deposition of the oil source is under fresh water or marine condition, and thus give a qualitative indication of the redox status of the environment of deposition (Berner and Raiswell, 1983; 1984; Berner, 1989; Phillips and Bustin, 1996). High C/S ratio (higher than 10) indicates the mainly oxic sediments in terrestrial depositional environment. In contrast, low C/S ratio (lower than 5) can be an indicator of a greater abundance of euxinic (oxygen-poor) basin environment. In addition, the C/S ratio in the range from 5-10 corresponds to deposition under periodic anoxia condition (ranging from oxic to anoxic environment).

The TOC/TS versus TOC plot

TOC/TS versus TOC plot can be used to determined condition of deposition of source rocks. High C/S ratio (higher than 10) can be indicates the mainly oxic sediments in terrestrial depositional environment. In contrast, low C/S ratio (lower than 5) can be an indicator that a greater abundance of euxinic (TOC/TS boundaries from Berner and Raiswell, 1984).

Rock-Eval divided S_1, S_2 and T_{max}

S_1 is free hydrocarbons, oil and gas, contained in the organic matter, expressed in mg HC/g rock. S_1 values less than 0.5 can be indicated no petroleum potential. S_1 values between 0.5 and 1 can be indicated as fair potential. S_1 values between 1 and 2 can be indicated as good potential and between 2 and 4 can be indicated as very good potential.

S_2 corresponds to present potential of the rock sample and expressed in mg HC/g rock. Most sediments have S_2 values lower than 2 mg HC/g rock. S_2 higher than 5 mg HC/g rock can be considered as fair potential sources (Bordenave *et al*., 1993).

T_{max}(^{o}C) is the oven temperature that corresponds to the maximum rate of the S_2 hydrocarbon generation which varies as a function of the thermal maturity of the organic matter.

Hydrogen index (HI)

The hydrogen index (HI) corresponds to the quantity of pyrolyzable organic compounds from S_2 relative to the TOC. HI is defined as the ratio between S_2 expressed in mg HC/g rock and TOC expressed per weight of rock (Tissot and Welte, 1984). Source rock which HI values of less than 200 mg HC/ g TOC can be generated gas. HI values 200 to 300 mg HC/g TOC can be generated mix oil and gas and HI values more than 300 mg HC/g TOC can be generated oil (Peters and Moldowan, 1993; Peters *et al*., 2005).

Oxygen index (OI)

The oxygen index (OI) corresponds to the quantity of carbon dioxide from S_3 relative to the TOC. OI is defined as the ratio between S_3 expressed in mg HC/g rock and TOC expressed per weight of rock (Tissot and Welte, 1984). However, in research Rock-Eval derided S_3 can not be measured because the CO_2 detector of Rock-Eval 6 instrument is broken.

Production index (PI)

The PI is $S_1/(S_1+S_2)$ ratio. The PI typically climbs from 0.1 to 0.4 from the beginning to the end of the oil generation window (Tissot and Welte, 1984).

Rock-Eval divided T_{max} and Production index (PI)

Peters (1986) reported that Rock-Eval T_{max} and production index (PI) values less than 435^{o}C and 0.1 respectively indicate an immature organic matter that has generated little or no petroleum. A T_{max} greater than 470^{o}C coincide with the wet-gas generation zone. The PI values reach about 0.4 at the bottom of the oil window (beginning of the wet-gas zone) and increase to 1.0 when the hydrocarbon-generative capacity of kerogen has been exhausted.

The S_2 yield against TOC cross plot

The potential of source rocks is determined by the S_2 yield against TOC cross plot can be indicated as potential of source rocks. S_2 value less than 2 and TOC value less than 0.5 can be interpreted as poor potential source rocks. S_2 value of 2-5 and TOC value of 0.5-1 can be interpreted as fair potential source rocks. S_2 value of 5-20 and TOC value of 1-2 can be interpreted as good potential source rocks. S_2 value more than 20 and TOC value more than 2 can be interpreted as excellent potential source rocks.

The Hydrogen Index against T_{max} plot

The hydrocarbon and kerogen types are classified by Hydrogen Index (HI, mg HC/g TOC) against T_{max} from Rock-Eval pyrolysis plot. This plot is used when the oxygen index has not been determined. The four principal types of kerogen in sedimentary rocks include type I (very oil-prone), II (oil-prone), III (gas-prone) and IV (inert). Some discussions modify these definitions to include transitional kerogen composition, such as type II/III (mix oil- and gas-prone).

4.1.1 Results of Fang basin samples

The TOC content ranges from 0.19 to 2.22 wt%, averaging 1.39 wt%. The maximum and minimum TOC values are at depth 879.30 and 557.80 m, respectively. Between the depth of 879.30 and 998.20 m samples have high TOC contents (1.56 to 2.22 wt%). The TOC content of the samples are generally low, and about half of samples, have TOC content higher than 1.5 wt%. The TC content varies between 0.76 to 6.2 wt% and averaging 2.39 wt%. The maximum and minimum TC values are at depth 544.10 and 557.80 m, respectively.The sulphur content (TS) is usually low and vary between 0.06 to 0.68 wt%. The maximum and minimum TS values are at depth 1,015 m and 557.80 m, respectively (Table 4.1 and Figure 4.1).

Rock-Eval derived S_1 for Fang basin sample is quite low; vary from 0.01 to 0.20 mg HC/g rock. The maximum and minimum S_1 values are at depth 1060.7 and 544.10

Table 4.1 Screening data of samples from Fang-MS well from Fang basin.

Sample no	Depth (m.) top	Depth (m.) bottom	TOC (wt%)	TC (wt%)	TS (wt%)	T_{max} (°C)	S_1 (mg HC/g rock)	S_2 (mg HC/g rock)	HI (mg HC/g TOC)	PI	TOC/TS
11856	539.50	548.64	1.32	6.20	0.23	420	0.01	1.85	140	0.01	5.79
11857	551.69	563.88	0.19	0.76	0.06	433	0.00	0.17	91	nd	3.33
11858	566.93	579.12	1.09	2.13	0.19	427	0.04	2.45	224	0.02	5.91
11859	582.17	594.36	1.39	2.68	0.20	422	0.03	3.78	273	0.01	7.02
11860	597.41	609.60	1.30	2.60	0.20	425	0.02	3.02	232	0.01	6.46
11861	612.65	624.84	1.83	2.52	0.35	432	0.05	6.38	349	0.01	5.24
11862	627.89	637.03	1.54	3.19	0.27	426	0.05	3.97	258	0.01	5.65
11863	658.37	670.56	1.90	2.09	0.36	429	0.09	7.94	417	0.01	5.30
11864	673.61	685.80	1.11	2.42	0.15	422	0.08	2.49	225	0.03	7.16
11865	688.85	701.04	1.43	3.23	0.12	419	0.16	2.66	185	0.06	11.81
11866	704.09	716.28	0.75	2.93	0.12	421	0.02	1.41	188	0.01	6.39
11867	719.33	731.52	1.14	3.28	0.68	422	0.16	2.23	195	0.07	1.69
11868	734.57	746.76	1.19	2.63	0.20	427	0.09	3.08	260	0.03	5.87
11869	749.81	762.00	1.64	1.89	0.25	428	0.11	5.78	353	0.02	6.62
11870	765.05	777.24	1.25	1.86	0.15	429	0.11	2.78	223	0.04	8.13
11871	780.29	792.48	1.25	1.99	0.23	435	0.09	4.81	385	0.02	5.46
11872	795.53	807.72	0.88	2.06	0.12	425	0.10	2.08	238	0.05	7.44
11873	810.77	822.96	0.82	1.32	0.12	429	0.10	1.96	239	0.05	6.91
11874	826.01	838.20	1.07	1.27	0.16	430	0.12	3.39	316	0.03	6.83
11875	847.34	847.34	0.86	2.29	0.15	423	0.05	1.62	189	0.03	5.93
11876	874.78	883.92	2.22	2.48	0.38	432	0.13	9.51	428	0.01	5.91

Table 4.1 (Cont.).

Sample no	Depth (m.)		TOC	TC	TS	T_{max} (°C)	S_1	S_2	HI (mg HC/g TOC)	PI	TOC/TS
	top	bottom	(wt%)				(mg HC/g rock)				
11877	886.97	899.16	1.95	2.62	0.32	432	0.11	6.78	348	0.02	5.99
11878	902.21	914.40	1.66	2.27	0.31	434	0.10	6.98	419	0.01	5.33
11879	917.45	929.64	1.86	2.05	0.26	433	0.05	6.55	352	0.01	7.12
11880	935.74	941.83	2.13	2.35	0.36	435	0.09	7.50	352	0.01	5.98
11881	947.93	960.12	1.66	2.01	0.29	435	0.05	4.82	291	0.01	5.76
11882	978.41	990.60	1.72	2.39	0.27	435	0.06	5.82	338	0.01	6.41
11883	993.65	1002.79	1.56	2.19	0.26	434	0.04	4.93	316	0.01	5.96
11884	1008.89	1021.08	1.28	2.04	0.63	432	0.04	2.91	227	0.01	2.03
11885	1024.13	1036.32	1.13	2.78	0.21	425	0.03	2.04	180	0.01	5.45
11886	1039.37	1051.56	0.98	1.70	0.18	435	0.02	2.06	209	0.01	5.37
11887	1054.61	1066.80	1.95	2.88	0.31	432	0.20	7.81	400	0.02	6.32
11888	1069.85	1082.04	1.14	1.78	0.20	430	0.08	3.01	265	0.03	5.61
11889	1085.09	1094.23	1.59	2.41	0.39	434	0.14	5.85	369	0.02	4.10
11890	1100.33	1112.52	1.80	2.60	0.38	-	-	-	-	-	4.78
11891	1115.57	1127.76	1.70	2.29	0.32	436	0.11	4.99	294	0.02	5.38
11892	1146.05	1146.05	1.31	2.31	0.26	432	0.15	3.72	283	0.04	5.12

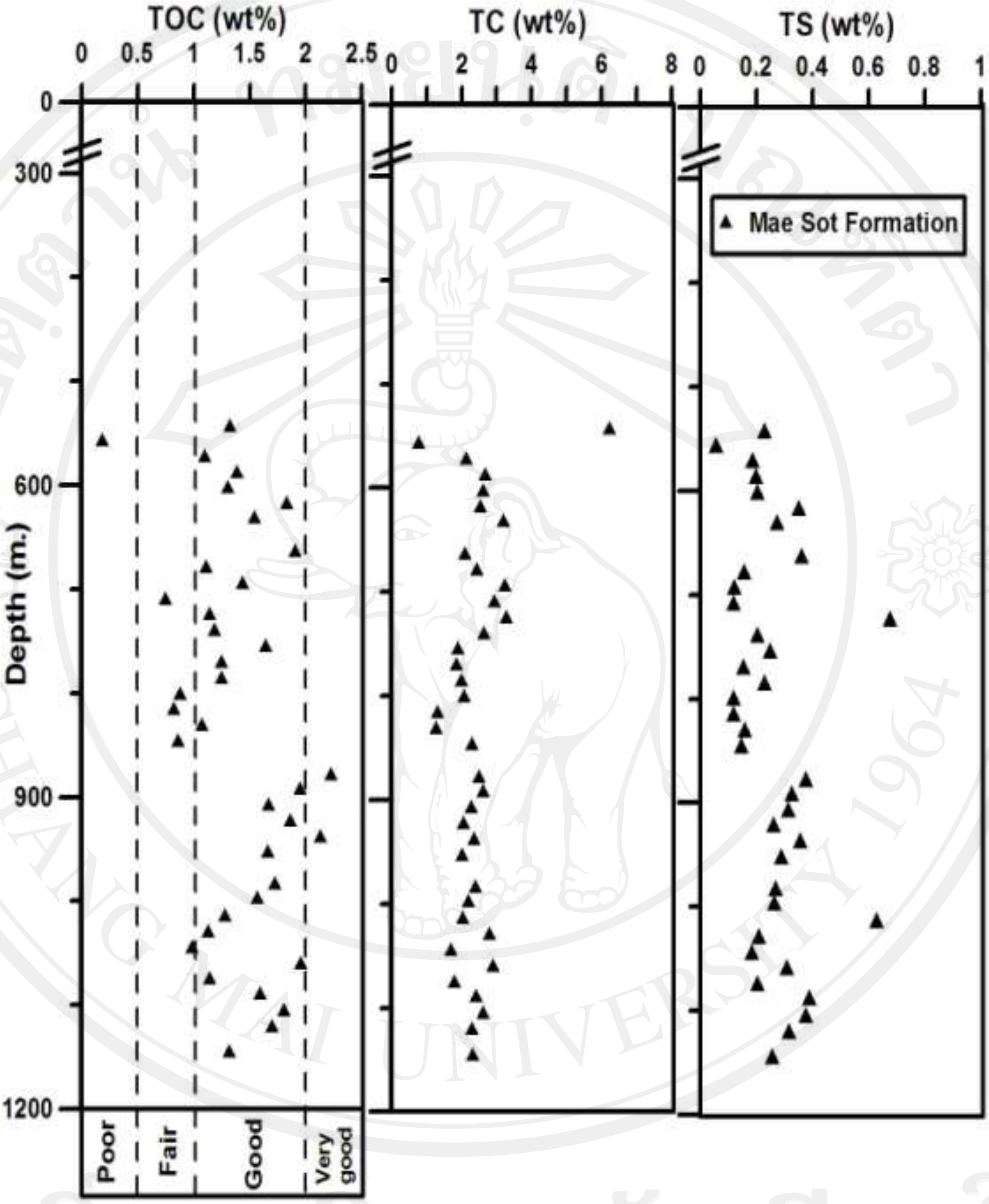

Figure 4.1 The plots of TOC content, TC content and TS content against depth show variation of screening data and source rock quality of Fang-MS well (diagram modified from Bordenave *et al*., 1993).

m, respectively. S_2 yields vary from 0.17 to 9.51 mg HC/g rock. The maximum and minimum S_2 values are at depth 879.3 and 557.8 m, respectively. S_1 yield is quite low and less than 0.5 mg HC/g rock. In contrast, about 75 % of the samples have S_2 yield-higher than 2.5 mg HC/ g rock. The HI ranges from 91 to 428 mg HC/g TOC. The maximum and minimum HI values are at depth 879.30 and 557.80 m, respectively (Table 4.1 and Figure 4.2). The 38 % of samples have HI values more than 300 mg HC/g TOC. The T_{max} values from all samples range from 419 to 436°C. The majority of the samples have T_{max} values above 425°C.The PI is quite low and ranges from 0.01 to 0.07 and the maximum PI value is of depth 725.43 m (Table 4.1 and Figure 4.3).

4.1.2 Results of Na Hong basin

The TOC content of the samples are generally high and ranges from 5.75 to 57.43 wt%, averaging 25.51 wt%. All of the samples have TOC content higher than 5 wt%. The coaly mudstones show the highest TOC value reaching more than 40 wt %. The TC content varies between 6.99 to 61.18 wt% and averaging 26.43 wt%. The sulphur content (TS) is varying from 0.31 to 16.79 wt%. Coaly mudstone contains maximum value of TOC, TC and TS contents while mudstone contains minimum value of TOC, TC and TS contents. Oil shale contains TOC, TC and TS contents about 10 to 40, 10-40 and 1 to 14 wt%, respectively (Table 4.2).

Rock-Eval derived S_1 yields vary from 0.28 to 7.54 mg HC/g rock. About 75 % of the sample have S_1 yield higher than 0.5 mg HC/g rock. The coaly mudstones show the highest S_1 value reaching more than 3 mg HC/g rock. The S_2 yields vary from 10.42 to 175.66 mg HC/g rock. The S_2 yields more than 100 mg HC/g rock are contained in coaly mudstone. HI ranges from 174 to 414 mg HC/g TOC. Half of the samples have HI values more than 300 mg HC/g TOC. The T_{max} values range from 410 to 432°C and the PI values quite low and ranges from 0.01 to 0.07 (Table 4.2).

4.1.3 Results of Ban Pa Kha sub-basin, Li basin

The TOC content ranges from 3.28 to 29.84 wt%, averaging 16.56 wt%. The maximum TOC content is contained in oil shale (Table 4.3). The TC content varies between 5.22 and 32.13 wt%, and averaging 18.68 wt%. The maximum TC content is also contained in oil shale (Table 4.3). The sulphur content (TS) is varying from 0.29

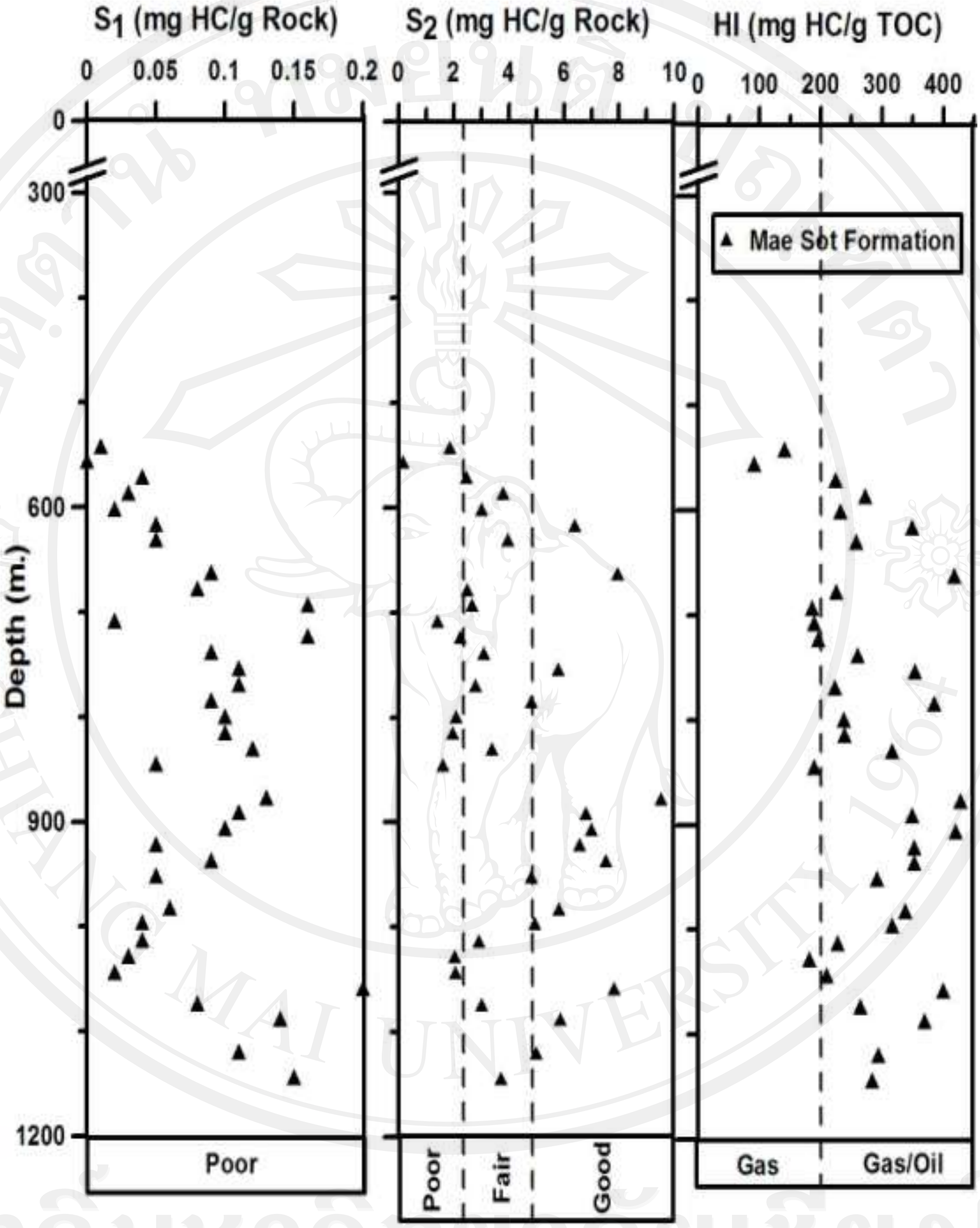

Figure 4.2 The plots of S_1, S_2 and HI against depth showing variation of screening data, source rock quality and petroleum generation potential of Fang-MS well (diagram modified from Bordenave *et al*., 1993).

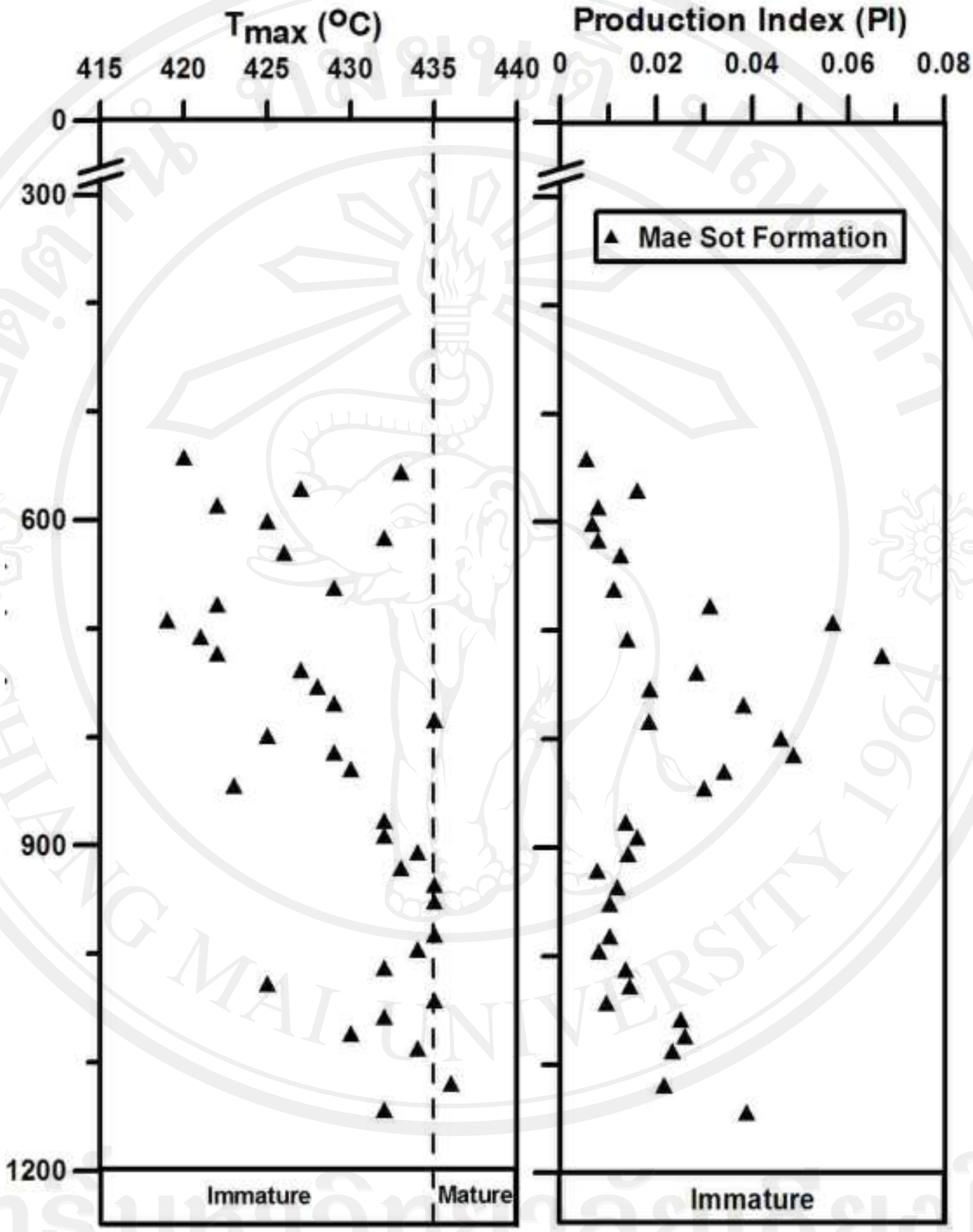

Figure 4.3 The plots of T_{max} and PI against depth showing variation of screening data and maturation of source rock of Fang-MS well (diagram modified from Bordenave *et al*., 1993).

Table 4.2 The screening data of Na Hong samples.

Sample No.	Basin	Lithology	TOC (wt%)	TC (wt%)	TS (wt%)	T_{max} (^oC)	S_1 (mg HC/g rock)	S_2 (mg HC/g rock)	HI (mg HC/ g TOC)	PI
14705	Na Hong Basin	Oil shale	14.64	15.85	1.07	427	0.93	43.81	299	0.02
14706	Na Hong Basin	Mudstone	5.75	7.15	0.31	424	0.15	10.42	181	0.01
14707	Na Hong Basin	Oil shale	10.90	13.46	0.63	422	0.50	24.30	223	0.02
14708	Na Hong Basin	Oil shale	19.14	20.79	1.14	416	0.89	33.25	174	0.03
14709	Na Hong Basin	Oil shale	42.41	42.92	5.20	411	3.33	122.55	289	0.03
14710	Na Hong Basin	Oil shale	42.94	43.65	14.21	427	6.24	175.66	409	0.03
14711	Na Hong Basin	Coaly mudstone	57.39	58.30	3.63	410	7.54	161.27	281	0.04
14712	Na Hong Basin	Coaly mudstone	57.43	61.18	4.73	415	6.29	157.88	275	0.04
14713	Na Hong Basin	Mudstone	15.54	16.66	1.61	429	1.80	47.96	309	0.04
14714	Na Hong Basin	Mudstone	13.67	14.11	0.82	430	1.26	46.52	340	0.03
14715	Na Hong Basin	Mudstone	8.10	8.43	0.42	430	0.32	27.17	335	0.01
14716	Na Hong Basin	Mudstone	8.86	9.07	0.29	431	0.43	32.77	370	0.01
14717	Na Hong Basin	Mudstone	6.80	6.99	0.24	428	0.28	22.24	327	0.01
14718	Na Hong Basin	Coaly mudstone	44.65	44.37	16.79	430	4.53	184.65	414	0.02
14719	Na Hong Basin	Coaly mudstone	48.54	48.55	7.29	423	3.56	140.09	289	0.02
14720	Na Hong Basin	Mudstone	11.38	11.46	5.35	432	3.14	41.50	365	0.07

Table 4.3: The screening data of Li samples.

Sample no.	Locality	Lithology	TOC	TC	TS	Tmax	S1	S2	HI	PI
			(wt %)			(°C)	(mg HC/g rock)		(mg HC/g TOC)	
14689	Li Basin	Shale	4.84	5.22	0.41	422	0.20	14.92	308	0.01
14690	Li Basin	Shale	9.20	10.93	0.33	415	0.55	31.50	342	0.02
14691	Li Basin	Shale	8.57	8.72	0.84	430	0.95	35.57	415	0.03
14692	Li Basin	Mudstone	10.30	11.23	1.06	427	0.84	39.80	386	0.02
14693	Li Basin	Oil shale	29.84	32.13	1.46	433	2.38	181.11	607	0.01
14694	Li Basin	Mudstone	3.53	5.46	0.29	426	0.16	13.47	382	0.01
14695	Li Basin	Oil shale	26.33	28.81	0.77	431	2.29	154.85	588	0.01
14696	Li Basin	Mudstone	10.20	11.04	0.52	429	0.54	39.47	387	0.01
14697	Li Basin	Shale	9.90	11.02	0.74	435	0.85	42.17	426	0.02
14698	Li Basin	Mudstone	3.28	12.73	0.82	439	0.29	22.24	679	0.01

to 1.46 wt%. The maximum TS content is contained in oil shale and minimum content is contained in mudstone (Table 4.3).

Rock-Eval derived S_1 yields vary from 0.16 to 2.38 mg HC/g rock. The maximum S_1 yield is contained in oil shale and minimum yield is contained in mudstone (Table 4.3). The S_2 yields vary from 13.47 to 181.11 mg HC/g rock. The S_2 yields more than 100 mg HC/g rock are contained in oil shale (Table 4.3). The Hydrogen Index (HI) ranges from 308 to 679 mg HC/g TOC. The HI values more than 500 mg HC/g TOC is contained in oil shale (Table 4.3). The T_{max} values of all samples range from 415 to 439°C (Table 4.3). The PI values are quite low and range from 0.01 to 0.03 (Table 4.3).

4.1.4 Results of Mae Sot basin

The TOC content ranges from 17.36 to 31.20 wt%, averaging 23.79 wt% (Table 4.4). The TC content varies between 19.19 and 33.88 wt%, and averaging 26.07 wt% (Table 4.4). The sulphur content (TS) is varying from 0.30 to 1.46 wt% (Table 4.4).

Rock-Eval derived S_1 yields vary from 3.42 to 5.35 mg HC/g rock (Table 4.4). Half of the samples have S_1 yield higher tha 4 mg HC/g rock. The S_2 yields vary from 142.07 to 219.01 mg HC/g rock (Table 4.4). The HI ranges from 760 to 831 mg HC/g TOC (Table 4.4). The T_{max} values from all samples range from 429 to 440°C. The PI values are quite low and ranges from 0.02 to 0.03 (Table 4.4).

4.1.5 Results of P-SK well, Phitsanulok basin

The samples were collected from Yom, Pratu Tao and Lan Krabu Formations between depths of 900 and 3,070 m of P-SK well in Sirikit oilfield, at 50 m interval. Yom Formation is between depths of 950 and 1,450 m and dominated by sandstone, claystone and siltstone. Pratu Tao Formation is between depths of 1,450 and 1,850 m and dominated by claystone, sandstone and shale. Chum Saeng Formation is between depths of 1,850 and 2,150 m and dominated by mudstone. Lan Krabu Formation is between depths of 2,150 and 3,070 m and dominated by siltstone and sandstone and mudstone.

Table 4.4: The screening data of Mae Sot samples.

Sample No.	Basin	Lithology	TOC	TC	TS	T_{max}	S_1	S_2	HI	PI
			(wt %)			(°C)	(mg HC/g rock)		(mg HC/g TOC)	
14699	Mae Sot Basin	Oil shale	26.21	28.04	1.34	440	4.15	199.16	760	0.02
14700	Mae Sot Basin	Oil shale	31.20	33.88	1.46	440	3.99	211.75	679	0.02
14701	Mae Sot Basin	Oil shale	28.39	32.03	0.81	440	5.35	219.01	771	0.02
14702	Mae Sot Basin	Oil shale	21.33	22.32	1.20	435	3.42	154.02	722	0.02
14703	Mae Sot Basin	Oil shale	18.24	20.94	0.85	430	4.20	151.51	831	0.03
14704	Mae Sot Basin	Oil shale	17.36	19.19	0.30	429	3.47	142.07	818	0.02

The TOC content ranges from 0.52 to 3.75 wt%, averaging 1.58 wt% (Table 4.5). The maximum TOC value is at depth of 2,075 m, in Chum Saeng Formation, and minimum value is at depth of 1,825 m in Pratu Tao Formation. The TC content varies between 1.56 and 4.65 wt%, and averaging 2.84 wt% (Table 4.5). The maximum TC value is at depth of 2,075 m in Chum Saeng Formation and minimum value is at depth of 1,825 m in Pratu Tao Formation. The TS content is varying from 0.19 to 0.85 wt% (Table 4.5). The minimum TS value is at depth of 2,475 m in Lan Krabu Formation and the maximum value is at depth of 925 m in Yom Formation (Figure 4.4).

Rock-Eval derived S_1 yields vary from 0.26 to 3.65 mg HC/g rock (Table 4.5). The maximum S_1 value is at depth of 2,025 m in Chum Saeng Formation. The S_1 value is lowest in the Yom Formation. The S_2 yields vary from 1.43 to 19.61 mg HC/g rock (Table 4.5). The maximum S_2 value is at depth of 2,075 m in Chum Saeng Formation. The HI ranges from 191 to 602 mg HC/g TOC (Table 4.5 and Figure 4.5). The T_{max} values from all samples range from 420° to 435°C and the PI ranges from 0.07 to 0.28 and the highest value is at depth 2,475 m in Lan Krabu Formation (Table 4.5 and Figure 4.6).

The Yom formation, TOC and TC value ranges from 0.78 to 1.23 wt % and 2.00 to 3.18 wt%, respectively. The TS value ranges from 0.33 to 0.85 wt%. The S_1 and S_2 yields range from 0.53 to 1.05 mg HC/g rock and 2.09 to 7.40 mg HC/g rock, respectively. The HI value is range from 248 to 602 mg HC/g TOC. The T_{max} and PI value are range from 421 to 432^{o}C and 0.07 to 0.26, respectively. TOC, TC, TS, S_1, S_2 and PI plots show unity data while TS, HI, PI and T_{max} plots show little of scatter data (Figures 4.4, 4.5 and 4.6).

The Pratu Tao Formation, TOC value ranges from 0.52 to 1.01 wt %. The TC value ranges from 1.56 to 2.78 wt% and the TS value ranges from 0.20 to 0.59 wt%. The S_1 and S_2 yields range from 0.26 to 0.92 mg HC/g rock and 1.43 to 4.45 mg HC/g rock, respectively. The HI values range from 197 to 440 mg HC/g TOC. The T_{max} and PI values range from 420^{o} to 425^{o}C and 0.12 to 0.2, respectively. TOC, TC, TS, S_1, S_2 and PI plots show unity data while TS, HI and T_{max} plots show scatter data (Figures 4.4, 4.5 and 4.6).

The Chum Saeng Formation, TOC value ranges from 1.42 to 3.75 wt %. The TC value ranges from 2.21 to 4.65 wt% and the TS value ranges from 0.30 to 0.52

Table 4.5 Screening data of samples from P-SK well from Phitsanulok basin.

Sample no.	Depth (m.)		TOC	TC	TS	T_{max}	S_1	S_2	HI	PI	TOC/TS
	top	bottom	(%)			(°C)	(mg HC/g rock)		(mg HC/g TOC)		
14721	900	950	1.23	2.00	0.85	431	0.57	7.40	602	0.07	15.50
14722	950	1000	0.78	2.31	0.37	428	0.53	2.59	334	0.17	14.72
14723	1000	1050	0.97	2.06	0.49	426	0.55	3.75	386	0.13	14.02
14724	1050	1100	0.93	2.76	0.39	426	1.05	3.03	327	0.26	13.39
14725	1100	1150	0.78	3.18	0.35	425	0.80	2.64	339	0.23	12.80
14726	1150	1200	0.84	2.85	0.51	421	0.60	2.09	248	0.22	12.27
14727	1200	1250	0.84	2.95	0.41	426	0.75	2.73	325	0.22	11.78
14728	1250	1300	0.87	2.99	0.36	425	0.94	2.73	315	0.26	11.33
14729	1300	1350	0.83	2.91	0.33	426	0.74	2.99	358	0.20	10.91
14730	1350	1400	1.07	2.16	0.49	426	0.72	4.29	402	0.14	10.52
14731	1400	1450	1.04	2.31	0.45	425	1.04	4.31	416	0.19	10.16
14732	1450	1500	1.01	2.21	0.46	420	0.92	4.45	440	0.17	9.82
14733	1500	1550	0.84	1.95	0.59	424	0.75	3.52	422	0.18	9.51
14734	1550	1600	0.94	1.85	0.39	424	0.68	3.67	390	0.16	9.21
14735	1600	1650	0.81	2.44	0.36	424	0.77	3.04	377	0.20	8.93
14736	1650	1700	0.85	2.19	0.37	425	0.65	3.22	378	0.17	8.67
14737	1700	1750	0.96	2.52	0.52	424	0.64	3.06	319	0.17	8.42
14738	1750	1800	0.73	2.73	0.25	420	0.31	1.43	197	0.18	8.19
14739	1800	1850	0.52	1.56	0.20	423	0.26	1.86	358	0.12	7.97
14740	1850	1900	1.42	2.21	0.30	427	0.95	5.05	357	0.16	7.76
14741	1900	1950	2.06	2.94	0.40	429	1.71	6.67	324	0.20	7.56

Table 4.5 (Cont.)

Sample no.	Depth (m.)		TOC	TC	TS	T_{max}	S_1	S_2	HI	PI	TOC/TS
	top	bottom	(%)			(°C)	(mg HC/g rock)		(mg HC/g TOC)		
14742	1950	2000	2.83	3.70	0.53	430	3.31	14.37	508	0.19	7.37
14743	2000	2050	3.19	4.27	0.40	431	3.65	15.19	476	0.19	7.19
14744	2050	2100	3.75	4.65	0.45	434	3.55	19.61	523	0.15	7.02
14745	2100	2150	3.34	4.12	0.44	432	3.40	13.88	415	0.20	6.86
14746	2150	2200	2.20	3.41	0.42	430	2.37	9.18	417	0.21	6.70
14747	2200	2250	1.97	3.34	0.41	426	1.71	5.35	271	0.24	6.55
14748	2250	2300	2.06	3.09	0.22	427	2.29	7.37	357	0.24	6.41
14749	2300	2350	1.70	2.97	0.18	426	1.88	5.66	333	0.25	6.28
14750	2350	2400	1.85	3.05	0.24	425	1.67	4.56	246	0.27	6.15
14751	2400	2450	1.85	2.83	0.36	425	1.75	6.10	330	0.22	6.02
14752	2450	2500	1.64	3.12	0.19	424	1.91	4.85	295	0.28	5.90
14753	2500	2550	1.96	3.13	0.24	429	1.63	5.64	288	0.22	5.79
14754	2550	2600	1.99	3.00	0.21	428	1.84	7.20	361	0.20	5.67
14755	2600	2650	2.63	3.66	0.22	427	1.73	5.85	223	0.23	5.57
14756	2650	2700	1.65	2.74	0.21	426	1.19	5.62	342	0.17	5.47
14758	2750	2800	2.41	3.24	0.38	433	2.27	10.70	443	0.18	5.27
14759	2800	2850	2.40	3.23	0.54	435	2.36	12.01	501	0.16	5.18
14760	2850	2900	2.15	3.08	0.41	434	1.70	7.90	368	0.18	5.09
14761	2900	2950	1.76	3.44	0.29	431	1.36	7.73	438	0.15	5.00
14762	2950	3000	1.59	2.67	0.34	431	1.24	7.05	445	0.15	4.92
14763	3000	3050	1.34	2.37	0.37	430	0.81	5.21	388	0.13	4.84
14764	3050	3070	1.30	1.97	0.26	429	0.70	5.92	455	0.11	4.81

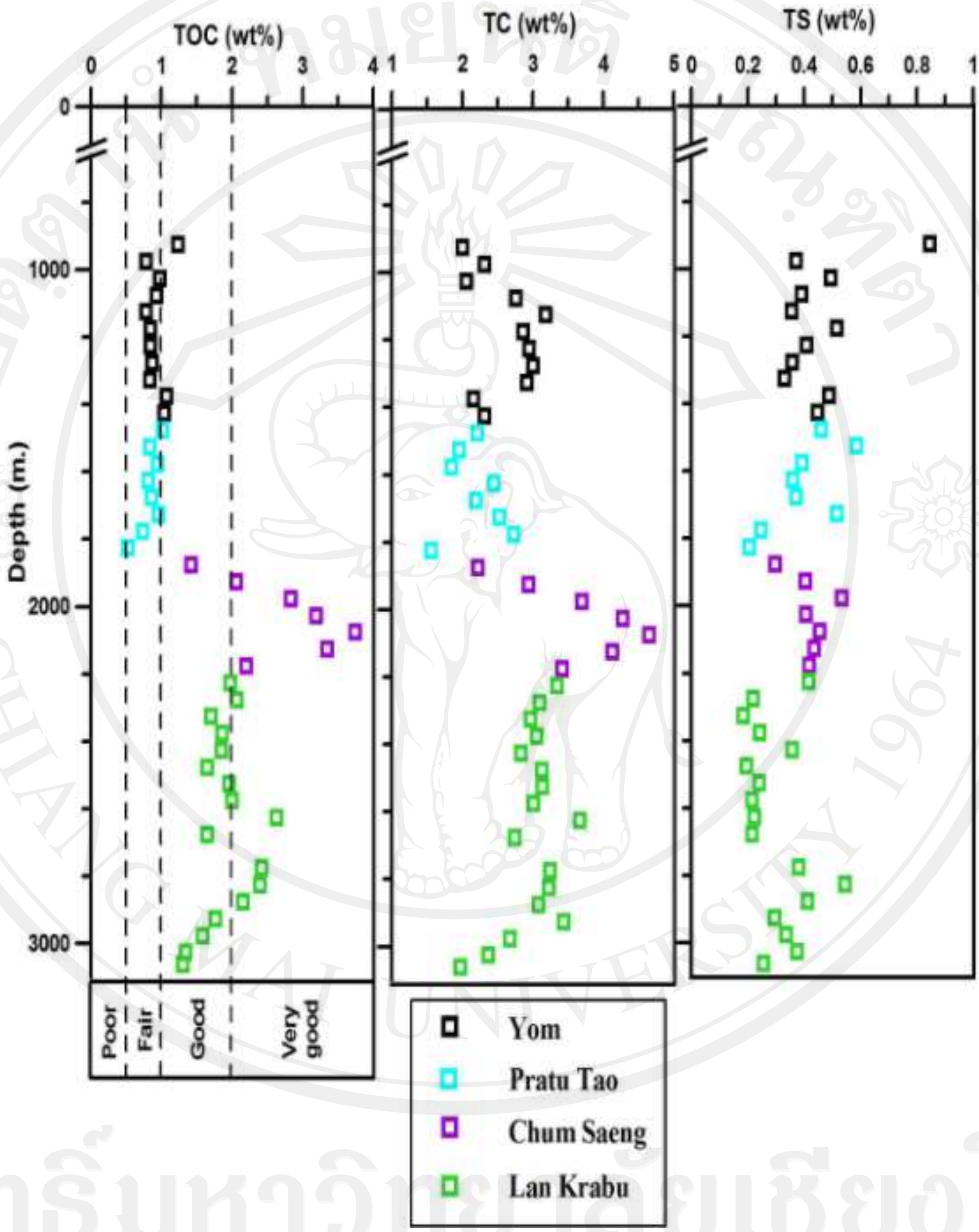

Figure 4.4 The plots of TOC content, TC content and TS content against depth show variation in screening data and source rock quality of P-SK well (diagram modified from Bordenave *et al*., 1993).

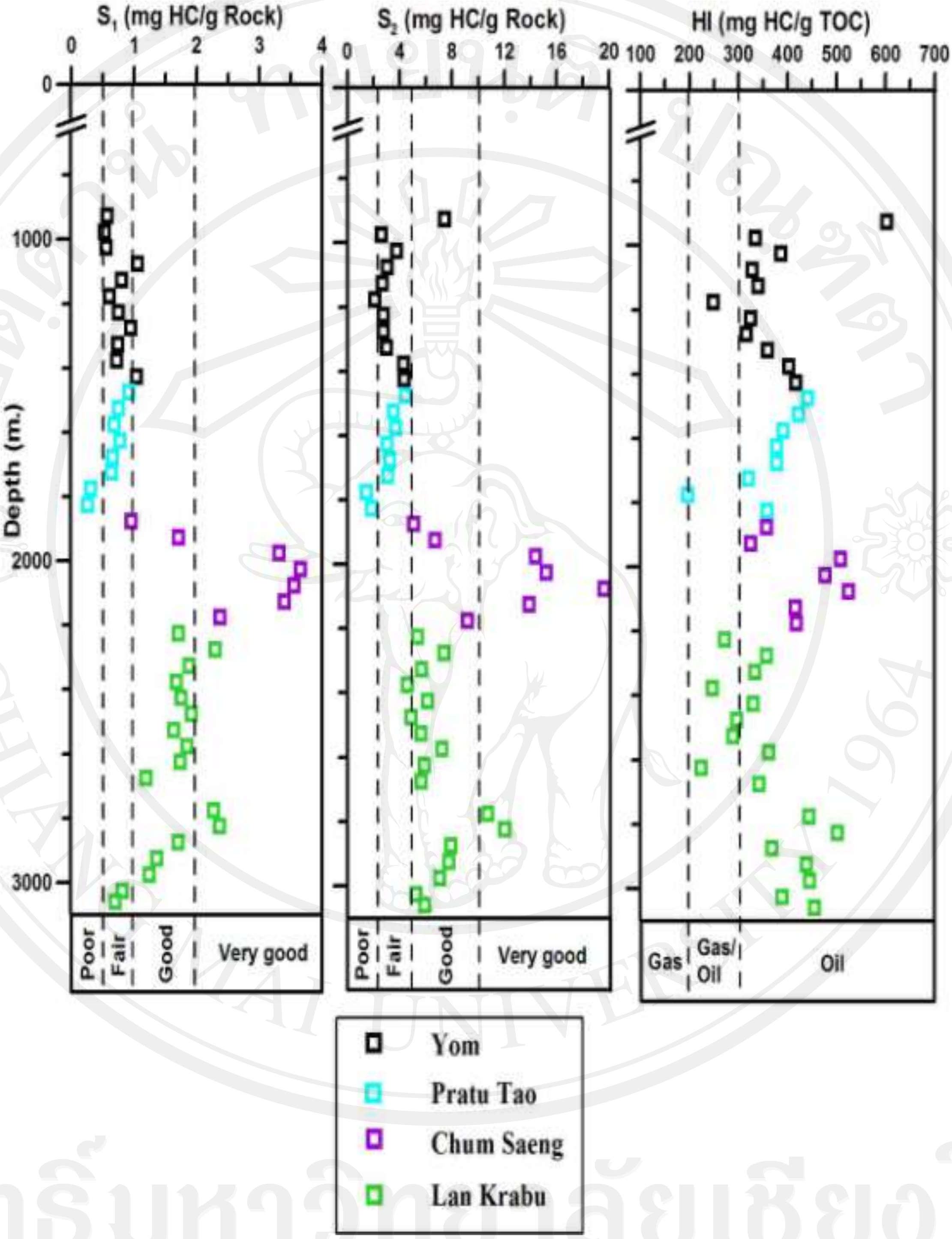

Figure 4.5 The plots of S_1, S_2 and HI against depth show variation of screening data, source rock quality and petroleum generation potential of P-SK well (diagram modified from Bordenave *et al*., 1993).

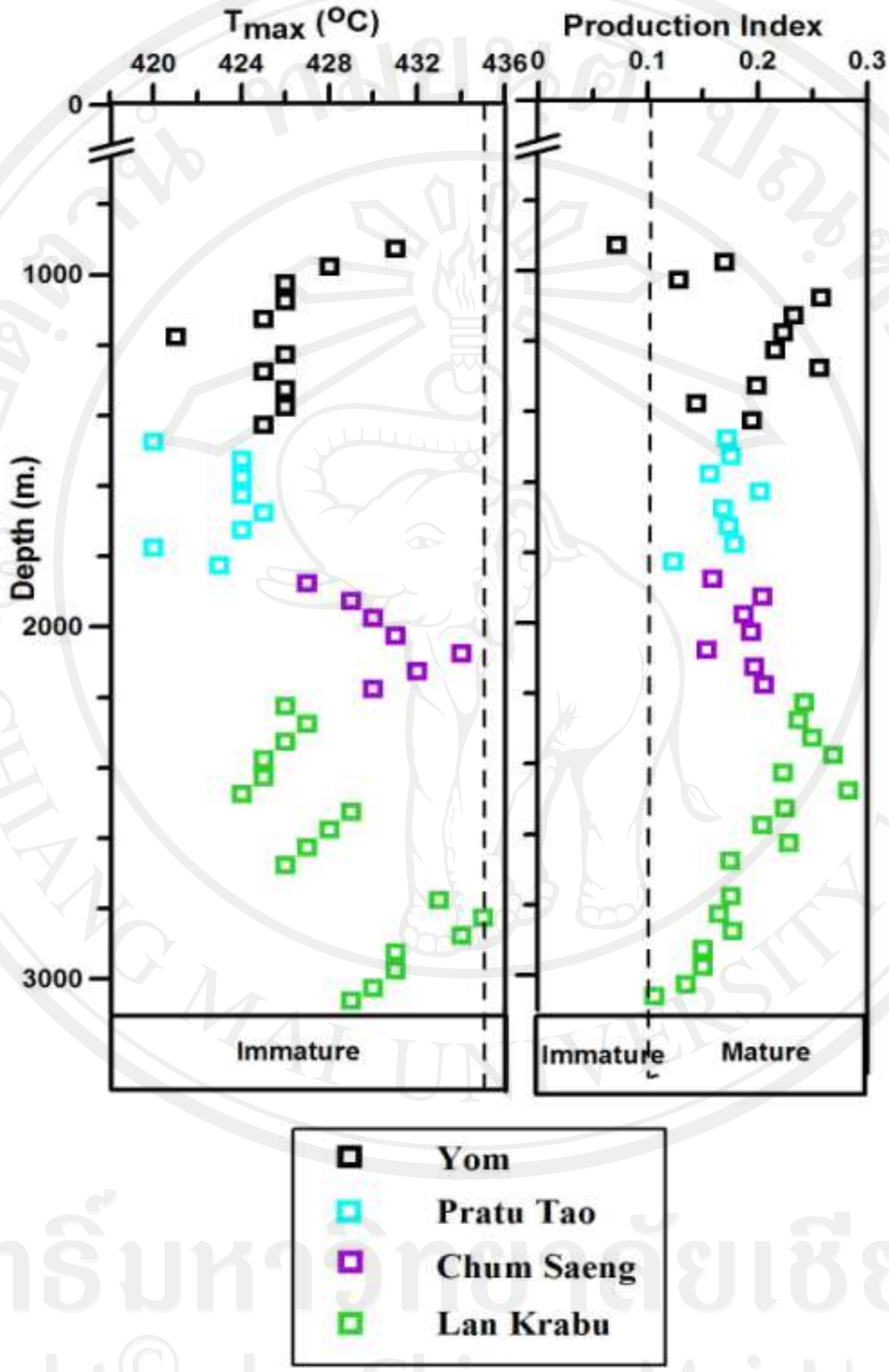

Figure 4.6 The plots of T_{max} and PI against depth show variation of screening data and maturation of source rock of P-SK well (diagram modified from Bordenave *et al*., 1993).

wt%. The S_1 and S_2 yields range from 0.95 to 3.65 mg HC/g rock and 5.05 to 19.61 mg HC/g rock, respectively. The HI value ranges from 324 to 508 mg HC/g TOC.The T_{max} and PI values range from 427° to 434°C and 0.15 to 0.21, respectively. TS and PI show little of scatter data while TOC, TC, HI, S_1, S_2 and T_{max} plots show more scatter data (Figures 4.4, 4.5 and 4.6).

The Lan Krabu Formation, TOC value ranges from 1.30 to 2.63 wt %. The TC value ranges from 1.97 to 3.66 wt% and the TS value ranges from 0.19 to 0.54 wt%. The S_1 and S_2 yields range from 0.70 to 2.36 and 4.85 to 12.01 mg HC/g rock, respectively. The HI values range from 223 to 501 mg HC/g TOC. The T_{max} and PI values range from 424° to 433°C and 0.11 to 0.27, respectively. TOC, TC, TS, S_1, S_2, HI, T_{max} and PI plots show scatter data (Figures 4.4, 4.5 and 4.6).

4.1.6 Results of Suphanburi Basin

SP1 well

The TOC content ranges from 0.02 to 6.78 wt%, averaging 1.29 wt% (Table 4.6). The maximum TOC value is at depth 1,537.5 m in Unit C and the minimum value is at depth 1,007.5 m in Unit D. The TC content varies between 1.27 and 9.85 wt%, and averaging 4.36 wt% (Table 4.6). The maximum TC value is at depth 1,537.5 m in Unit C and the minimum value is at depth 1,132.5 m in Unit D. The TS is varying from 0.02 to 1.47 wt% (Table 4.6). The maximum TS value is at depth 2,112.5 m in Unit B and the minimum value is at depth 1,007.5 m in Unit D (Figure 4.7).

Rock-Eval derived S_1 yields vary from 0.01 to 1.24 mg HC/g rock (Table 4.6). The maximum S_1 value is at depth of 1,967.5 m in Unit B. The S_2 yields vary from 0.01 to 41.58 mg HC/g rock (Table 4.6 and Figure 4.8). The maximum S_2 value is at depth of 1,460 m in Unit C. The Hydrogen Index (HI) ranges from 22 to 623 mg HC/g TOC (Table 4.6 and Figure 4.9). The T_{max} values from all samples range from 319° to 492°C and the PI values range from 0.01 to 0.67 (Table 4.6 and Figure 4.10).

Unit D, TOC value ranges from 0.02 to 0.24 wt %. The TC value ranges from 1.27 to 5.38 wt% and the TS value ranges from 0.02 to 0.12 wt%. The S_1 and S_2 yields range from 0.01 to 0.19 and zero to 0.48 mg HC/g rock, respectively. The HI

Table 4.6 Screening data of samples from SP1 well from Suphanburi basin.

Sample no.	Depth (m)		TOC	TC	TS	Tmax	S_1	S_2	HI	PI	TOC/TS
	top	bottom	(wt%)			(°C)	(mg HC/g rock)		(mg HC/g TOC)		
11698	1000	1015	0.02	5.02	0.02	406	0.01	0.01	40	0.50	1.00
11699	1020	1030	0.03	5.38	0.04	439	0.01	0.00	-	-	0.95
11700	1035	1050	0.04	1.82	0.04	319	0.02	0.01	26	0.67	0.93
11701	1050	1065	0.03	4.02	0.03	432	0.02	0.01	29	0.67	1.16
11702	1065	1080	0.04	3.88	0.04	319	0.02	0.00	-	-	1.14
11703	1100	1105	0.04	4.84	0.05	325	0.02	0.01	22	0.67	0.99
11704	1125	1140	0.05	1.27	0.04	315	0.04	0.00	-	-	1.49
11705	1140	1155	0.04	1.56	0.02	493	0.02	0.00	-	-	1.67
11706	1155	1170	0.04	2.71	0.03	339	0.01	0.00	-	-	1.36
11707	1170	1185	0.04	3.02	0.04	319	0.03	0.00	-	-	1.05
11708	1185	1200	0.04	2.86	0.06	408	0.02	0.00	-	-	0.66
11709	1200	1215	0.06	1.96	0.04	439	0.02	0.02	33	0.50	1.39
11710	1215	1230	0.12	3.03	0.12	342	0.19	0.43	346	0.31	1.04
11711	1230	1245	0.10	2.72	0.04	354	0.04	0.18	185	0.18	2.62
11712	1245	1260	0.10	3.59	0.03	355	0.03	0.17	172	0.15	3.04
11713	1260	1275	0.11	2.31	0.03	352	0.05	0.24	210	0.17	3.50
11714	1275	1290	0.13	2.38	0.04	348	0.06	0.27	202	0.18	3.63
11715	1290	1305	0.16	2.19	0.04	354	0.06	0.32	203	0.16	4.31
11716	1305	1320	0.13	1.85	0.04	380	0.02	0.18	134	0.10	3.23
11717	1320	1335	0.16	2.59	0.04	444	0.02	0.09	55	0.18	3.77

Table 4.6 (Cont.)

Sample no.	Depth (m.)		TOC	TC	TS	T_{max}	S_1	S_2	HI	PI	TOC/TS
	top	bottom	(wt%)			(°C)	(mg HC/g rock)		(mg HC/g TOC)		
11718	1335	1350	0.20	3.24	0.07	441	0.01	0.30	151	0.03	2.97
11719	1350	1365	0.14	2.52	0.04	432	0.01	0.12	88	0.08	3.59
11720	1365	1380	0.24	2.98	0.06	441	0.02	0.48	202	0.04	4.16
11721	1380	1395	0.46	2.62	0.06	434	0.02	1.11	239	0.02	7.24
11722	1395	1410	0.60	2.09	0.11	433	0.03	1.00	167	0.03	5.59
11723	1410	1425	0.66	2.43	0.08	433	0.01	0.88	134	0.01	8.54
11724	1425	1440	0.66	1.79	0.10	429	0.03	1.01	153	0.03	6.66
11725	1440	1450	3.87	5.82	0.45	432	0.15	19.44	502	0.01	8.66
11726	1455	1465	6.67	9.56	0.66	427	0.40	41.58	623	0.01	10.06
11727	1470	1485	0.82	3.17	0.38	432	0.10	2.08	255	0.05	2.17
11728	1485	1500	0.56	5.03	0.48	431	0.17	13.00	2315	0.01	1.17
11729	1500	1515	1.56	3.82	0.39	435	0.04	4.98	319	0.01	4.04
11730	1515	1530	1.71	3.80	0.34	431	0.05	6.42	375	0.01	5.11
11731	1530	1545	6.78	8.55	0.79	428	0.37	37.84	558	0.01	8.57
11732	1545	1560	0.55	2.24	0.18	436	0.01	1.30	237	0.01	2.98
11733	1560	1570	0.55	2.43	0.63	435	0.06	0.96	173	0.06	0.88
11734	1575	1590	0.55	2.39	0.96	435	0.02	1.16	212	0.02	0.57
11735	1590	1605	0.49	2.29	0.58	436	0.02	1.10	224	0.02	0.84
11736	1605	1620	0.37	2.43	0.23	434	0.01	0.74	200	0.01	1.60
11737	1620	1635	0.65	2.81	0.18	431	0.03	1.09	168	0.03	3.63
11738	1635	1650	0.61	2.79	0.35	436	0.01	1.29	211	0.01	1.76
11739	1650	1665	0.45	2.77	0.45	438	0.03	0.79	177	0.04	1.00

Table 4.6 (Cont.)

Sample no.	Depth (m.)		TOC	TC	TS	T_{max}	S_1	S_2	HI	PI	TOC/TS
	top	bottom	(wt.%)			(°C)	(mg HC/g rock)		(mg HC/g TOC)		
11740	1665	1680	0.28	1.94	0.21	438	0.01	0.41	144	0.02	1.37
11741	1680	1695	0.34	2.70	0.08	438	0.04	0.43	128	0.09	4.46
11742	1695	1710	0.54	3.24	0.16	436	0.06	0.58	108	0.09	3.31
11743	1710	1725	1.49	4.86	0.21	437	0.08	5.74	386	0.01	7.02
11744	1725	1740	2.70	6.22	0.44	435	0.13	10.28	380	0.01	6.12
11745	1740	1755	2.67	6.38	0.39	435	0.19	10.98	411	0.02	6.92
11746	1755	1770	3.99	7.21	0.70	436	0.31	13.34	335	0.02	5.67
11747	1770	1775	1.51	4.55	0.30	437	0.11	4.97	328	0.02	5.03
11748	1900	1905	0.48	2.39	0.91	437	0.02	0.69	145	0.03	0.52
11749	1907	1910	0.54	2.40	0.20	436	0.04	1.00	186	0.04	2.68
11750	1911	1913	0.64	2.27	0.18	439	0.01	1.09	170	0.01	3.54
11751	1917	1930	2.45	5.73	0.52	435	0.25	8.59	351	0.03	4.73
11752	1935	1945	0.88	4.26	0.52	436	0.07	2.00	228	0.03	1.68
11753	1945	1960	4.47	8.18	0.36	432	0.83	20.17	451	0.04	12.46
11754	1960	1975	6.04	9.85	0.34	433	1.24	26.30	435	0.05	17.90
11755	1975	1990	1.57	4.77	0.36	-	-	-	-	-	4.32
11756	1990	2000	0.62	3.67	0.18	440	0.05	1.18	191	0.04	3.36
11757	2080	2095	2.60	6.68	0.35	436	0.44	8.27	318	0.05	7.47
11758	2090	2105	1.88	5.62	0.28	439	0.29	6.01	320	0.05	6.66
11759	2105	2120	1.34	4.02	1.47	442	0.13	2.86	214	0.04	0.91
11760	2120	2135	2.33	6.64	0.22	442	0.35	6.96	299	0.05	10.45
11761	2135	2150	3.32	7.66	0.31	438	0.72	12.94	390	0.05	10.68

Table 4.6 (Cont.)

Sample no.	Depth (m.)		TOC	TC	TS	T_{max}	S_1	S_2	HI	PI	TOC/TS
	top	bottom		(wt.%)		(°C)	(mg HC/g rock)		(mg HC/g TOC)		
11762	2150	2165	2.45	6.44	0.83	439	0.54	7.61	310	0.07	2.95
11763	2165	2180	2.64	5.99	0.23	436	0.72	8.45	320	0.08	11.62
11764	2180	2195	2.31	6.01	0.21	439	0.52	6.77	294	0.07	11.13
11765	2195	2210	2.08	5.77	0.25	440	0.41	5.15	247	0.07	8.42
11766	2210	2225	1.78	5.24	0.21	444	0.28	4.24	238	0.06	8.38
11767	2225	2240	2.05	4.90	0.31	442	0.27	5.10	249	0.05	6.52
11768	2435	2450	1.37	4.33	0.93	452	0.20	2.08	152	0.09	1.47
11769	2465	2480	1.48	5.65	0.51	451	0.24	2.17	147	0.10	2.90
11770	2480	2485	1.58	5.33	0.63	455	0.29	2.30	145	0.11	2.52
11771	2495	2515	1.31	4.76	0.54	453	0.21	1.59	122	0.12	2.42
11772	2515	2530	1.22	4.17	0.54	443	0.15	1.64	134	0.08	2.25
11773	2530	2545	0.96	4.25	0.48	457	0.14	0.99	103	0.12	1.99
11774	2545	2560	1.01	4.45	0.67	457	0.12	0.91	90	0.12	1.51
11775	2560	2575	1.08	4.72	0.50	439	0.19	1.35	126	0.12	2.16
11776	2575	2590	1.17	4.79	0.38	457	0.30	1.19	102	0.20	3.08
11777	2590	2605	1.02	4.54	0.38	459	0.17	0.89	87	0.16	2.67
11778	2605	2620	1.02	5.04	0.44	455	0.28	1.07	105	0.21	2.34
11779	2620	2635	0.99	4.79	0.40	462	0.12	0.81	82	0.13	2.49
11780	2635	2640	0.97	4.74	0.50	447	0.19	0.95	98	0.17	1.91
11781	2655	2670	1.03	4.40	0.53	454	0.18	0.91	88	0.17	1.94
11782	2675	2680	0.87	5.18	0.71	453	0.18	0.80	92	0.18	1.22
11783	2705	2720	0.58	4.72	0.54	432	0.12	0.64	110	0.16	1.08

Table 4.6 (Cont.)

Sample no.	Depth (m.)		TOC	TC	TS	T_{max}	S_1	S_2	HI	PI	TOC/TS
	top	bottom	(wt.%)			(°C)	(mg HC/g rock)		(mg HC/g TOC)		
11784	2740	2755	0.42	5.75	0.42	438	0.09	0.43	103	0.17	0.99
11785	2760	2775	0.82	7.76	0.24	473	0.13	0.78	95	0.14	3.34
11786	2790	2805	0.93	4.91	0.43	481	0.24	0.68	73	0.26	2.15
11787	2830	2840	0.27	7.00	0.24	492	0.03	0.16	58	0.16	1.13

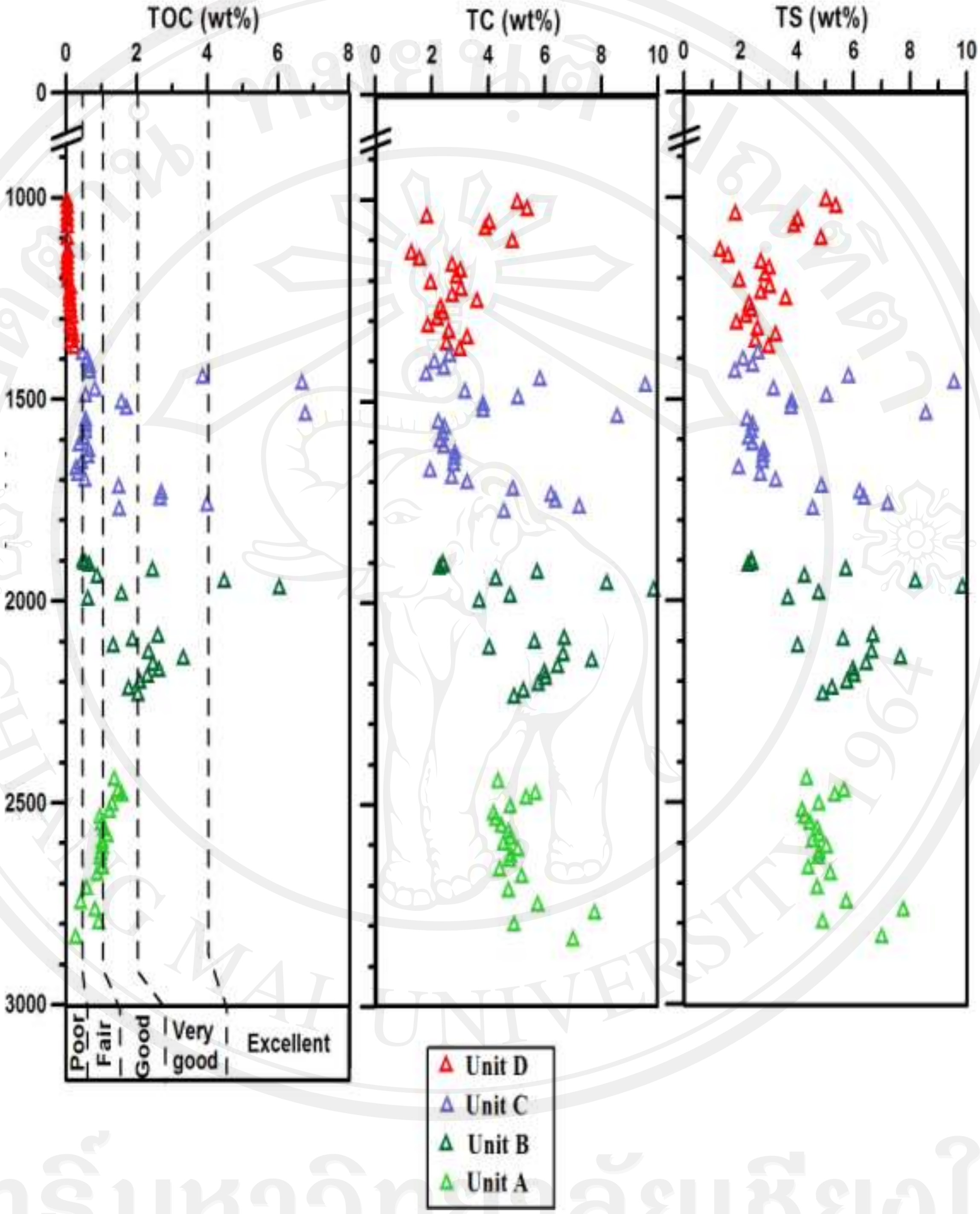

Figure 4.7 The plots of TOC content, TC content and TS content against depth show variation of screening data and source rock quality of SP1 well (diagram modified from Bordenave *et al*., 1993)

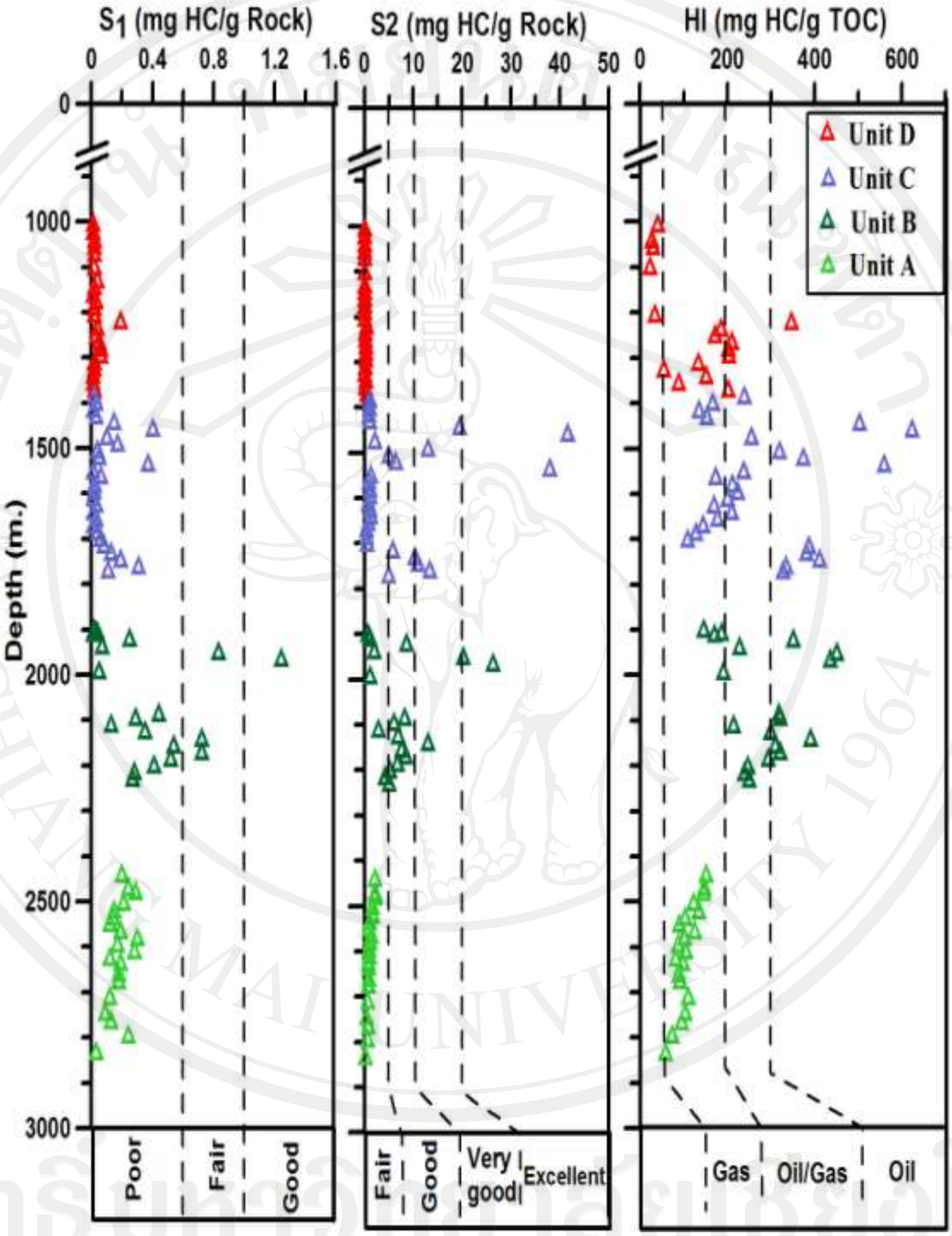

Figure 4.8 The plots of S_1, S_2 and HI against depth show variation of screening data, source rock quality and petroleum generation potential of SP1 well (diagram modified from Bordenave *et al*., 1993).

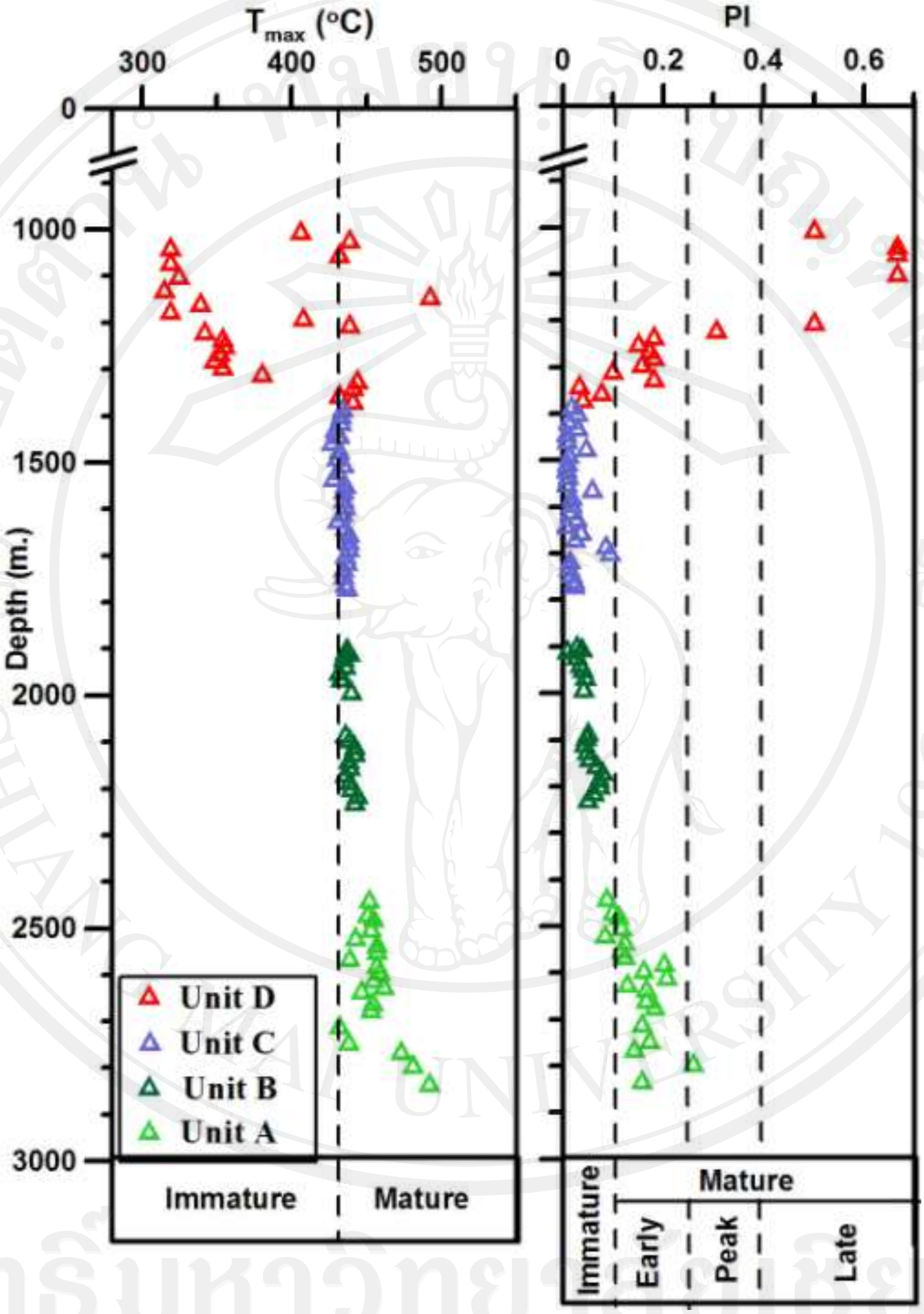

Figure 4.9 The plots of T_{max} and PI against depth show variation of screening data and maturation of source rock of SP1 well (diagram modified from Bordenave *et al*., 1993).

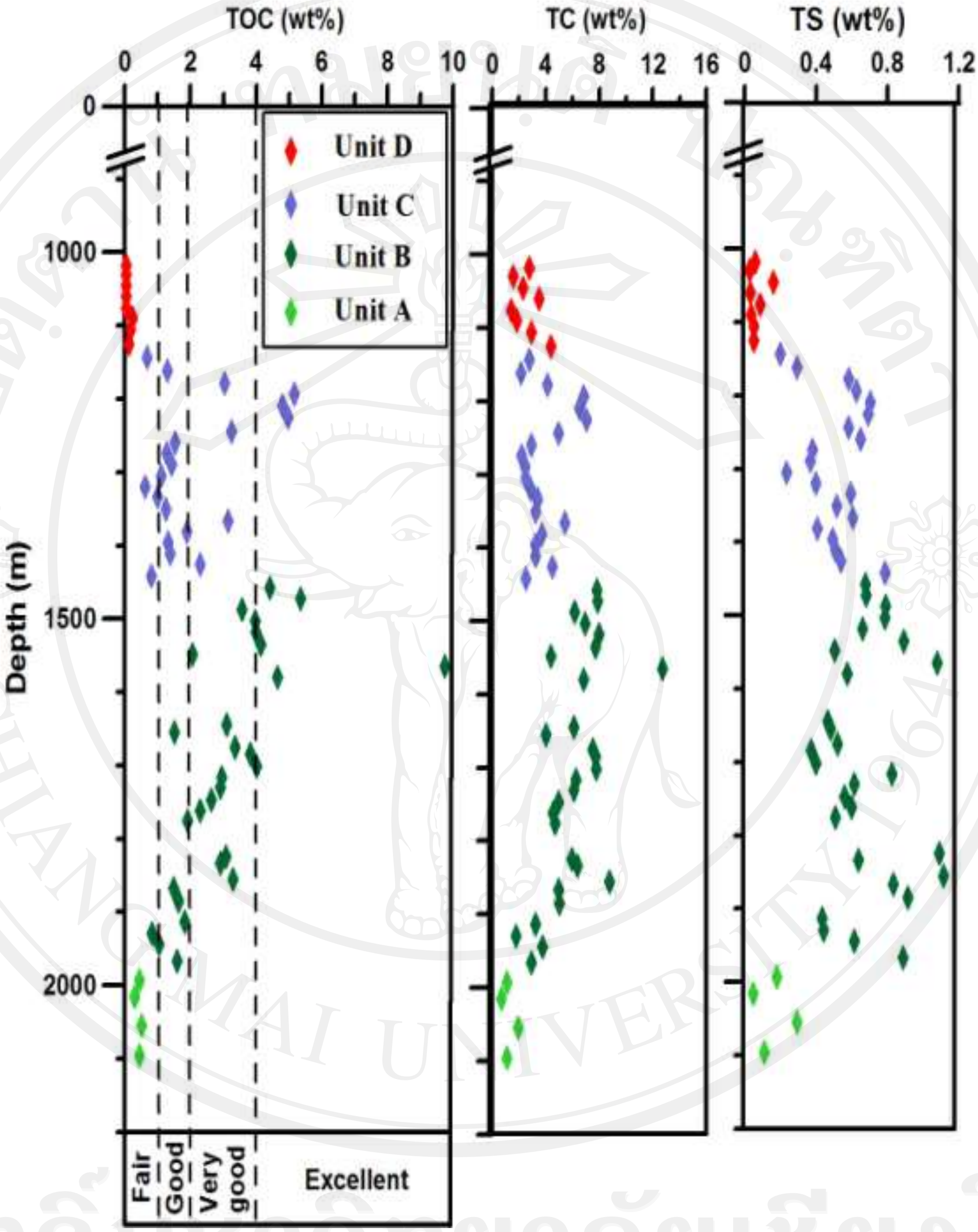

Figure 4.10 The plots of TOC content, TC content and TS content against depth show variation of screening data and source rock quality of SP2 well (diagram modified from Bordenave *et al*., 1993).

values range from zero to 346 mg HC/g TOC. The T_{max} and PI values range from 315^o to 444^oC and zero to 0.67, respectively. TOC, S_1, and S_2 plots show unity data.TC and HI plots show little of scatter data. TS, T_{max} and PI plots show more scatter data.

Unit C, TOC value ranges from 0.48 to 6.78 wt %. The TC value ranges from 1.79 to 9.56 wt% and the TS value ranges from 0.06 to 0.79 wt%. The S_1 and S_2 yields range from 0.01 to 0.40 and 0.41 to 41.58 mg HC/g rock, respectively. The HI values range from 134 to 623 mg HC/g TOC. The T_{max} and PI values range from 427^o to 437^oC and 0.01 to 0.09, respectively. TOC, S_1, S_2, PI and T_{max} plots show unity data while TC, TS and HI plots show scatter data.

Unit B, TOC value ranges from 0.48 to 3.32 wt %. The TC value ranges from 2.27 to 9.85 wt% and the TS value ranges from 0.18 to 1.47 wt%. The S_1 and S_2 yields range from 0.01 to 1.24 and 0.69 to 26.30 mg HC/g rock, respectively. The HI values range from 145 to 451 mg HC/g TOC. The T_{max} and PI values range from 432^o to 444^oC and 0.01 to 0.08, respectively. TOC, TC, TS, S_1, S_2 and HI plots show scatter data while T_{max} and PI plots show unity data.

Unit A, TOC value ranges from 0.27 to 1.58 wt %. The TC value ranges from 4.17 to 7.76 wt% and the TS value ranges from 0.24 to 0.93 wt%. The S_1 and S_2 yields range from 0.03 to 0.29 and 0.16 to 2.30 mg HC/g rock, respectively. The HI values range from 58 to 152 mg HC/g TOC. The T_{max} and PI values range from 438^o to 492^oC and 0.08 to 0.21, respectively. TOC, TC, TS, S_1, S_2, HI, T_{max} and PI plots show scatter data.

SP2 well

The samples were collected from Units A to D between depths of 1,000 to 2,095 m of SP2 well of U-thong oilfield, at 5 to 10 m interval. Unit D is between depths 410 and 1,100 m. and dominated by thick non-calcareous mudstone interbedded with thin sandstone and calcareous mudstone. Unit C is between depths 1,100 and 1,450 m. and dominated by mudstone with marlstone. Unit B is between depths 1,450 and 1,980 m and dominated by mudstone interbedded with sandstone and siltstone. Unit A is between depths 1,980 and 2,100 m and dominated by mudstone interbeded with sandstone.

The TOC content ranges from 0.03 to 9.74 wt% (Table 4.7), averaging 2.21 wt%. The maximum TOC value is depth of 1,564 m from Unit B and the minimum value is depth of 1,018 m in Unit D. The TC content varies between 0.65 and 12.70 wt% and averaging 4.54 wt% (Table 4.7). The maximum TC value is depth of 1,564 m in Unit B and the minimum value is depth of 2,015 m in Unit A. TS is varying from 0.03 to 1.11 wt% (Table 4.7). The maximum TS value is depth of 1,855 m in Unit B and the minimum value is depth of 1,090 m in Unit D (Figure 4.10).

Rock-Eval derived S_1 yields vary from 0.01 to 4.16 mg HC/g rock (Table 4.7). The maximum S_1 value is depth of 1,833.38 m in Unit B. The S_2 yields vary from 0.01 to 55.93 mg HC/g rock (Table 4.7). The maximum S_2 value is depth of 1,563.63 m in Unit B. HI ranges from 55 to 675 mg HC/g TOC (Table 4.7 and Figure 4.11). The maximum HI value is depth of 1,517.91 m in Unit B. The T_{max} values from all samples range from 355 to 435°C and the PI range from zero to 0.30 (Table 4.7 and Figure 4.12).

Unit D, TOC value ranges from 0.03 to 0.24 wt %. The TC value ranges from 1.41 to 3.49 wt% and the TS value ranges from 0.03 to 0.06 wt%. The S_1 is zero. S_2 yield range from 0.01 to 0.13 mg HC/g rock, respectively. The HI value ranges from 28 to 102 mg HC/g TOC. The T_{max} and PI values range from 355^o to 418^{o}C and zero, respectively. TOC, TC, TS, S_1, S_2, HI and PI plots show utility data while T_{max} plot shows scatter data.

Unit C, TOC value ranges from 0.13 to 9.74 wt %. The TC value ranges from 2.24 to 12.70 wt% and the TS value ranges from 0.05 to 1.08 wt%. The S_1 and S_2 yields range from zero to 1.17 and 0.11 to 55.93 mg HC/g rock, respectively. The HI value ranges from 84 to 675 mg HC/g TOC. The T_{max} and PI values range from 423^o to 437^{o}C and zero to 0.04, respectively. S_1, T_{max} and PI plots show utility data while TOC, TC, TS, S_2 and HI plots show scatter data.

Unit B, TOC value ranges from 1.49 to 4.00 wt %. The TC value ranges from 3.99 to 7.75 wt% and the TS value ranges from 0.37 to 0.82 wt%. The S_1 and S_2 yields range from 0.06 to 0.52 and 5.99 to 24.79 mg HC/g rock, respectively. The HI value ranges from 402 to 620 mg HC/g TOC. The T_{max} and PI values range from 431^o to 437^{o}C and 0.01 to 0.03, respectively. TOC, TC, TS, S_1, S_2, HI and PI plots show scatter data while T_{max} plot shows utility data.

Table 4.7 Screening data of samples from SP2 well from Suphanburi basin.

Sample no.	Depth (m.)		TOC	TC	TS	T_{max} (°C)	S_1	S_2	HI (mg HC/g TOC)	PI	TOC/TS
	top	bottom	(wt.%)				(mg HC/g rock)				
11788	1014.98	1021.08	0.03	2.77	0.06	418	0.00	0.02	75	0.00	0.46
11789	1024.13	1036.32	0.03	1.54	0.03	367	0.00	0.03	102	0.00	1.06
11790	1039.37	1051.56	0.03	2.32	0.16	355	0.00	0.02	63	0.00	0.20
11791	1054.61	1066.80	0.04	3.49	0.03	416	0.00	0.01	28	0.00	1.12
11792	1069.85	1082.04	0.03	1.41	0.09	401	0.00	0.03	93	0.00	0.38
11793	1085.09	1094.23	0.24	1.82	0.03	421	0.00	0.13	55	0.00	6.95
11794	1100.33	1112.52	0.17	2.89	0.05	421	0.00	0.12	69	0.00	3.36
11795	1115.57	1133.86	0.13	4.36	0.05	423	0.00	0.11	84	0.00	2.61
11796	1133.86	1152.14	0.68	2.75	0.20	435	0.01	1.88	275	0.01	3.42
11797	1152.14	1170.43	1.28	2.14	0.29	435	0.03	2.86	223	0.01	4.40
11798	1170.43	1185.67	3.03	4.14	0.58	434	0.05	12.82	424	0.00	5.20
11799	1185.67	1200.91	5.16	6.81	0.63	430	0.12	27.40	531	0.00	8.25
11800	1200.91	1216.15	4.78	6.49	0.70	428	0.18	23.55	492	0.01	6.83
11801	1216.15	1234.44	4.97	7.03	0.69	428	0.21	31.63	637	0.01	7.19
11802	1237.49	1249.68	3.25	4.94	0.58	430	0.07	17.16	528	0.00	5.59
11803	1252.73	1264.92	1.51	2.92	0.65	435	0.02	3.47	229	0.01	2.33
11804	1267.97	1280.16	1.26	2.21	0.38	433	0.02	2.47	196	0.01	3.34
11805	1283.21	1295.40	1.41	2.44	0.36	437	0.02	3.41	242	0.01	3.87
11806	1298.45	1310.64	1.10	2.49	0.23	434	0.02	2.14	195	0.01	4.71
11807	1313.69	1325.88	0.61	2.88	0.40	434	0.01	2.20	361	0.00	1.53
11808	1325.88	1341.12	0.99	3.40	0.59	429	0.11	2.64	265	0.04	1.67

Table 4.7 (Cont.).

Sample no.	Depth (m)		TOC	TC	TS	T_{max} (°C)	S_1	S_2	HI (mg HC/g TOC)	PI	TOC/TS
			(wt%)				(mg HC/g rock)				
11809	1344.17	1356.36	1.25	3.25	0.51	429	0.04	3.48	279	0.01	2.43
11810	1359.41	1371.60	3.13	5.43	0.61	431	0.14	17.38	554	0.01	5.17
11811	1374.65	1386.84	1.88	3.70	0.40	432	0.07	8.07	430	0.01	4.66
11812	1389.89	1402.08	1.30	3.22	0.49	432	0.02	4.72	364	0.00	2.64
11813	1405.13	1417.32	1.37	3.22	0.51	433	0.03	4.76	346	0.01	2.70
11814	1420.37	1432.56	2.29	4.49	0.54	431	0.06	11.06	484	0.01	4.26
11815	1435.61	1447.80	0.81	2.52	0.78	432	0.02	2.44	303	0.01	1.03
11816	1450.85	1463.04	4.42	7.81	0.68	432	0.28	29.83	675	0.01	6.54
11817	1466.09	1478.28	5.34	7.89	0.68	428	0.51	34.37	643	0.01	7.88
11818	1481.33	1493.52	3.55	6.17	0.79	430	0.17	20.24	570	0.01	4.51
11819	1496.57	1508.76	3.97	6.95	0.78	430	0.30	25.34	639	0.01	5.06
11820	1511.81	1524.00	3.99	7.99	0.66	430	1.17	27.19	681	0.04	6.05
11821	1530.10	1539.24	4.13	7.73	0.89	431	0.34	27.56	668	0.01	4.64
11822	1542.29	1554.48	2.05	4.37	0.50	430	0.06	9.16	446	0.01	4.07
11823	1557.53	1569.72	9.74	12.70	1.08	430	1.40	55.93	574	0.02	9.03
11824	1572.77	1584.96	4.64	6.83	0.58	430	0.34	25.00	539	0.01	8.06
11825	1642.87	1645.92	3.09	6.09	0.46	432	0.19	17.95	581	0.01	6.68
11826	1652.02	1658.11	1.49	3.99	0.48	432	0.06	5.99	402	0.01	3.10
11827	1673.35	1676.40	3.35	7.52	0.52	432	0.35	19.81	592	0.02	6.45
11828	1682.50	1685.54	3.83	7.73	0.37	431	0.47	19.64	513	0.02	10.29
11829	1697.74	1703.83	4.00	7.75	0.40	431	0.52	24.79	620	0.02	10.04

Table 4.7 (Cont.)

Sample no.	Depth (m)		TOC (wt%)	TC (wt%)	TS (wt%)	T_{max} (°C)	S_1 (mg HC/g rock)	S_2 (mg HC/g rock)	HI (mg HC/g TOC)	PI	TOC/TS
11830	1709.93	1722.12	2.95	6.24	0.82	433	0.21	15.41	522	0.01	3.58
11831	1725.17	1734.31	2.90	6.08	0.61	433	0.31	16.27	562	0.02	4.72
11832	1740.41	1752.60	2.63	4.97	0.56	437	0.30	15.36	584	0.02	4.71
11833	1755.65	1767.84	2.29	4.56	0.60	433	0.30	12.27	535	0.02	3.84
11834	1773.94	1776.98	1.90	4.67	0.51	434	0.24	8.35	438	0.03	3.74
11835	1819.66	1828.80	3.08	5.92	1.09	427	2.28	17.66	573	0.11	2.83
11836	1831.85	1834.90	2.91	6.37	0.64	433	4.16	14.89	512	0.22	4.57
11837	1853.18	1856.23	3.28	8.75	1.11	435	1.58	17.98	548	0.08	2.96
11838	1865.38	1868.42	1.48	4.96	0.83	432	0.84	7.41	500	0.10	1.78
11839	1880.62	1889.76	1.63	5.03	0.91	432	1.25	8.72	536	0.13	1.78
11840	1908.05	1917.19	1.83	3.25	0.43	427	1.50	5.20	284	0.22	4.22
11841	1923.29	1935.48	0.81	1.77	0.44	425	1.24	2.91	357	0.30	1.85
11842	1938.53	1950.72	1.04	3.75	0.61	431	1.80	5.86	561	0.23	1.70
11843	1959.86	1972.06	1.58	2.92	0.89	425	3.33	7.50	476	0.31	1.78
11844	1990.34	1996.44	0.45	1.10	0.18	434	0.20	1.17	262	0.15	2.51
11845	2008.63	2020.82	0.29	0.65	0.05	430	0.32	0.87	304	0.27	6.15
11846	2051.30	2057.40	0.51	1.94	0.29	423	0.56	2.38	464	0.19	1.75
11847	2093.98	2097.02	0.45	1.10	0.11	429	0.81	1.98	441	0.29	4.07

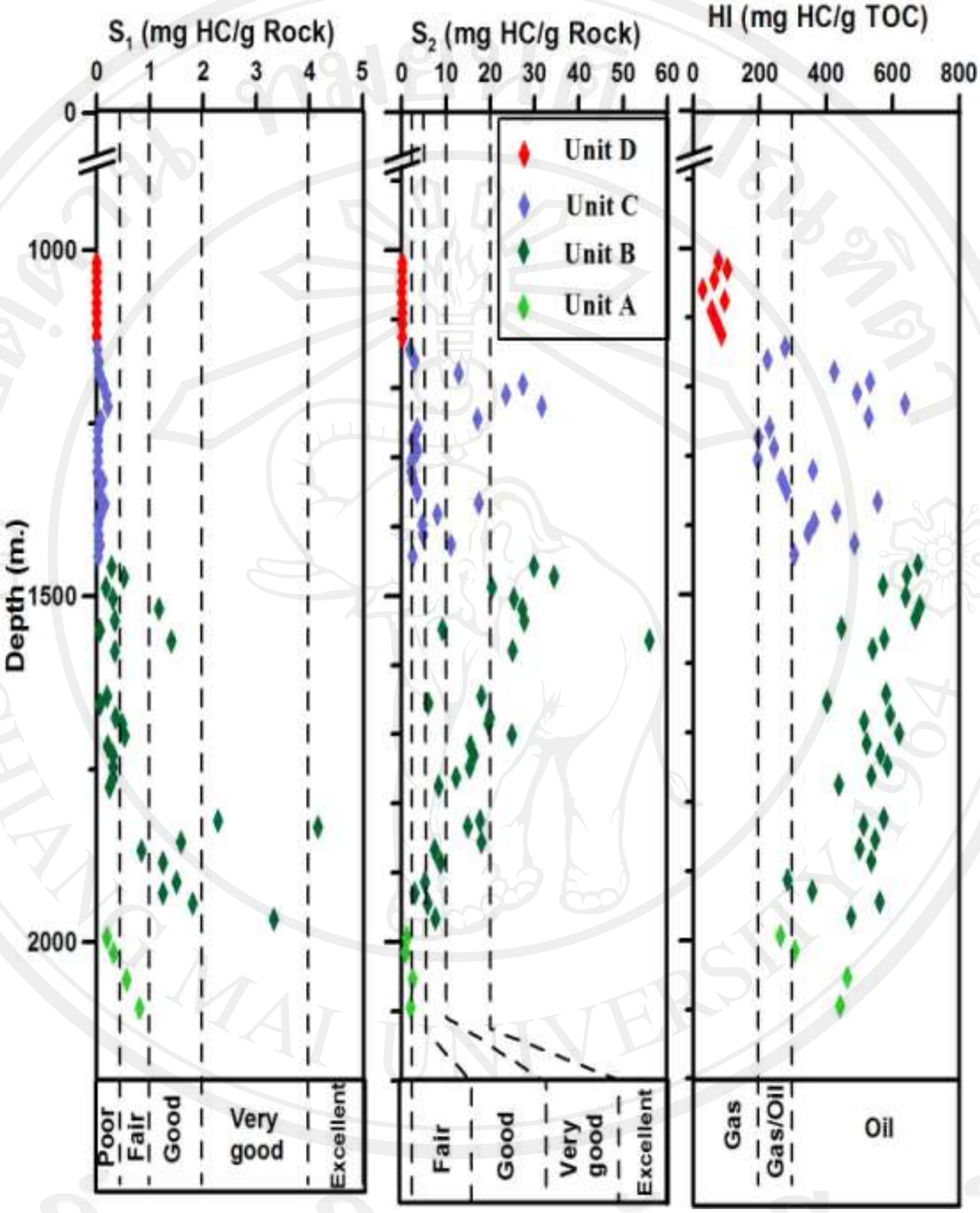

Figure 4.11 The plots of S_1, S_2 and HI against depth show variation of screening data, source rock quality and petroleum generation potential of SP2 well (diagram modified from Bordenave *et al*., 1993).

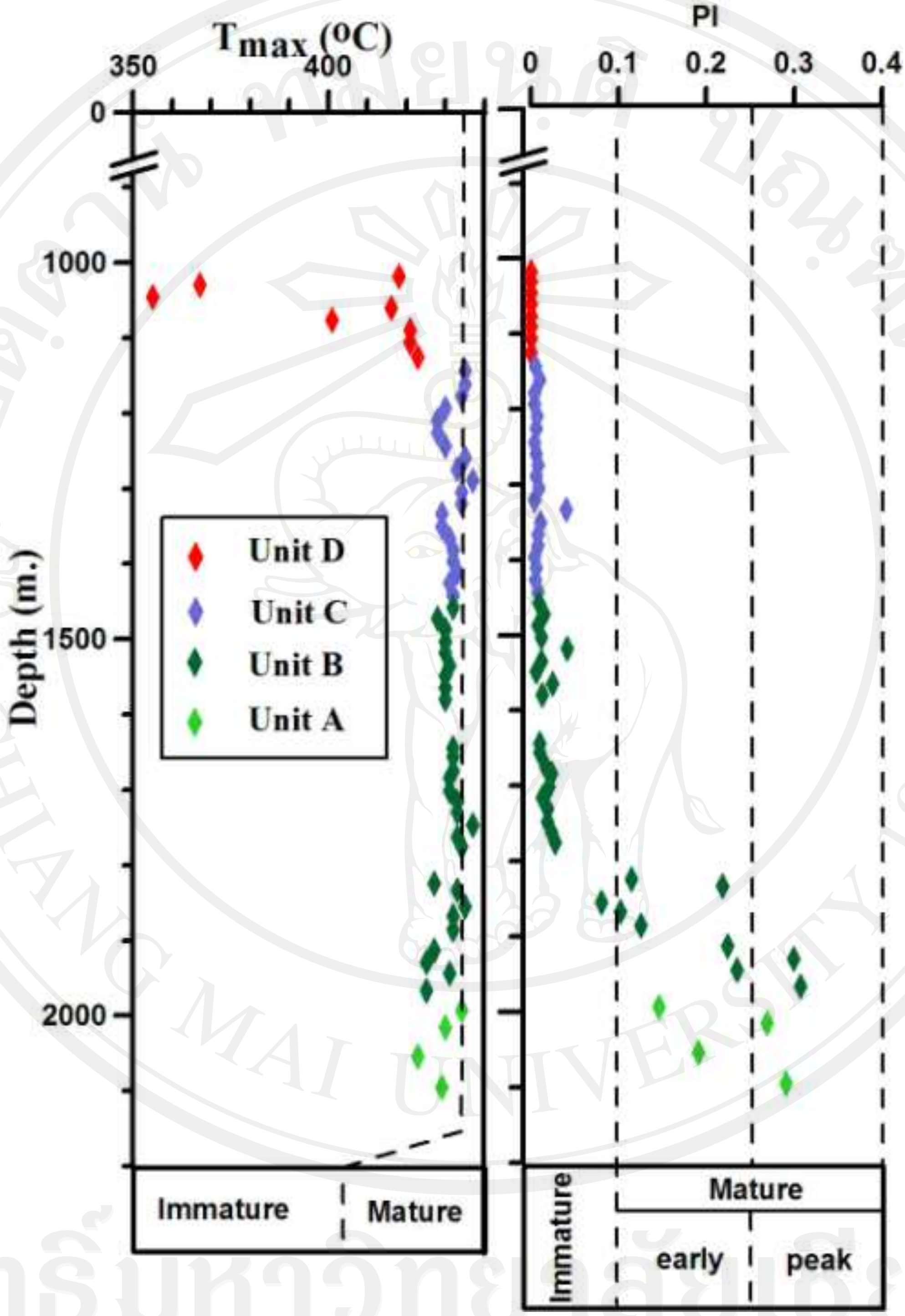

Figure 4.12 The plots of T_{max} and PI against depth show variation of screening data and maturation of source rock of SP2 well (diagram modified from Bordenave *et al*., 1993).

Unit A, TOC value ranges from 0.45 to 3.28 wt %. The TC value ranges from 0.65 to 8.75 wt% and the TS value ranges from 0.11 to 1.11 wt%. The S_1 and S_2 yields range from 0.20 to 4.16 and 0.87 to 17.98 mg HC/g rock, respectively. The HI values range from 284 to 573 mg HC/g TOC. The T_{max} and PI values range from 423^o to 435^{o}C and 0.08 to 0.30, respectively. TOC, TC, TS, S_1, S_2 and T_{max} plots show utility data while HI and PI plots show scatter data.

4.2 *n*-Alkane distribution by gas chromatography

The peak area of gas chromatograms profile of the *n*-alkane (Appendix II) has been used to calculate Pristane/Phytane ratio (Pr/Ph ratio), Pristane/nC_{17} and Phytane/nC_{18}, as an indicator for source of organic materials or depositional environment; and Carbon Preference Index (CPI), as an indicator for thermal maturity of the source rock (Table 4.8).

Pristane/Phytane ratio (Pr/Ph ratio)

Pristane is the C_{19} regular isoprenoid hydrocarbon with chemical formula $C_{19}H_{40}$ and phytane is the C_{20} isoprenoid hydrocarbon ($C_{20}H_{42}$). They are mainly de rived from the side chain of the chlorophyll "a" and "b" in purple sulphur bacteria (Brook et al., 1969; Powell and McKirdy, 1973). Phistane and phytane are ubiquitous in most oils and sediment extracts. In gas chromatography pristine (Pr) and phytane (Ph) occur as a distinctive doublet with normal C_{17} and C_{18} alkane, respectively. The Pr/Ph ratio was used as an indicator of oxicity of depositional environment (Miles, 1989). Didyk *et al* (1978) proposed that the Pr/Ph ratio may be correlated with the environmental conditions prevailing when the sediment was deposited.

Thus, sediments deposited in aquatic environments where both the water column and sediment are anoxic generally have ratios much less than unity, whereas when oxic conditions occur ratios much greater than unity are found. Ratios close to unity are thought to occur when there are alternating oxic and anoxic conditions or when the depth of the oxic-anoxic interface fluctuates. Anoxic conditions tend to preserve the C_{20} skelleton whereas oxic conditions cause greater degradation. Thus, phytane is presumed to be formed from phytol by several reductive pathways whereas

Table 4.8: Gas chromatogram data of n-alkane hydrocarbon from Fang-MS well, Na Hong, Li, Mae Sot, P-SK well, SP1 well and SP2 well.

Basin	Formation/ Unit/ Lithology	Sample no.	Depth (m.)	Range	Pr/Ph	Pr/nC_{17}	Ph/nC_{18}	CPI
Fang Fang-MS well	Mae Sot	11863	664.5	$nC_{13} - nC_{36}$	1.50	1.79	1.21	1.31
	Mae Sot	11876	879.5	$nC_{15} - nC_{35}$	1.73	2.13	0.94	1.32
	Mae Sot	11880	938.8	$nC_{15} - nC_{38}$	2.64	3.13	1.31	1.31
	Mae Sot	11887	1,060.7	$nC_{13} - nC_{38}$	3.02	3.15	0.93	1.40
Na Hong	Oil shale	14709	-	$nC_{11} - nC_{38}$	0.46	3.25	9.28	3.24
	Coaly mudstone	14712	-	$nC_{11} - nC_{38}$	0.60	3.09	8.10	3.41
	Mudstone	14714	-	$nC_{14} - nC_{37}$	1.13	2.58	2.66	4.58
	Coaly mudstone	14718	-	$nC_{13} - nC_{35}$	0.46	5.18	15.59	5.10
Li	Oil shale	14693	-	$nC_{12} - nC_{37}$	1.66	5.93	4.73	2.47
	Oil shale	14695	-	$nC_{12} - nC_{37}$	1.71	3.70	3.23	3.05
Mae Sot	Oil shale	14700	-	$nC_{10} - nC_{38}$	0.55	1.42	5.33	2.55
	Oil shale	14702	-	$nC_{12} - nC_{38}$	0.42	1.00	5.24	2.48

Table 4.8: Cont.

Basin	Formation/ Unit/ Lithology	Sample no.	Depth (m.)	Range	Pr/Ph	Pr/nC_{17}	Ph/nC_{18}	CPI
Phitsanulok P-SK well	Yom	14730	1,350	$nC_{12} - nC_{35}$	0.85	0.84	0.65	0.99
	Chum Saeng	14744	2,050	$nC_{10} - nC_{31}$	1.47	0.88	0.63	0.97
	Lan Krabu	14755	2,600	$nC_{10} - nC_{35}$	1.25	0.69	0.57	1.00
	Lan Krabu	14759	2,800	$nC_{10} - nC_{35}$	1.63	0.58	0.42	1.06
	Lan Krabu	14761	2,900	$nC_{12} - nC_{36}$	1.13	0.74	0.56	1.05
Suphan Buri (SP1)	C	11726	1,460	$nC_{17} - nC_{33}$	0.93	2.28	1.88	1.04
	C	11731	1,537.5	$nC_{17} - nC_{35}$	1.85	2.95	1.16	1.16
	C	11746	1,762.5	$nC_{16} - nC_{37}$	1.65	1.57	0.58	1.10
	B	11754	1,967.5	$nC_{14} - nC_{38}$	3.74	1.86	0.47	0.98
	B	11761	2,142.5	$nC_{13} - nC_{40}$	3.52	1.31	0.32	1.09
Suphan Buri (SP2)	C	11799	1,193	$nC_{15} - nC_{37}$	1.30	2.79	1.51	1.21
	C	11810	1,366	$nC_{17} - nC_{36}$	0.70	1.08	0.85	0.93
	B	11817	1,472	$nC_{15} - nC_{36}$	1.67	2.23	0.97	1.09
	B	11823	1,564	$nC_{13} - nC_{36}$	2.56	2.55	1.05	1.08
	B	11829	1,701	$nC_{13} - nC_{40}$	2.56	2.15	0.73	1.06

oxidation of phytol to phytanic and/or phytenic acid is considered to be a prerequisite for pritane formation (Johns, 1986).

Pristane/nC$_{17}$ and Phytane/nC$_{18}$

The abundance of pristine relative to nC_{17} and the relation between phytane and nC_{18} can be determined from gas chromatography of oils and sediment extracts. The ratios of Pristane/nC_{17} and Phytane/nC_{18} are often used as indicator of depositional environment and to indicate approximate levels of maturity and biodegradation.

Carbon Preference Index (CPI)

The relative abundance of odd carbon *n*-alkanes versus even number *n*-alkanes measured from gas chromatography of saturated fraction of an oil or extract is know as the carbon preference index (CPI), which can be used to estimate of thermal maturity of petroleum. The predominance of odd-number alkanes decrease with increasing maturity, where even and odd alkanes are present at equal amounts, i.e. an index of 1.0. Hence a high CPI,> 1.1, means that an oil or extract is immature. Generally, the CPI value of 1.5 is considered to be at the top of oil generative window, while a value of 1.0 ±0.1 is considered to be at peak oil generation (Miles, 1989). The full range of carbon numbers which have been included in these calculations is 20 to 34, but most analysts prefer to use a more restricted range. The most widely CPI was calculated from below formula (Bray and Evans, 1961):

$$CPI = \frac{1}{2}\left[\frac{(C_{25} + C_{27} + C_{29} + C_{31} + C_{33})}{(C_{24} + C_{26} + C_{28} + C_{30} + C_{32})} + \frac{(C_{25} + C_{27} + C_{29} + C_{31} + C_{33})}{(C_{26} + C_{28} + C_{30} + C_{32} + C_{34})}\right]$$

4.2.1 Fang-MS well, Fang basin

The samples of Fang-MS well have *n*-alkanes distributions in molecular weight range from nC_{13} - nC_{38} and maximize in the nC_{27}, nC_{29} and nC_{31}. The Pr/Ph ratio ranges from 1.5 to 3.02. The Pristane/nC_{17} and Phytane/nC_{18} ratio range from 1.79 to 3.15 and 0.93 to 1.31, respectively. The CPI ranges from 1.31 to 1.40

4.2.2 Na Hong basin

The samples of Na Hong have *n*-alkanes distributions in molecular weight range from nC_{11} - nC_{38} and maximize in the nC_{27}, nC_{29} and nC_{31}. The Pr/Ph ratio ranges from 0.46 to 1.13. The Pristane/nC_{17} and Phytane/nC_{18} ratio range from 2.58 to 5.18 and 2.66 to 15.59, respectively. The CPI ranges from 3.24 to 5.10.

4.2.3 Li basin

The samples of Li have *n*-alkanes distributions in molecular weight range from nC_{12} - nC_{37} and maximize in the nC_{27}, nC_{29} and nC_{31}. The Pr/Ph ratio ranges from 1.66 to 1.71. The Pristane/nC_{17} and Phytane/nC_{18} ratio range from 3.70 to 5.91 and 3.23 to 4.73, respectively. The CPI ranges from 2.47 to 3.05.

4.2.4 Mae Sot basin

The samples of Mae Sot have *n*-alkanes distributions in molecular weight range from nC_{10} - nC_{38} and maximize in the nC_{27} and nC_{29}. The Pr/Ph ratio ranges from 0.42 to 0.55. The Pristane/nC_{17} and Phytane/nC_{18} ratio range from 1.00 to 1.42 and 5.24 to 5.33, respectively. The CPI ranges from 2.48 to 2.55.

4.2.5 P-SK well, Phitsanulok basin

The samples of PH have *n*-alkanes distributions in molecular weight range from nC_{10} - nC_{36} and maximize in the nC_{15} and nC_{17}. The Pr/Ph ratio ranges from 0.85 to 1.63. The Pristane/nC_{17} and Phytane/nC_{18} ratio range from 1.58 to 0.88 and 0.42 to 0.65, respectively. The CPI ranges from 0.99 to 1.06.

4.2.6 SP1 and SP2 wells, Suphanburi basin

SP1 well

The samples of SP1 have *n*-alkanes distributions in molecular weight range from nC_{13} – nC_{40} and maximize in the nC_{27} to nC_{31}. The Pr/Ph ratio ranges from 0.93 to 3.74. The Pristane/nC_{17} and Phytane/nC_{18} ratio range from 1.31 to 2.95 and 0.32 to 1.88, respectively. The CPI ranges from 0.98 to 1.16.

SP2 well

The samples of SP2 have *n*-alkanes distributions in molecular weight range from nC_{13} - nC_{36} and maximize in the nC_{31}. The Pr/Ph ratio ranges from 0.70 to 2.56. The Pristane/nC_{17} and Phytane/nC_{18} ratio range from 1.08 to 2.79 and 0.73 to 1.51, respectively. The CPI ranges from 0.93 to 1.21.

4.3 Biomarkers parameters: Gas Chromatography-Mass Spectrometer

Biomarkers are a group of compounds, primarily hydrocarbons, found in oil, rock extracts, recent sediment extracts and soil extracts. Biomarkers are structurally similar to, and are diagenetic alteration products of, specific natural products (compounds produced by living organisms). Specifically, biomarkers in oil can reveal the relative amount of oil-prone and gas-prone organic matter in the source kerogen, the age of the source rock, the environment of deposition as marine, lacustrine, fluvio-deltaic or hypersaline, the lithology of the source (carbonate and shale) and the thermal maturity of the source rock during generation (Peters and Moldowan, 1993). The peak area of gas chromatograms-mass spectrometer profile has been used to calculate biomarker parameters.

Homohopane isomerization [22S/ (22S+22R)] ratio

Isomerization at C-22 in the C_{31}-C_{35} 17α-hopane (Ensminger *et al*., 1977) occur earlier than many biomarker reactions used to assess the thermal maturity of oil and bitumen for immature to early oil generation, such as isomerization at C-20 in the regular steranes, measured using m/z 191 chromatogram or GCMS/MS typically the C_{31} or C_{32}. Schoell *et al.*, (1983) showed that equilibrium for the C_{32} hopanes occurs at vitrinite reflectance of ~0.5 % in Mahakam Delta rocks. The biologicall produced hopane precursors carry a 22R configuration that is converted gradually to a mixture of 22R and 22S diastereomers. The proportions of 22R and 22S can be calculated for any or all of the C_{31}-C_{35} compounds. These 22R and 22S doublets in the range C_{31}-C_{35} on the m/z 191 mass chromatogram are called homohopanes.

The 22S/(22S+22R) ratios for the C_{31}-C_{35} 17α- homohopane may differ slightly. Typically, the C-22 epimer ratios increase slightly for the higher homologs from C_{31}-C_{35}. For example, Zumberge (1987) calculated the average equilibrium

22S/(22S+22R) ratio for 27 low-maturity oils at C_{31}, C_{32}, C_{33}, C_{34}, and C_{35} to be 0.55, 0.58, 0.60, 0.62, and 0.59, respectively.

Ts/(Ts+Tm)

Thermal parameter based on relative stability of C_{27} hopane applicable over the range immature to mature to postmature. The ratio of trisnorneohopane (Ts or 18α-22, 29, 30-trisneohopane), formular $C_{27}H_{46}$, to trisnorhopane (Tm or 17α-22, 29, 30-trinorhopane) is calculated from relative peak areas of both Ts and Tm in the m/z 191 mass chromatogram or GCMS/MS (m/z 370→191) (Appendix IV). During catagenesis, C_{27} 17α-Trisnorhopane (Tm) is less stable than C_{28} 18α-trinorhopane II (Ts) (Seifert and Moldowan, 1978; Kolaczkowska *et al*., 1990).

C_{29} ααα 20S/(20S+20R) sterane epimer ratio

The sterane isomerization ratios are reported most often for the C_{29} compounds (24-ethylcholestanes or stigmastanes) due to the ease of analysis using m/z 217 mass chromatograms. Isomerization ratio based on the C_{27} and C_{28} steranes commonly show interference by coelution peaks. However, GCMS/MS measurements allow reasonably good accuracy for C_{27}, C_{28} and C_{29} 20S/(20S+20R), all of which have equivalent potential as maturity parameters when measured by this method.

The elution patterns for steranes are highly complex because of an overlap of rearranged and non-rearranged steranes. Although in principle we could determine maturity by following the change in 20S/(20S+20R) in any of the C_{27}, C_{28} or C_{29} steranes, measured using m/z 217 mass chromatogram. The most accurate data is derived from C_{29} species which are the least susceptible form is exclusive the ααα(20R) and βαα(20R) configurations. Isomerization at C-20 in the C_{29} 5α, 14α, 17α (H)-sterane causes 20S/(20S+20R) to rise from 0 to ~0.5 with increasing thermal maturity (Seifert and Moldowan, 1978).

C_{29} (S+R)αββ/((S+R)αββ+(S+R)ααα) sterane ratio

C_{29} ββ/ (ββ+αα) sterane ratio is proportion of 14β (H), 17β (H) and 14α (H), 17α (H) forms. The αα form is produced biologically but gradually converts to a mixture of αα and ββ. This transformation involves the poorly understood but apparently nearly simultaneous change of two hydrogen atoms from alpha positions to beta. Measured is using peak area of m/z 217 or preferable by GCMS/MS of C_{29} sterane (Seifert and Moldowan, 1978).

C_{27}-C_{29} regular steranes

The steranes inherited directly from higher plants, animals, and algae are the 20R epimers of the 5α (H), 14α (H), 17α (H) forms of the C_{27}, C_{28}, C_{29} steranes. The relative proportions of each of these “regular” steranes can very greatly from sample to sample, however, depending upon the type of organic material contributing to the sediment. The ratio of C_{27}: C_{28}: C_{29} represents a composite of the data for oil or extracts of the source rock from various depositional environments (Miles, 1989).

4.3.1 Fang-MS well, Fang basin

The ratio of 22S/ (22S+2R) of Fang-MS samples range from 0.2 to 0.6 and Ts/(Ts+Tm) ratio ranges from 0.2 to 0.36. The C_{29} 20S/ (20S+20R) sterane epimer and C_{29} ββ/(ββ+αα) sterane ratio range from 0.08 to 0.23 and 0.35 to 0.36, respectively. The samples are dominated by C_{29} sterane, except sample 11876 is dominated by C_{27} sterane (Table 4.9).

4.3.2 Na Hong basin

The ratio of 22S/(22S+2R) of Na Hong samples range from 0.04 to 0.05 and Ts/(Ts+Tm) ratio ranges from 0 to 0.04. The C_{29} 20S/(20S+20R) sterane epimer and C_{29} ββ/(ββ+αα) sterane ratio are not present. The samples are dominated by C_{29} sterane (Table 4.9).

4.3.3 Li basin

The ratio of 22S/(22S+2R) of Li samples is 0.04 and Ts/(Ts+Tm) ratio is 0.05. The C_{29} 20S/(20S+20R) sterane epimer and C_{29} ββ/(ββ+αα) sterane ratio range from 0 to 0.22 and 0 to 0.43, respectively. The samples are dominated by C_{28} sterane (Table 4.9).

Table 4.9: Summarized data of biomarkers from Fang, Na Hong, Li, Mae Sot, Phitsanulok, and Suphanburi basns.

Basin	Formation/ Unit/ Lithology	Sample no.	Depth (m.)	22S/(22S+22R) homohopane	Ts/(Ts+Tm)	Sterane		Sterane (R-epimer)		
						C_{29} 20S/(20S+20R)	C_{29} ββ/(ββ+αα)	C_{27}	C_{28}	C_{29}
Fang	Mae Sot	11863	664.5	0.27	0.25	0.08	0.35	36.45	22.23	41.32
	Mae Sot	11876	879.5	0.41	0.34	0.06	0.34	44.91	20.34	34.74
Fang-MS well	Mae Sot	11880	938.8	0.47	0.32	0.11	0.36	37.40	22.68	39.92
	Mae Sot	11887	1060.7	0.60	0.36	0.23	0.36	37.95	21.89	40.16
Na Hong	coaly mudstone	14709	-	0.04	0.02	0.00	0.00	26.96	12.32	60.72
	mudstone	14712	-	0.03	0.00	0.00	0.00	23.27	15.30	61.44
	coaly mudstone	14714	-	0.03	0.04	0.00	0.00	36.59	20.23	43.18
	oil shale	14718	-	0.05	0.00	0.00	0.00	26.49	17.67	55.88
Li	oil shale	14693	-	0.04	0.05	0.22	0.43	40.70	44.28	15.02
	oil shale	14695	-	0.04	0.05	0.00	0.00	33.39	35.74	30.86
Mae Sot	oil shale	14700	-	0.23	0.03	0.11	0.00	17.00	19.36	63.64
	oil shale	14702	-	0.26	0.04	0.07	0.00	10.03	10.16	79.81

Table 4.9: (Cont.)

Basin	Formation/ Unit/ Lithology	Sample no.	Depth (m.)	22S/(22S+22R) homohopane	Ts/(Ts+Tm)	Sterane		Sterane (R-epimer)		
						C_{29} 20S/(20S+20R)	C_{29} ββ/(ββ+αα)	C_{27}	C_{28}	C_{29}
Phitsanulok P-SK well	Yom	14730	1350	0.56	0.25	0.35	0.32	25.56	42.03	32.41
	Chum Saeng	14744	2050	0.51	0.21	0.29	0.31	27.89	39.97	32.14
	Lan Krabu	14755	2600	0.54	0.30	0.31	0.31	25.41	40.66	33.93
	Lan Krabu	14759	2800	0.57	0.34	0.33	0.33	25.94	42.18	31.88
	Lan Krabu	14761	2900	0.56	0.36	0.33	0.30	27.26	39.54	33.21
Suphanburi SP1 well	C	11726	1460	0.30	0.36	0.00	0.30	36.43	22.80	40.76
	C	11731	1537.5	0.36	0.35	0.00	0.29	33.75	17.37	48.88
	C	11746	1762.5	0.56	0.44	0.16	0.31	46.77	16.67	36.56
	B	11754	1967.5	0.61	0.48	0.37	0.43	27.00	13.82	59.18
	B	11761	2142.5	0.60	0.74	0.51	0.55	32.78	16.65	50.57
Suphanburi SP2 well	C	11799	1193	0.27	0.13	0.00	0.00	37.77	23.54	38.69
	C	11810	1366	0.35	0.24	0.06	0.00	38.87	24.29	36.85
	B	11817	1472	0.42	0.35	0.00	0.00	69.41	10.04	20.54
	B	11823	1564	0.46	0.44	0.14	0.05	32.32	16.11	51.58
	B	11829	1701	0.58	0.44	0.11	0.00	40.89	15.03	44.08

4.3.4 Mae Sot basin

The ratio of 22S/(22S+2R) of Mae Sot samples range from 0.23 to 0.26 and Ts/(Ts+Tm) ratio ranges from 0.03 to 0.04. The C_{29} 20S/(20S+20R) sterane epimer ratio range from 0.07 to 0.11. The samples are dominated by C_{29} sterane (Table 4.9).

4.3.5 PH, Phitsanulok basin

The ratio of 22S/(22S+2R) of PH samples range from 0.51 to 0.57 and Ts/(Ts+Tm) ratio ranges from 0.21 to 0.36. The C_{29} 20S/ (20S+20R) sterane epimer and C_{29} ββ/(ββ+αα) sterane ratio range from 0.298 to 0.35 and 0.30 to 0.32, respectively. The samples are dominated by C_{28} sterane (Table 4.9).

4.3.6 SP1 and SP2 wells, Suphanburi basin

SP1 well

The ratio of 22S/(22S+2R) of SP1 samples range from 0.3 to 0.61 and Ts/(Ts+Tm) ratio ranges from 0.26 to 0.74. The C_{29} 20S/(20S+20R) sterane epimer and C_{29} ββ/(ββ+αα) sterane ratio range from 0 to 0.51 and 0.29 to 055, respectively. The samples are dominated by C_{29} sterane (Table 4.9).

SP2 well

The ratio of 22S/(22S+2R) of SP2 samples range from 0.27 to 0.58 and Ts/(Ts+Tm) ratio ranges from 0.13 to 0.44. The C_{29} 20S/ (20S+20R) sterane epimer and C_{29} ββ/(ββ+αα) sterane ratio range from 0 to 0.14 and 0 to 0.05, respectively. The samples are dominated by C_{27} and C_{29} sterane (Table 4.9).

4.4 Organic petrographic results

Macerals are organic substances derived from plant tissues, cell contents and exudates that were variably subjected to decay, incorporated in to sedimentary strata and then altered physically and chemically by natural processes (diagenetic and metamorphic). There are three basic groups of macerals, the vitrinite group derived from coalified woody tissue, the liptinite group derived from the resinous and waxy parts of plants and the inertinite group derived from charred and biologically altered plant cell wall material.

Vitrinite reflectance

Vitrinite reflectance data is widely used to determine the thermal maturity of maceral in sedimentary rocks (Bostick, 1979). It is more related to the thermal stress experienced by the vitrinite than to petroleum generation. The value of 0.45 to 0.6%R_o have been suggested for onset of hydrocarbon generation (Ammosov, 1968; Hood *et al*., 1975) and the end of oil window at 1.3 to 1.5%R_o (Shinbaoka *et al*., 1973; Stach, 1975).

4.4.1 Fang-MS well, Fang basin

The macerals of the sample from the Fang-MS well are given in Table 4.10. The liptinite content ranges from 69.60 to 78.20 percent. The liptinitic material is principally composed of lamalginite, litodetrinite, telalginite, fluorescing amorphous organic matter (AOM), exsudatinite, sporinite, cutinite and resinite (Figures 4.13, 4.14, 4.15, 4.16 and 4.17). The huminite content ranges from 8.50 to 12.3 percent. The inertinite content ranges from 0 to 2.4 percent (Figure 4.18). The non-fluorescing mineral matter content ranges from 9.2 to 17.3 percent and pyrite content is around 2 percent (Figure 4.19).

In all samples, the fluorescence properties of liptinite showed a range of yellowish orange to yellowish brown. The liptinite and telalginite are most common and easily recognizable. The lamalginite show laminated and filamentous morphology and telalginite (*Botryococcus*) generally show sheet-like and disc-shaped forms. Under fluorescence-inducing blue light, they display yellow to yellowish brown. In groundmass of all samples, the fluorescing AOM is found associated with liptodetrinite and non-fluorescing mineral matter. The fluorescing AOM considered to be derived from alginite and is generally irregular morphology and in fluorescence-inducing blue light display orange to orange brown colour. The liptodetrinites are small fragments (<0.01 mm.) and also considered to be derived from alginite. They display dark yellow to yellowish brown color. The sporinite generally display yellow color and present in some of samples. The cutinite is also display yellow color and present in the top of well. The exsudatinite, representing early generated heavy petroleum, display yellow to yellowish brown color and present in some samples. The resinite display yellowish orange color and present in some samples.

Table 4.10: Organic composition and vitrinite reflectance of the samples of Fang-MS well from Fang basin.

Sample	Depth (m)	Liptinite								Lipt	Hum	Inert	Non-fl	Py	VR (%R_o)
		Telalg	Lamalg	Fl. AOM	Lipto	Sp	Cu	Ex	Re						
		Vol.%								Vol. %			Vol.%		
11859	582.17-594.36	15.6	23.5	10.3	11.9	1.8	3.4	3.4	2.5	72.4	11.2	2.4	10.7	3.3	0.38
11861	612.65-624.84	18.2	23.3	9.8	14.8	0.6	0.5	1.3	1.7	70.2	11.8	1.7	13.6	2.7	0.42
11863	658.37-670.50	15.3	24.1	7.4	19.6	2.8	1.3	3.1	2.4	76	10.7	0.8	9.3	3.2	-
11864	673.61-685.80	14.5	30.4	4.8	19.1	1.6	0.8	2.1	0	73.3	12.3	0.5	11.4	2.5	0.41
11869	749.81-762.00	16.9	28.6	5.3	18.5	2.3	1.7	2.8	0	76.1	9.2	0	12.6	2.1	0.42
11870	765.05-777.24	14.8	23.9	6.9	24.8	1.3	0	2.9	0	74.6	12.1	0	11.8	1.5	-
11871	780.29-792.48	12.1	26.4	6.3	27.3	2.1	0	2.9	0.5	77.6	10.2	0	10.5	1.7	0.47
11874	826.01-838.20	14.3	23.5	11.7	24.9	1.6	0	2.2	0	78.2	9.1	0	10.6	2.1	0.47
11876	874.78-883.92	13.6	23.8	12.9	23.4	2.9	0	1.5	0	78.1	9.2	0	11.4	1.3	0.57
11877	886.97-899.16	12.5	25.7	13.8	20.3	0.5	0	0	0	72.8	9.2	0	11.5	1.6	-
11878	902.21-914.40	11.7	25.4	11.2	23.4	1.2	0	1.7	0	74.6	9.3	0	14.5	1.6	-
11879	917.45-929.64	14.6	19.5	15.3	22.9	0	0	2.7	0	75	10.5	0.1	12.3	2.1	-
11880	935.74-941.83	13.7	18	9.4	29.3	2.4	0	3.1	0	75.9	11.3	0	11.5	1.3	0.58
11882	978.41-990.60	16.2	22.4	10.3	26.4	2.9	0	0	0	78.2	10.2	0	9.2	2.4	0.58
11883	993.65-1,002.79	14.9	20.2	9.3	29.3	0	0	4.3	0	78	9.2	0.2	11.5	1.1	-
11884	1,008.89-1,021.08	12.7	25.6	9.7	24.7	0	0	3.9	0	76.6	11.3	0	10.3	1.8	-
11887	1,054.61-1,066.80	13.9	23.6	11.6	20.4	1.2	0	1.7	0	72.4	10.2	0.7	15.2	1.5	0.63
11889	1,085.09-1,094.23	11.8	18.5	15.2	21.3	0	0	2.8	0	69.6	14.8	0	14.2	1.4	0.66
11891	1,115.57-1,127.76	11.8	21.6	16.1	19.7	0	0	3.7	0	72.9	8.5	0	17.3	1.3	-

Telalg: telalginite; Lamalg: lamalginite; Fl. AOM: fluorescing amorphous organic matter; Lipto: liptodetrinite; Sp: sporinite; Cu: cutinite; Ex: exsudatinite; Re: resenite; Lipt: liptinite; Hum: huminite; Inert: inertinite; Non-fl: non-fluoresencing mineral matter; Py: pyrite; VR: vitrinite reflectance, -: non measurement

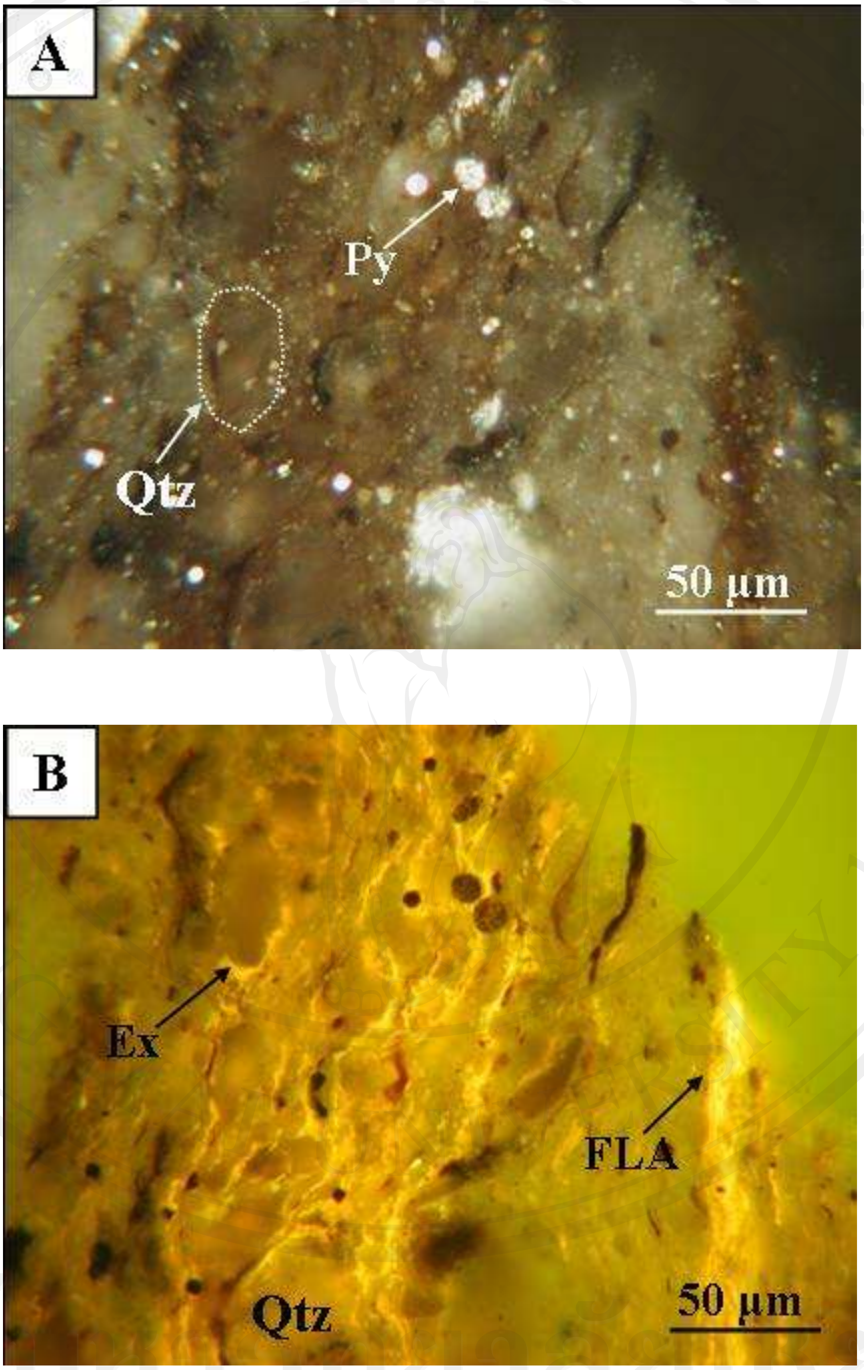

Figure 4.13 Photomicrographs of filamentous lamalginite (FLA), exsudatinite (Ex) surrounding quartz grain (Qtz) and framboidal pyrite (Py) of sample 11859 (588.30 m) from Fang-MS well in cross polarize light (A) and in fluorescence-inducing blue light (B).

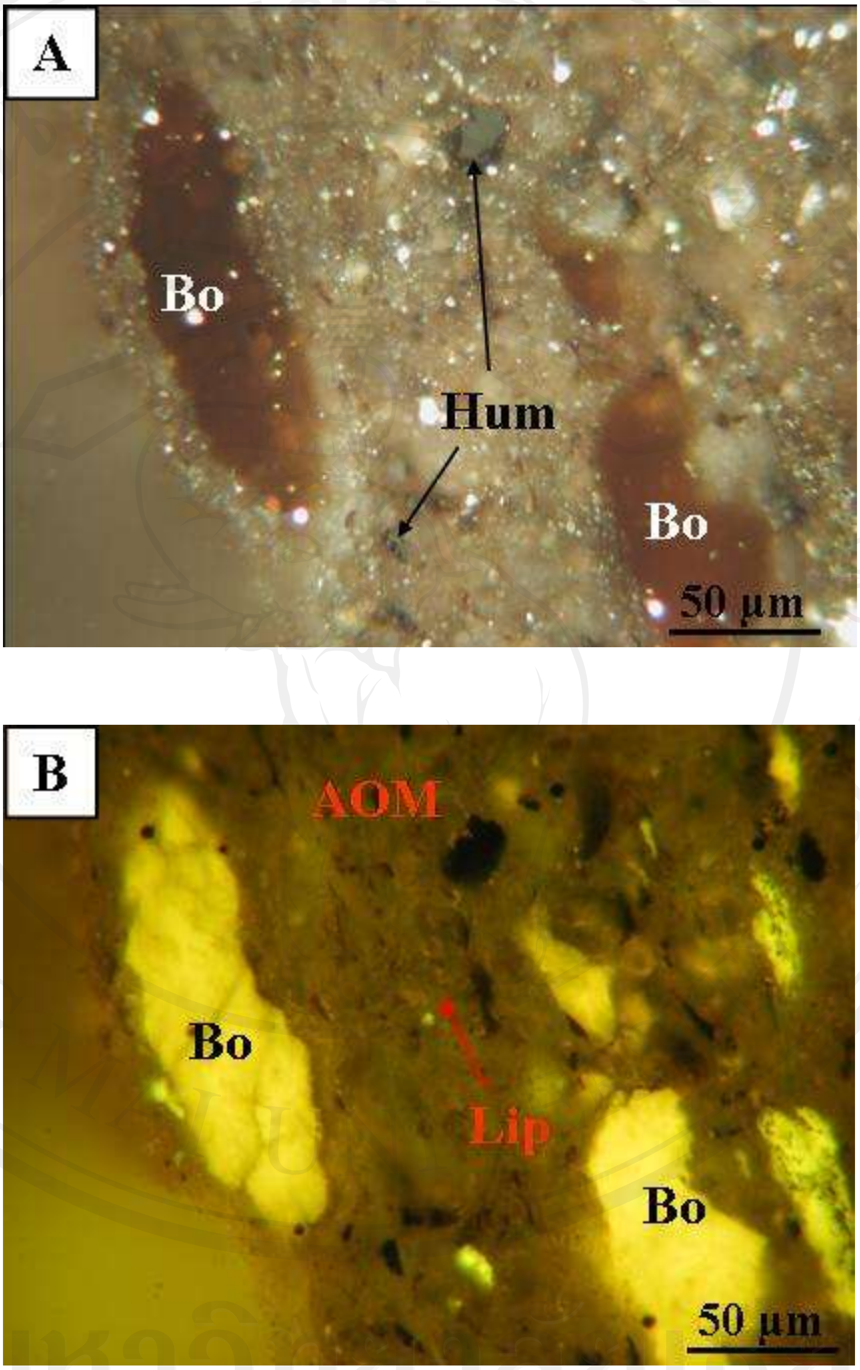

Figure 4.14 Photomicrographs of *Botryococcus*-type telalginite (Bo) and huminite fracments (Hum) in groundmass of yellowish brown fluorescing amorphous organic matter (AOM) and liptodetrinite (Lip) of sample 11859 (588.30 m) from Fang-MS well in cross polarize light (A) and in fluorescence-inducing blue light (B).

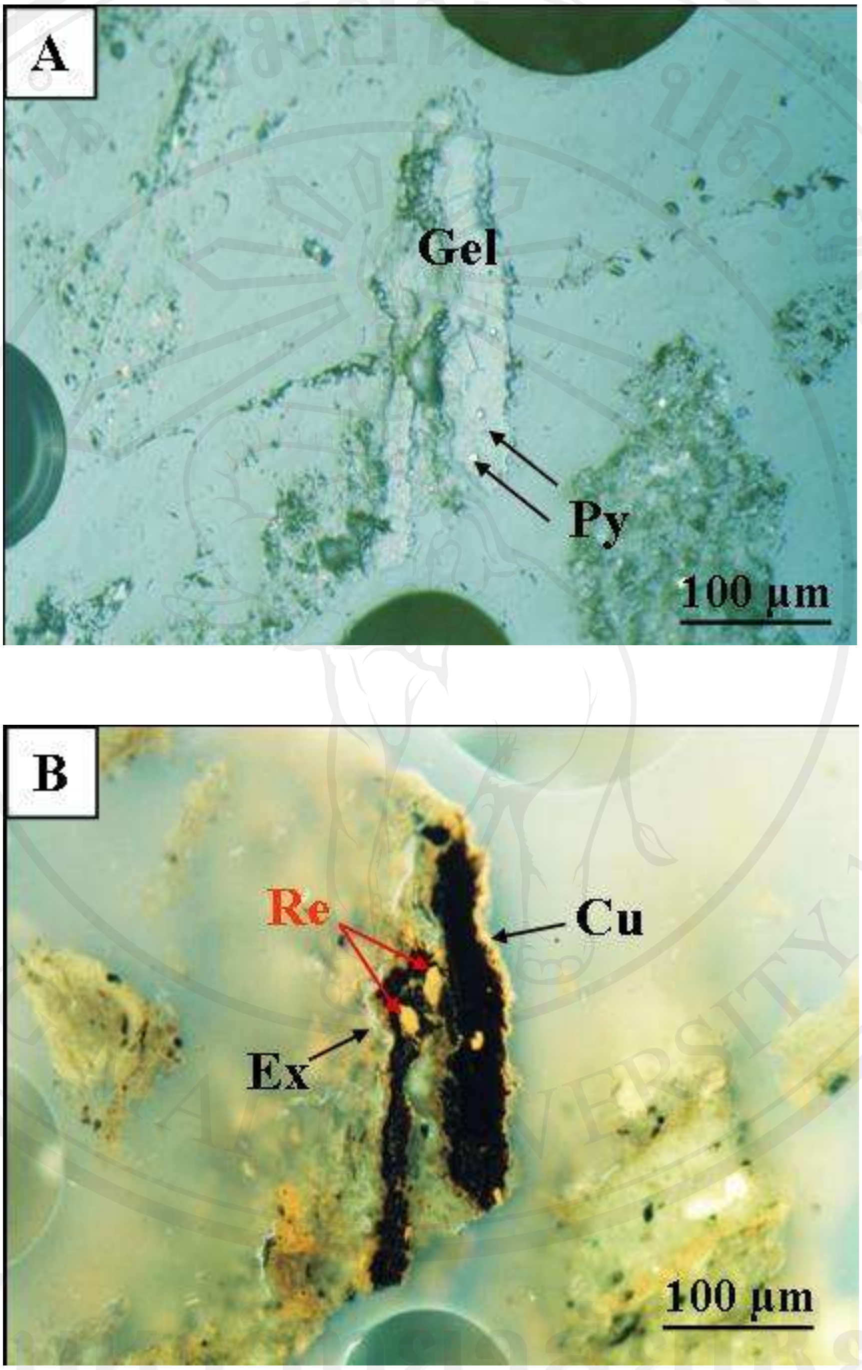

Figure 4.15 Photomicrographs of gelinite (Gel), cutinite (Cu), resinite (Re) and exsudatinite (Ex) intruded into cleats of gelinite of sample 11861 (618.70 m) from Fang-MS well in white light (A) and in fluorescence -inducing blue light (B).

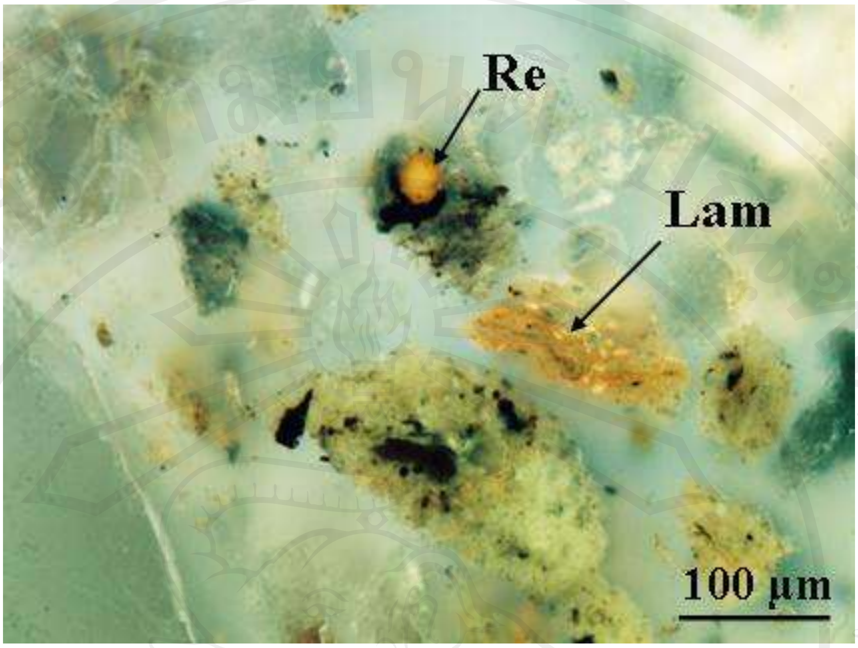

Figure 4.16 Photomicrograph of resinite (Re) and lamalginite (Lam) display yellowish orange color in fluorescence-inducing blue light of sample 11871 (786.40 m) from Fang-MS well.

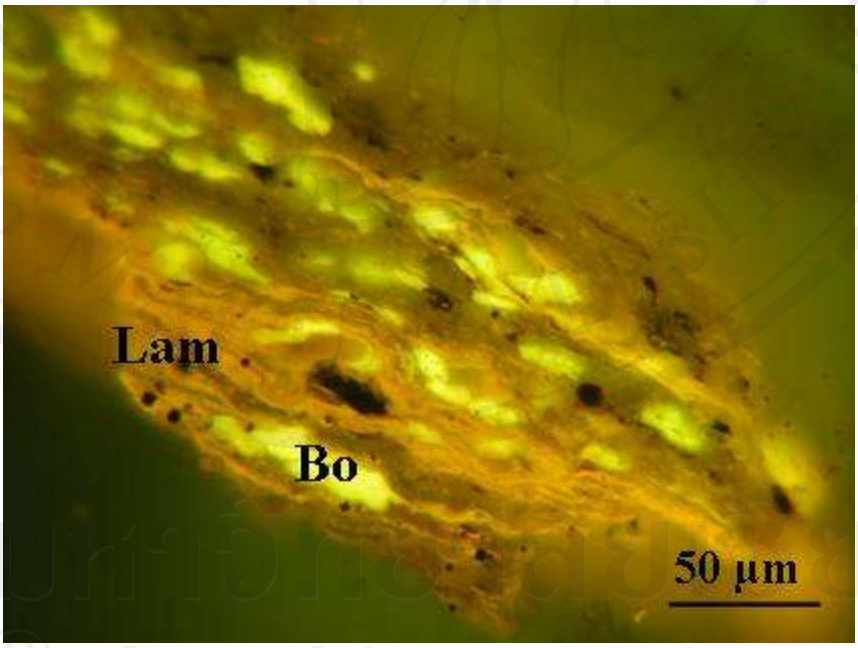

Figure 4.17 Photomicrograph of association of disc-shaped *Botryococcus*-type telalginite (Bo) and lamalginite (Lam) in groundmass of weakly brownish florescing amorphous organic matter and liptodetrinite in fluorescence-inducing blue light of sample 11871 (786.40 m) from Fang-MS well.

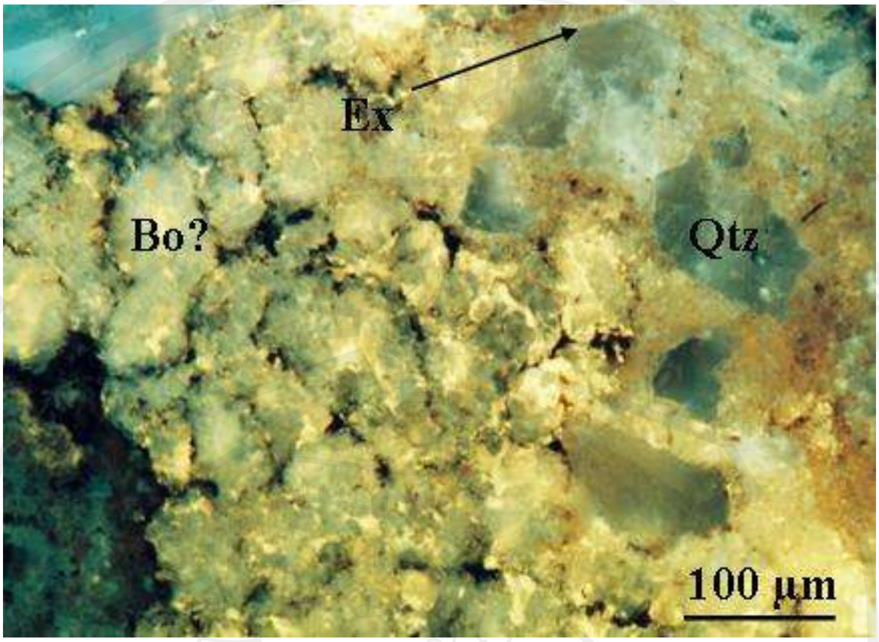

Figure 4.18 Photomicrograph of exsudatinite (Ex) surrounding quartz (Qtz) grains and displays greenish yellow color and *Botryococcus*? (Bo?) in fluorescence-inducing blue light of sample 11876 (879.30 m) from Fang-MS well.

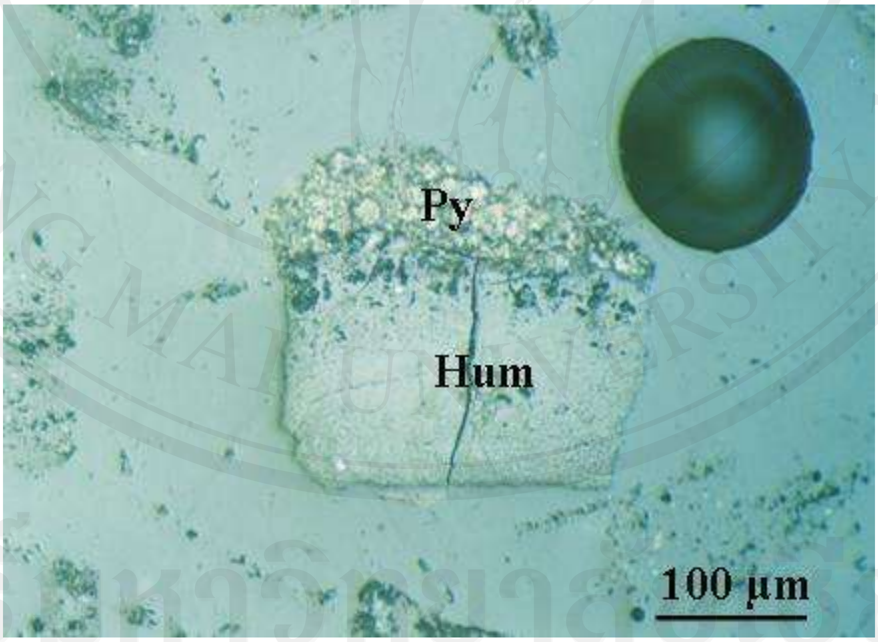

Figure 4.19 Photomicrograph of framboidal pyrite (Py) in humic coal (Hum) in white light of sample 11882 (984.5 m) from Fang-MS well.

Random reflectance data (% R_o) determined from eleven cutting samples from Mae Sot formation range from 0.38% to 0.66% R_o (Table 4.10).

4.4.2 Na Hong basin

The macerals of the sample from the Na Hong are given in the Table 4.11. The liptinite content ranges from 59.0 to 80.1 percent. The liptinitic material is principally composed of lamalginite, liptodetrinite, telalginite, resinite, fluorescing AOM, sporinite, exsudatinite and cutinite (Figures 4.20). The huminite content ranges from 6.8 to 28.9 percent. The huminite composed of dentinite and gelinite (Figure 4.26, 4.21, 4.22, 4.23, 4.24 and 4.25). The inertinite content does not exceed 1 percent in all samples. The non-fluorescing mineral matter content ranges from 6.4 to 8.3 percent and pyrite content is around 5 percent.

Sample 14714 of oil shale, shows the hightest proportion of filamentous lamalginite and telalginite, predominantly with morphology similar to the extant algae *Botryococcus*. Under fluorescence-inducing blue light, they display yellow to yellowish orange. In groundmass, the fluorescing AOM is found associated with liptodentrinite and mineral matter. The fluorescing AOM is considered to be derived from alginite and is generally irregular in form. In fluorescence-inducing blue light they display orange to orange brown color. The liptodentrinites display dark yellow to yellowish brown color. The sporinite generally display yellow color.

Samples 14709, 14712 and 14719 of coaly mudstone, show high proportion of huminite content which composed of dentinite and gelinite. Early generated heavy bitumen or hydrocarbons (exsudatinite) have been observed in all coaly mudstone samples. Random reflectance data (% R_o) determined from four samples from Na Hong range from 0.40% to 0.49% R_o (Table 4.11).

4.4.3 Li basin

The macerals of the sample from the Li are given in the Table 4.11. The liptinite content ranges from 70.6 to 80.6 percent. The liptinitic material is principally composed of lamalginite, fluorescing amorphous organic matter, telalginite, liptodentrinite, sporinite and exsudatinite (Figures 4.26 and 4.27). The huminite content ranges from 6.7 to 9.1 percent (Figures 4.26 and 4.27). The inertinite maceral is

Table 4.11: Organic composition and vitrinite reflectance of the samples from Na Hong, Li and Mae Sot basins.

Sample	Depth (m)	Liptinite								Lipt	Hum	Inert	Non-fl	Py	VR (%R_o)
		Telalg	Lamalg	Fl. AOM	Lipto	Sp	Cu	Ex	Re						
		Vol.%								Vol. %			Vol.%		
14709	Na Hong	3.7	24.3	2.5	5.2	6.6	2.7	6.2	7.8	59	28.9	0	7.6	4.5	0.46
14712	Na Hong	4.7	23.9	5.6	6.5	5.6	3.5	8.7	7.9	66.4	24.6	0.5	6.4	5.1	0.49
14714	Na Hong	12.8	37.6	10.2	15.9	1.3	0	2.3	0	80.1	6.8	0.2	7.1	5.8	0.40
14719	Na Hong	2.0	22.3	2.9	12.3	6.8	4.2	3.4	6.5	60.4	25.8	0.7	8.3	4.8	0.45
14690	Li	12.8	32.4	14.8	9.3	2.7	0	0.5	0	72.5	8.9	0	12.8	5.8	0.40
14693	Li	12.5	33.4	15.2	8.4	1.1	0	0	0	70.6	9.1	0	11.9	6.4	0.36
14695	Li	21.2	33.5	13.6	11.7	0.6	0	0	0	80.6	6.7	0	9.2	3.5	0.40
14700	Mae Sot	0	63.9	22.7	0.5	0	0	0	0	87.1	1.8	0	9.2	1.9	0.37
14702	Mae Sot	7.4	52.6	25.8	0.7	0	0	0	0	86.5	2.6	0	9.7	2.1	0.35

Telalg: telalginite; Lamalg: lamalginite; Fl. AOM: fluorescing amorphous organic matter; Lipto: liptodetrinite; Sp: sporinite; Cu: cutinite; Ex: exsudatinite; Re: resenite; Lipt: liptinite; Hum: huminite; Inert: inertinite; Non-fl: non-fluorescing mineral matter; Py: pyrite; VR: vitrinite reflectance

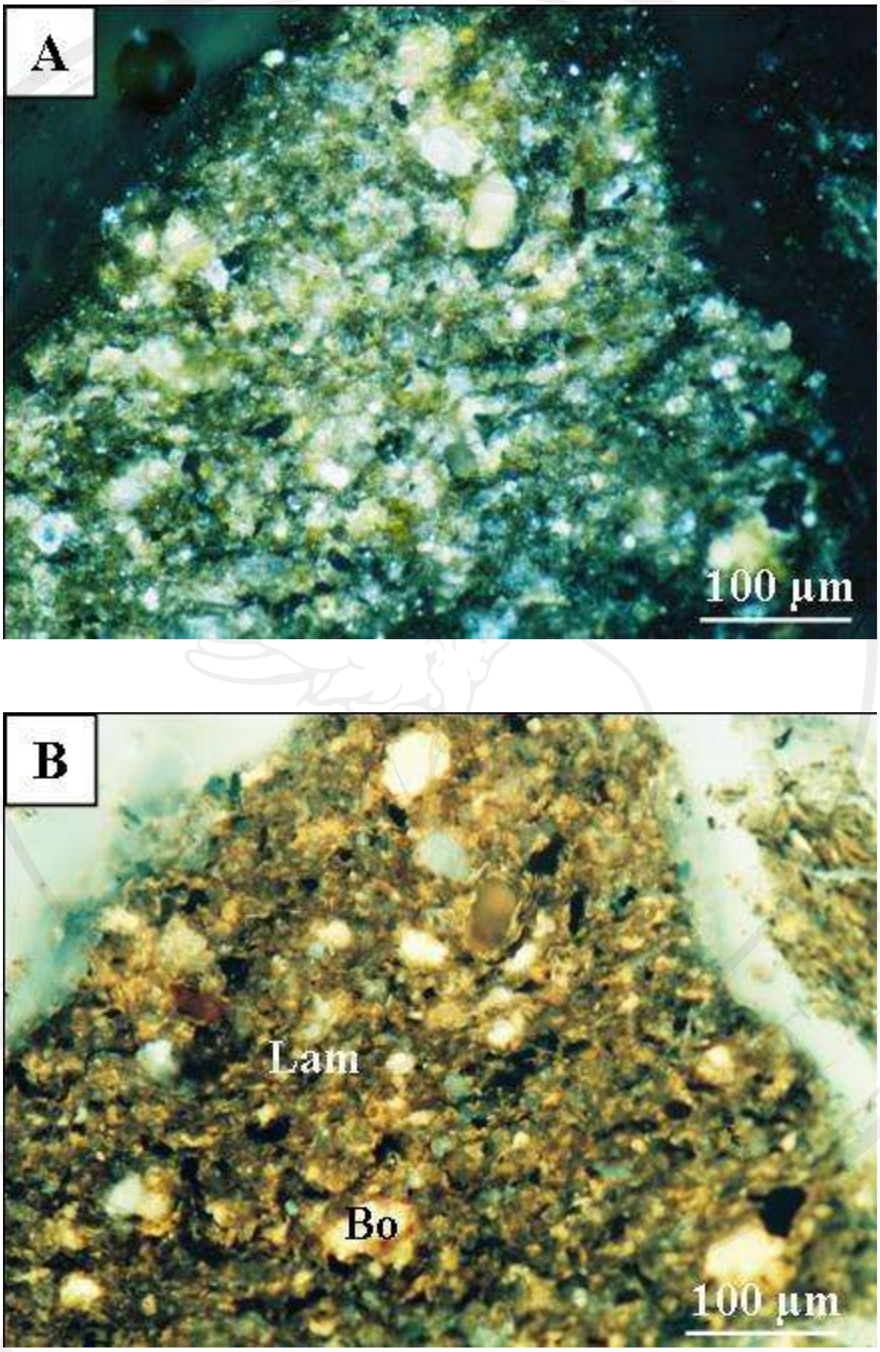

Figure 4.20 Photomicrographs of association of disc-shaped *Botryococcus*-type telalginite (Bo) and lamalginite (Lam) in groundmass of fluorescing amorphous organic matter and liptodetrinite of sample 14714 from Na Hong basin in cross polarize light (A) and in fluorescence-inducing blue light (B).

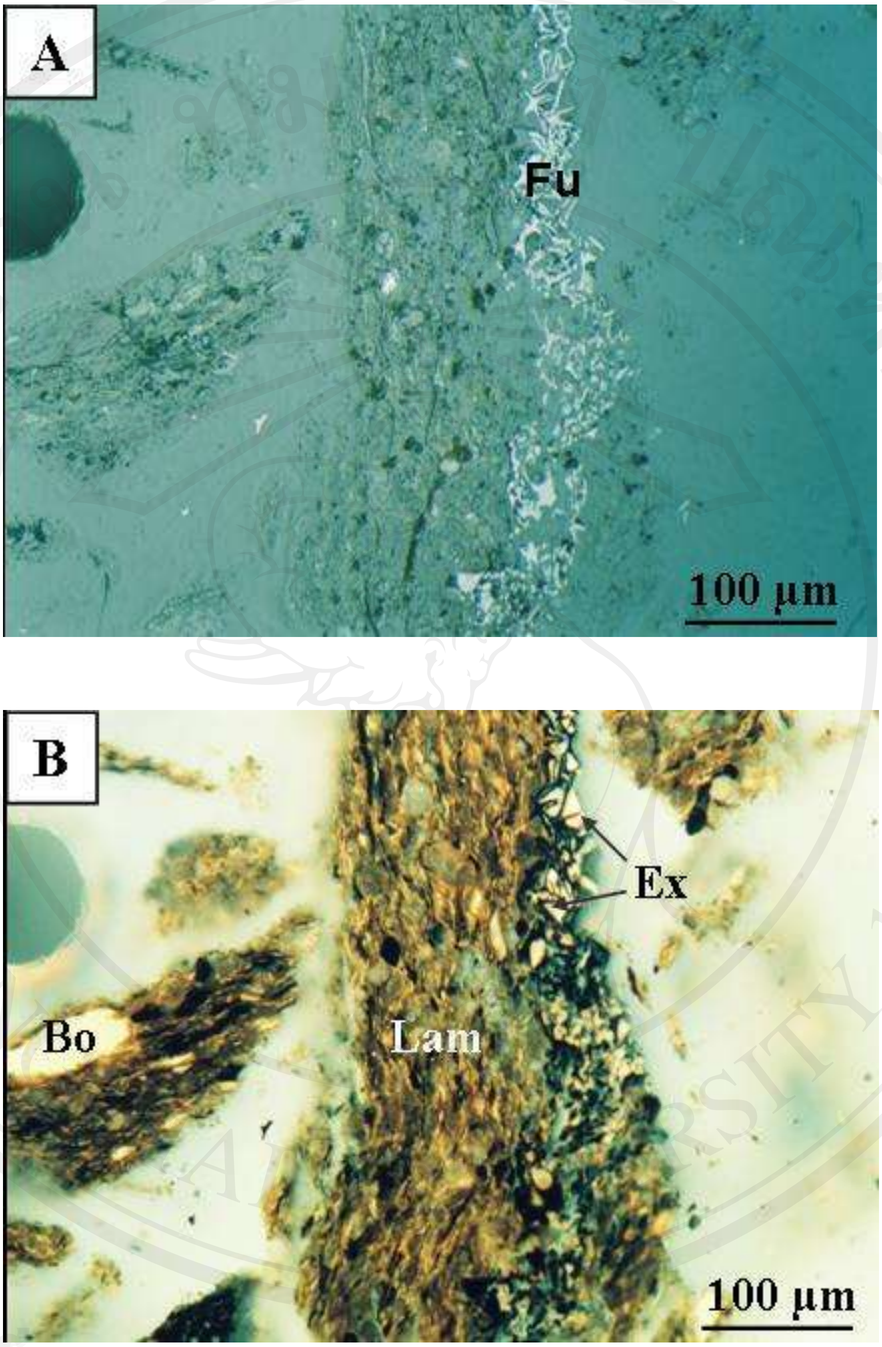

Figure 4.21 Photomicrographs of association of disc-shaped *Botryococcus*-type telalginite (Bo) and lamalginite (Lam) in groundmass of fluorescing amorphous organic matter and liptodetrinite; exsudatinite (Ex) filled in pore of fusinite (Fu) layer of sample 14714 from Na Hong basin in white light (A) and in fluorescence-inducing blue light (B).

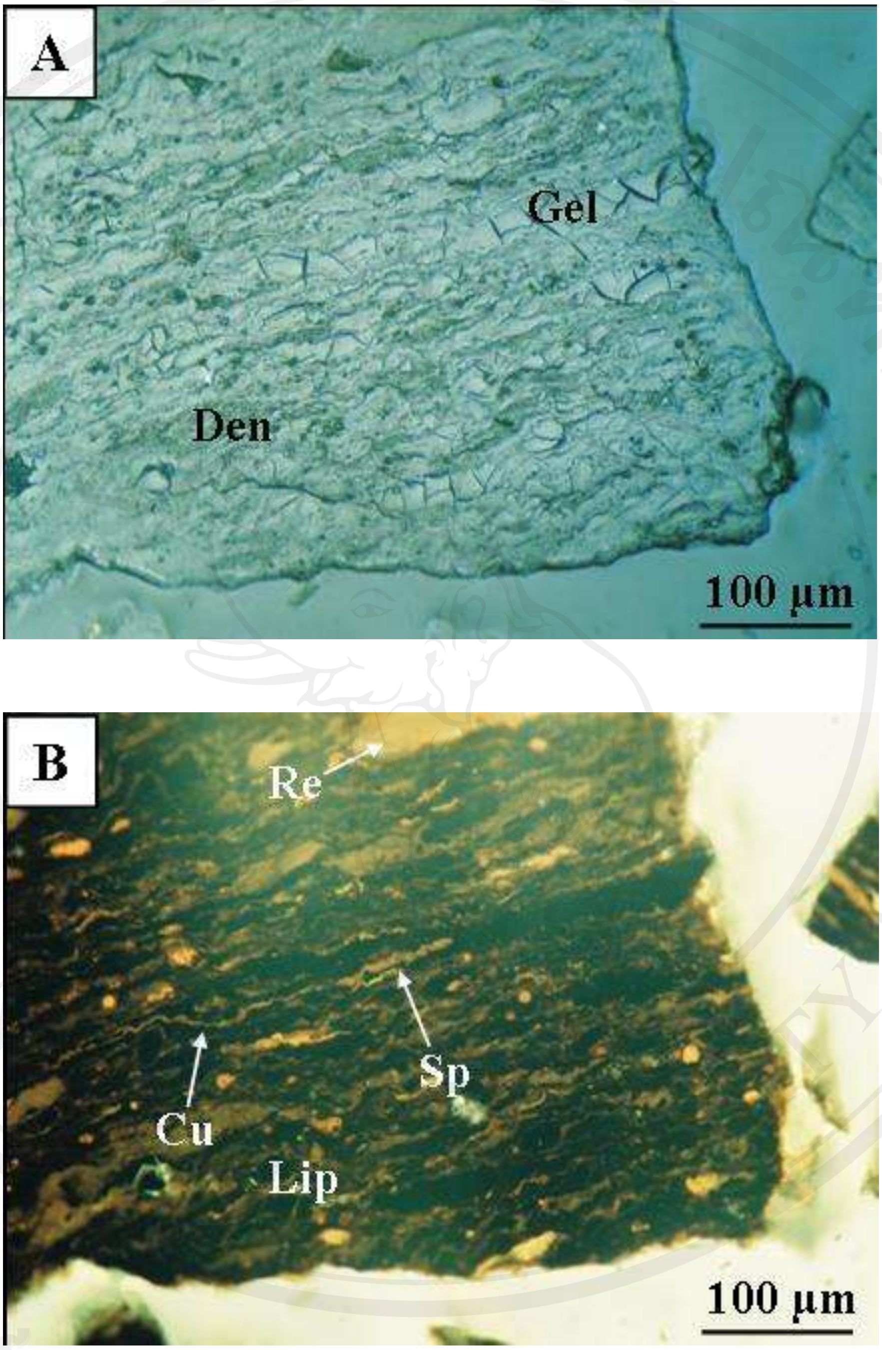

Figure 4.22 Photomicrographs of resinite (Re), sporinite (Sp), liptodetrinite (Lip) and cutinite (Cu) in densinite (Den) and gelinite (Gel) groundmass in sample 14709 from Na Hong basin in white light (A) and in fluorescence-inducing blue light (B).

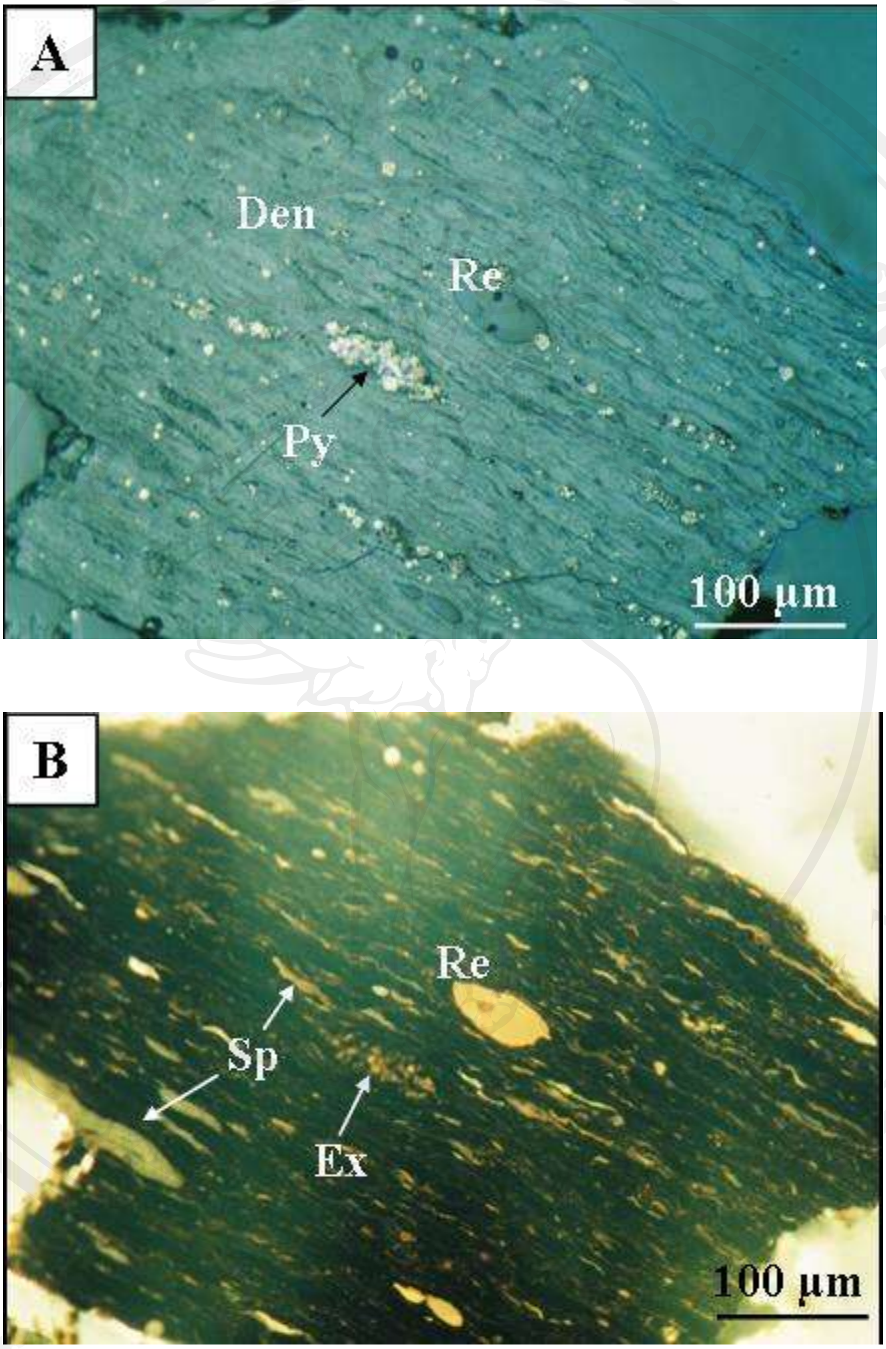

Figure 4.23 Photomicrographs of resinite (Re), sporinite (Sp), exsudatinite (Ex) and framboidal pyrite (Py) in densinite (Den) groundmass in sample 14709 from Na Hong basin in white light (A) and in fluorescence-inducing blue light (B).

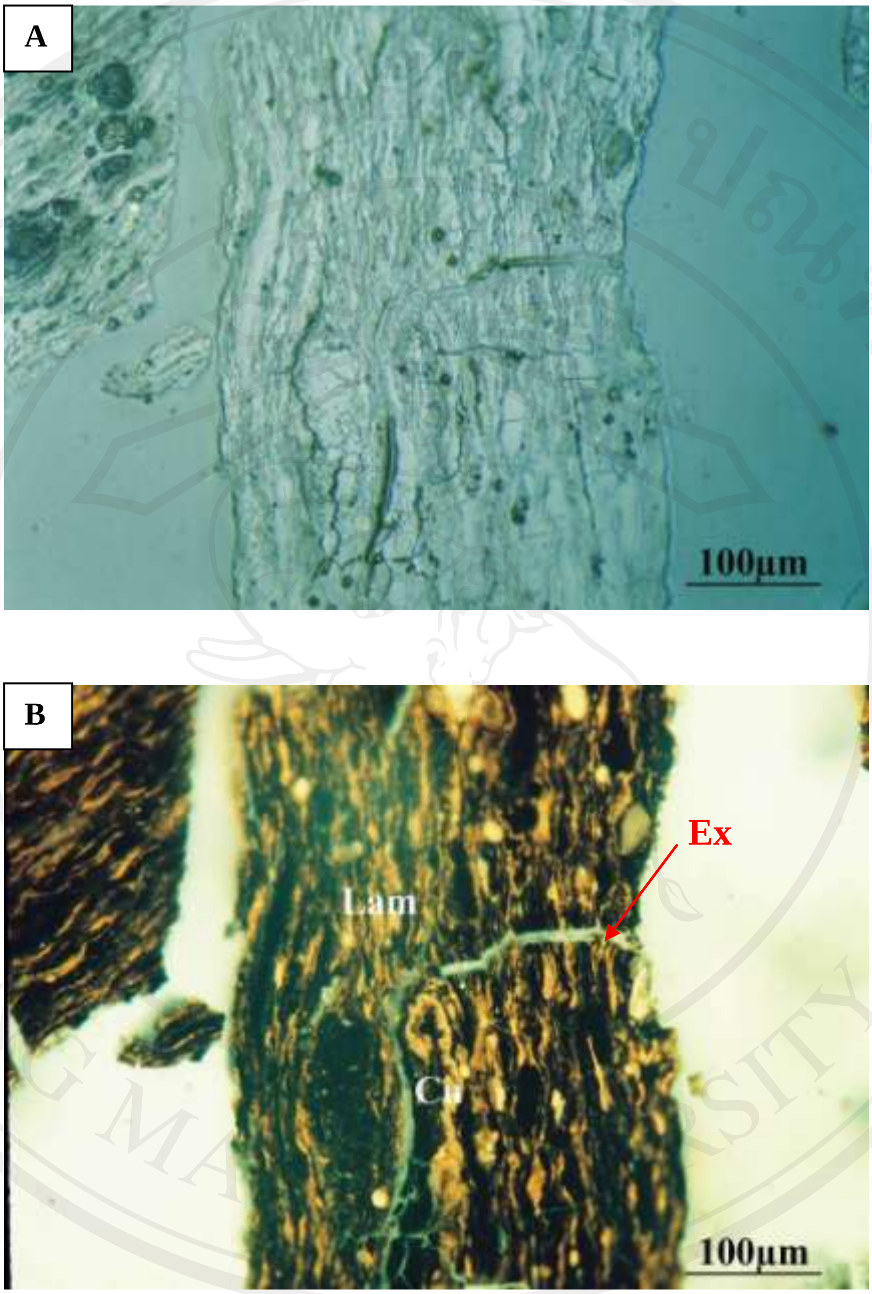

Figure 4.24 Photomicrographs of lamalginite (Lam), exsudatinite (Ex) and cutinite (Cu) in dentinite groundmass of sample 14719 from Na Hong basin, in white light (A) and white color in fluoresceence-inducing blue light (B).

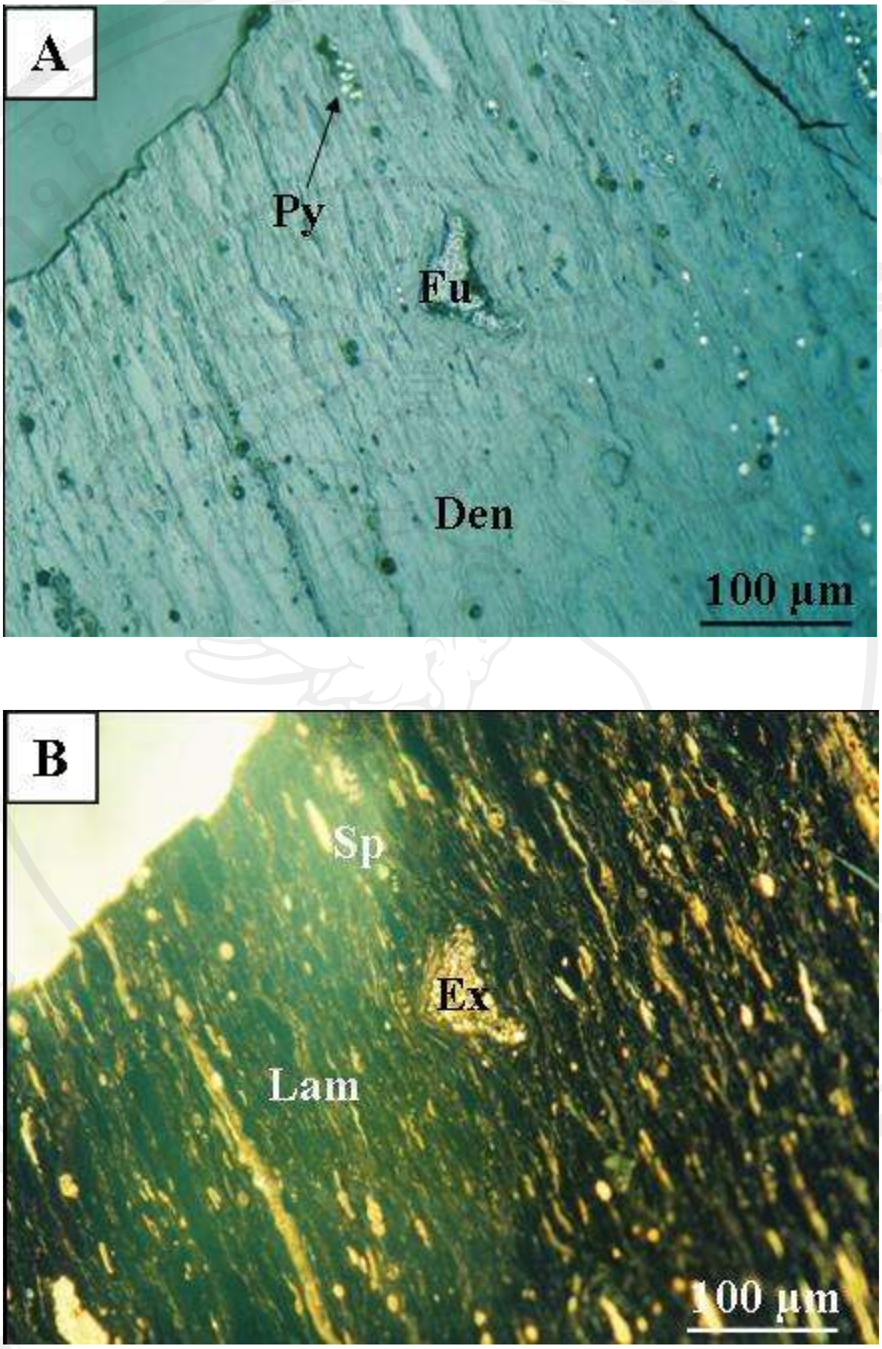

Figure 4.25 Photomicrographs of lamalginite (Lam), sporinite (Sp), exsudatinite (Ex) filled in pore of fusinite (Fu) and framboidal pyrite (Py) in densinite groundmass of sample 14712 from Na Hong basin in white light (A) and in fluorescence-inducing blue light (B).

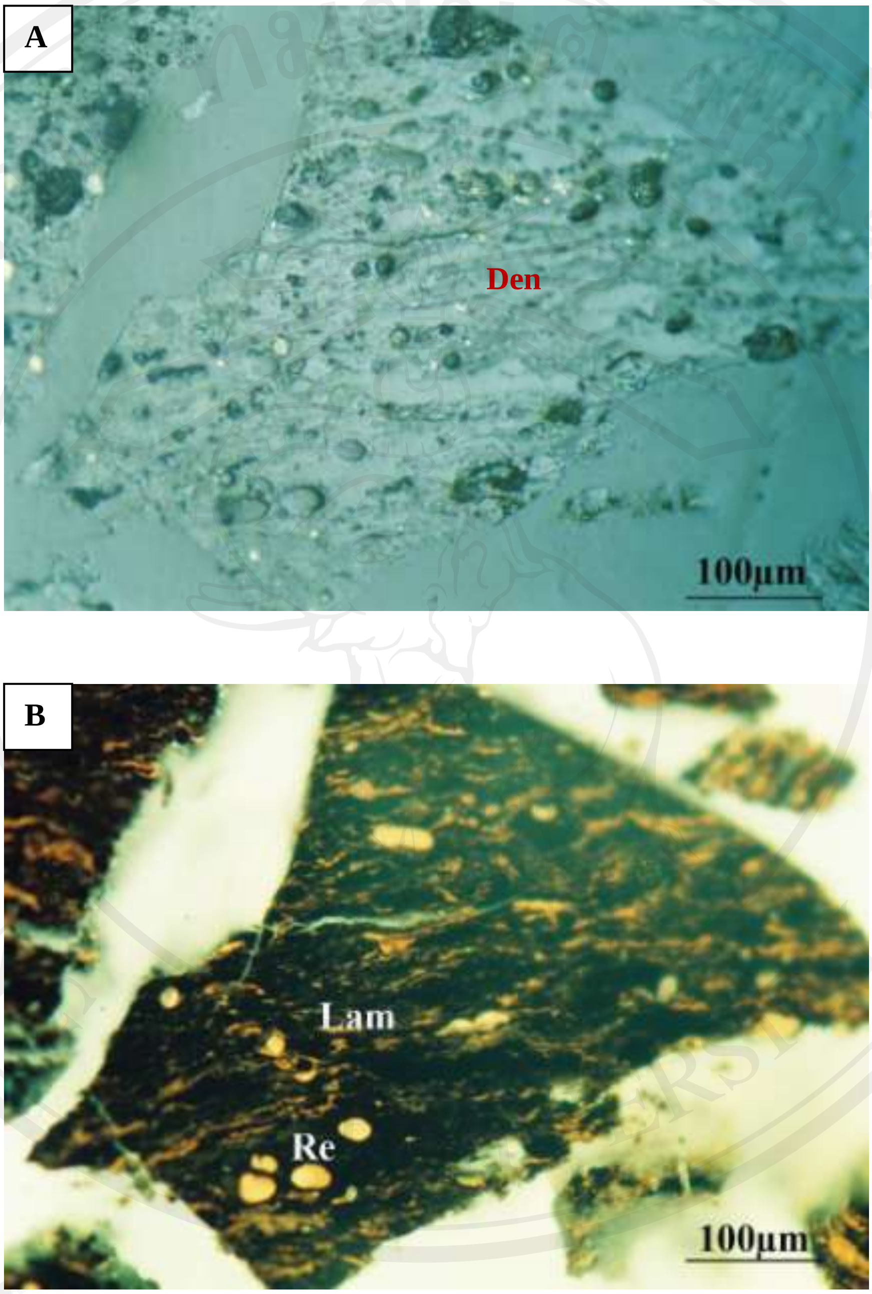

Figure 4.26 Photomicrographs of lamalginite (Lam) and resinite (Re) in densinite (Den) groundmass of sample 14719 from Na Hong basin in white light (A) and in fluorescence-inducing blue light (B).

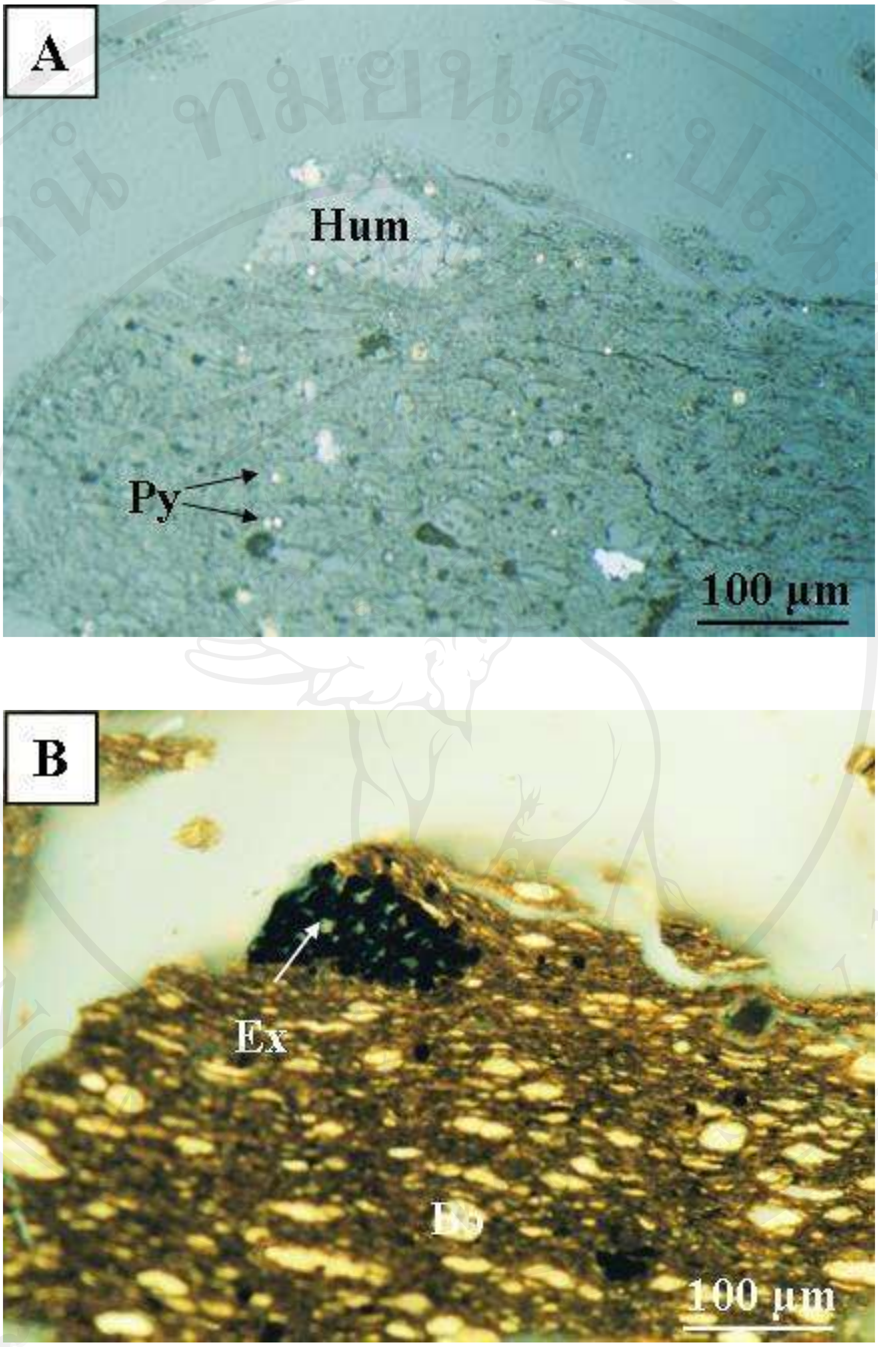

Figure 4.27 Photomicrographs of exsudatinite (Ex) in huminite (Hum) and association of disc-shaped *Botryococcus*-type telalginite (Bo), lamalginite and pyrite (Py) in groundmass of fluorescing amorphous organic matter and liptodetrinite of sample 14690 Ban Pa Kha subbasin, Li basin in white light (A) in fluorescence-inducing blue light (B).

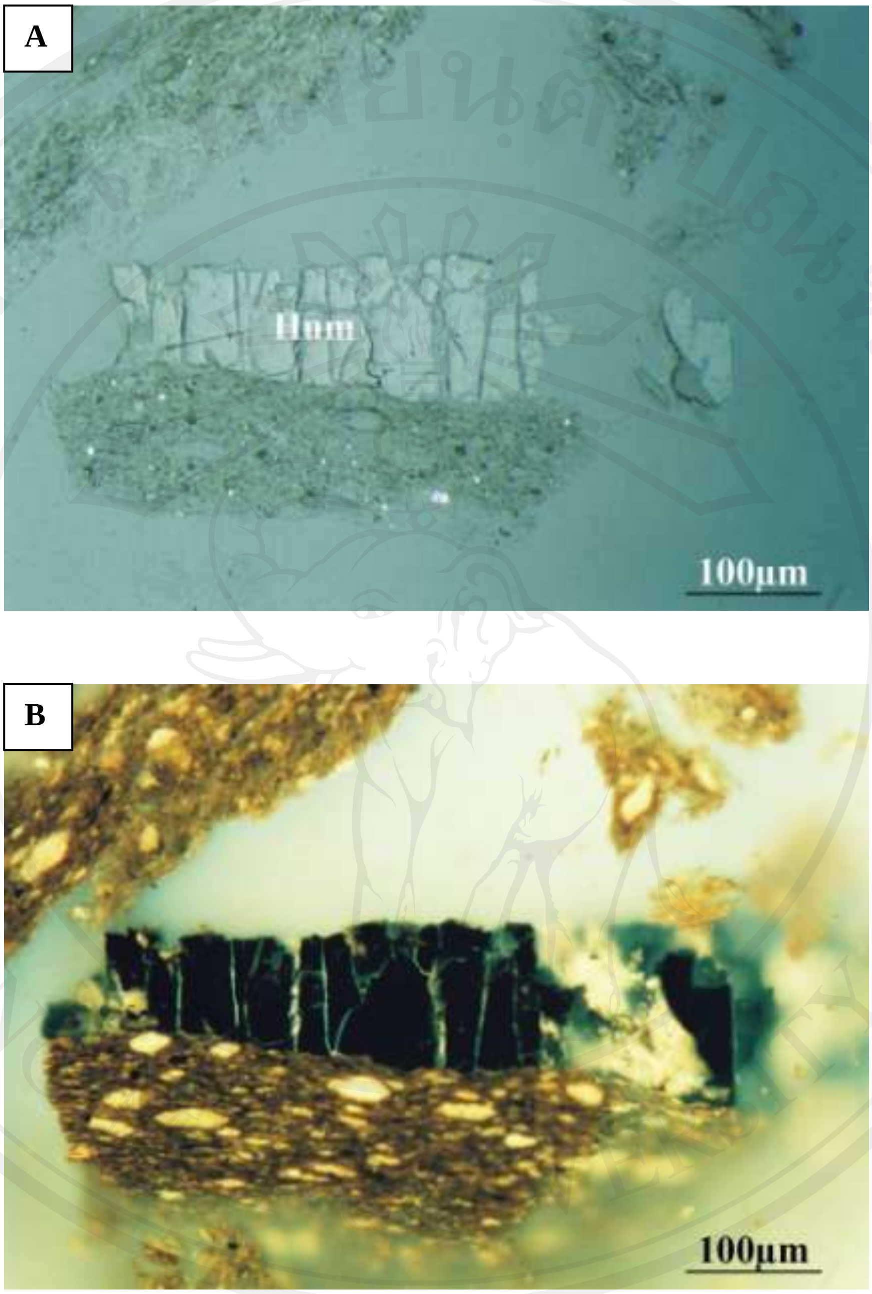

Figure 4.28 Photomicrographs of gelinite huminite (Hum) with exsudatinite in cleates and association of disc-shaped *Botryococcus*-type telalginite and lamalginite in groundmass of fluorescing amorphous organic matter and liptodetrinite of sample 14693 from Li basin in white light (A) in fluorescence-inducing blue light (B).

absent. The non fluorescing mineral matter content range from 11.9 to 12.8 percent and pyrite is 5.8 to 8.7 percent (Figure 4.29).

In all samples, the lamalginite show laminated and filamentous morphology and telalginite (*Botryococcus*) generally show sheet-like and disc shaped forms. Under fluorescence-inducing blue light, they display yellow to yellowish brown.

In groundmass of all samples, the fluorescing AOM is found associated with liptodetrinite and non fluoresing mineral matter. The Fluorescing AOM considered to be derived from alginite and is generally irregular morphology and in fluorescing-inducing blue light display orange to orange brown color. The liptodetrinites also considered to be derived from alginite. They display dark yellow to yellowish brown color. The sporinite generally display yellow color and present in all samples.

Random reflectance data (% R_o) determined from three samples from Li basin range from 0.36% to 0.40% R_o (Table 4.11).

4.4.4 Mae Sot basin

The macerals of the sample from the Mae Sot basin are given in the Table 4.12. The liptinite content is high proportion (~ 87 percent). The liptinitic material is principally composed of laminated lamalginite, fluorescing amorphous organic matter, telalginite, predominantly with morphology similar to the extant algae *Botryococcus*, liptodetrinite (Figures 4.30, 4.31 and 4.32). The huminite content ranges from 1.8 to 2.6 percent (Figure 4.33). The inertinite group is absent. The non-fluorescing mineral matter content ranges from 9.2 to 9.7 percent. Pyrite content is from 1.9 to 2.1 percent.

Sample 14700 is characterized by having high proportions laminated lamalginite (up to ~ 64 %), compact structurelass fluorescing AOM and small amount of liptodetrinite but no telalginite. In sample 14702 telalginite and liptodetrinite are found in small amount. Under fluorescence-inducing blue light, the laminated lamalginite display yellowish orange color while telalginite display yellow color. The fluorescing AOM and liptodetrinite display yellowish brown and considered to be derived from lamalginite.

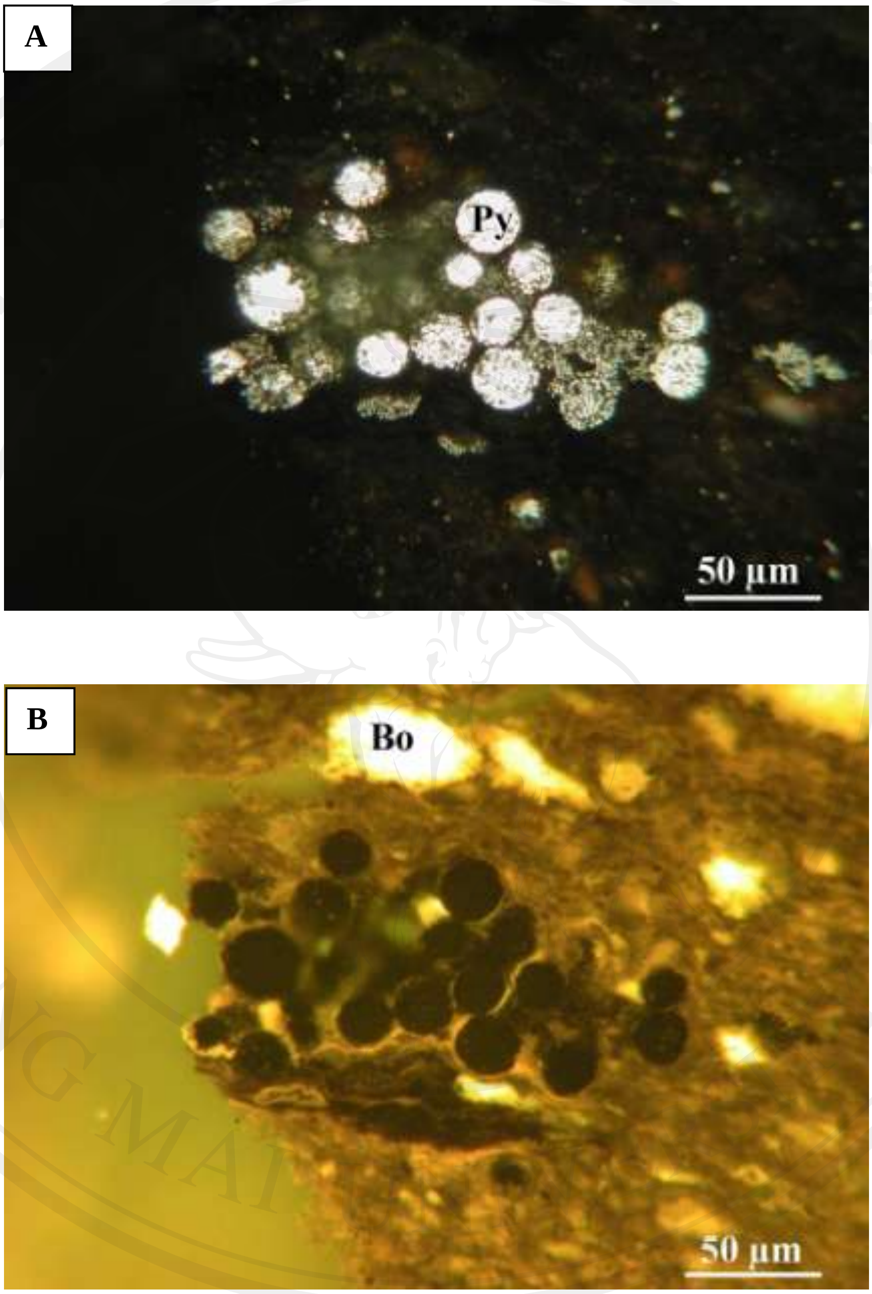

Figure 4.29 Photomicrographs of framboidal pyrite (Py) and association of disc-shaped *Botryococcus*-type telalginite (Bo) and lamalginite in groundmass of fluorescing amorphous organic matter and liptodetrinite of sample 14693 from Li basin in cross polarize light (A) and in fluorescence-inducing blue light (B).

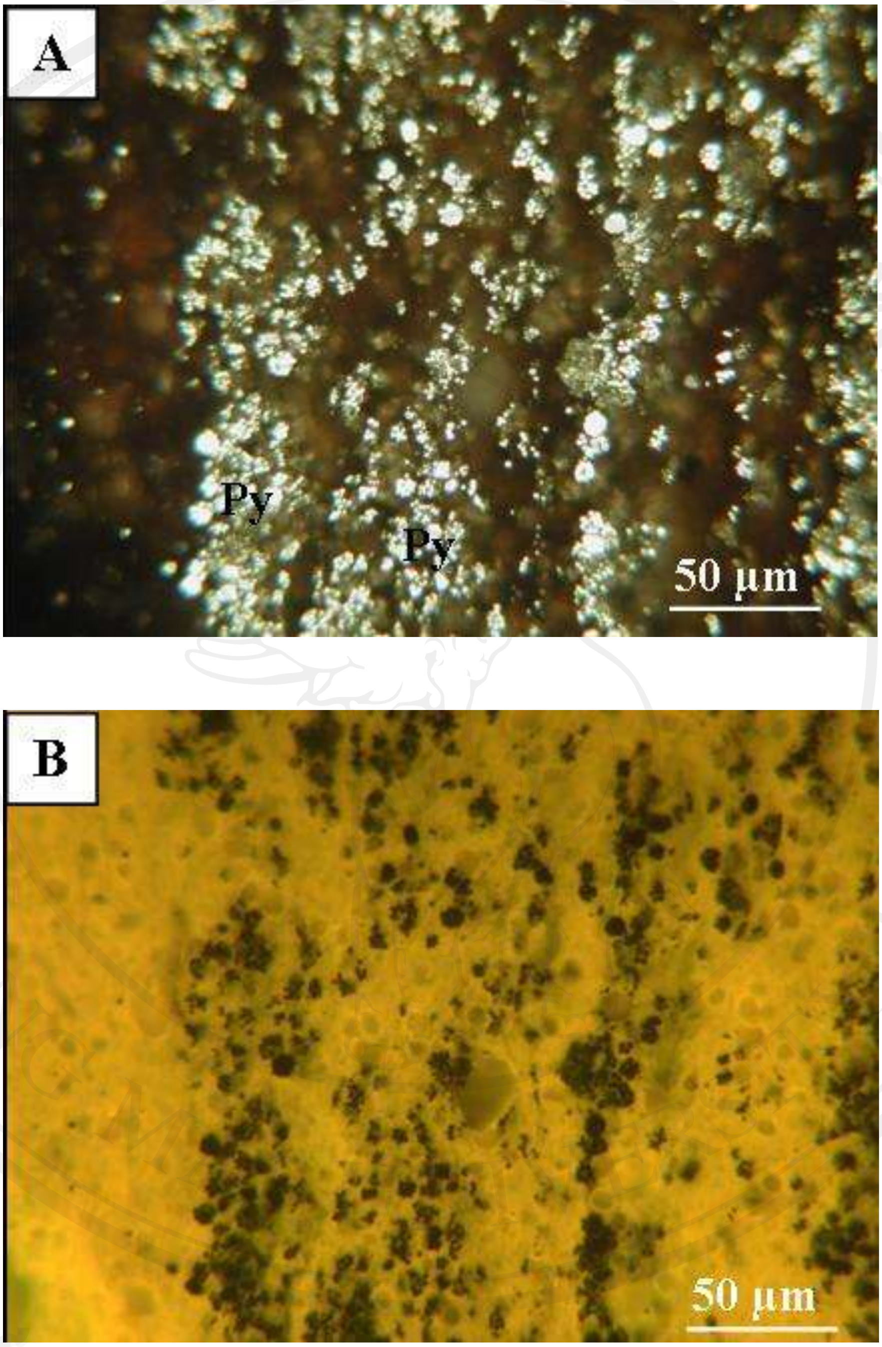

Figure 4.30 Photomicrographs of framboidal pyrite (Py) (white in polarize light and black in blue light) in homogeneous AOM which considered mainly to be derived from alginite of sample 14700 from Mae Sot basin in cross polarize light (A); in fluorescence-inducing blue light (B).

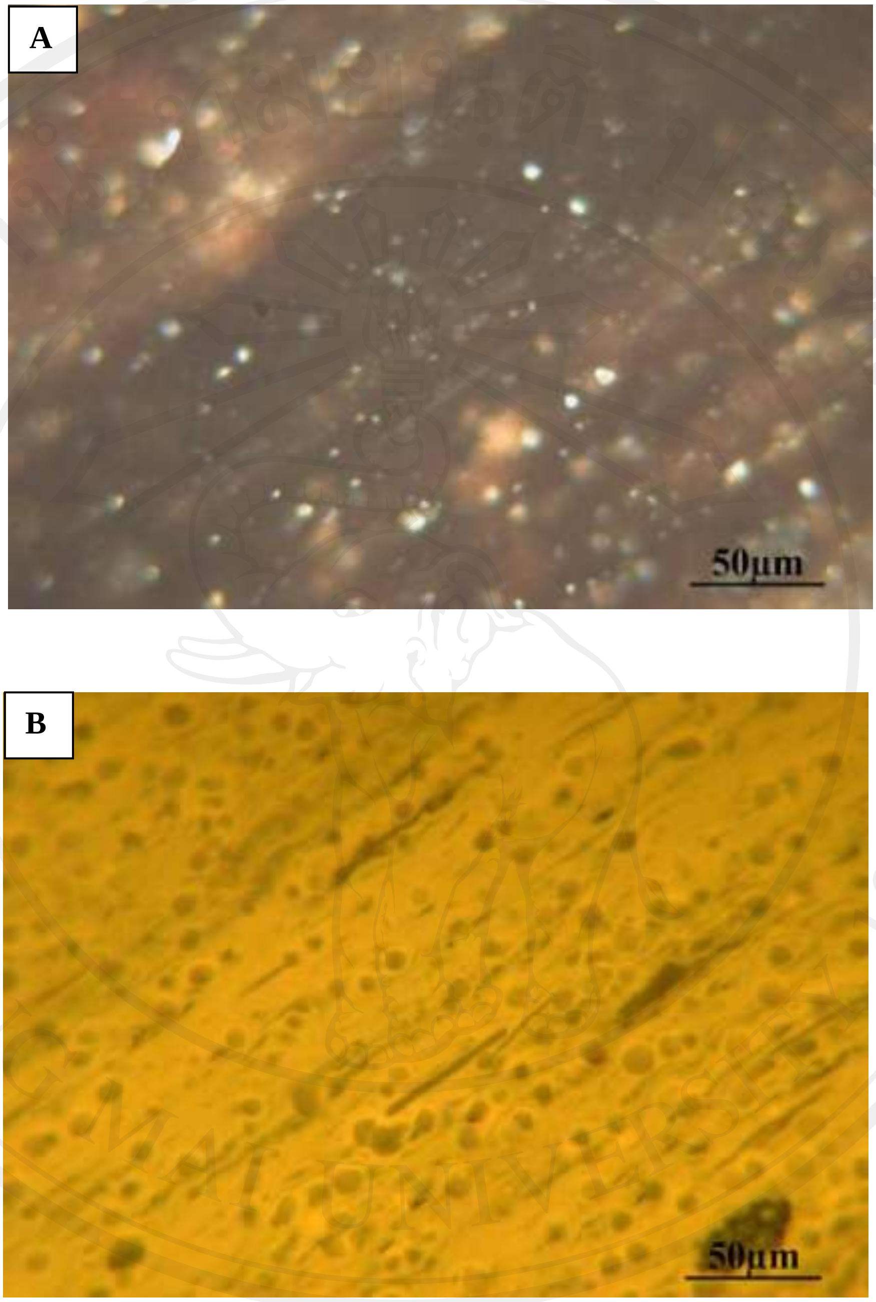

Figure 4.31 Photomicrographs of homogeneous AOM which considered mainly to be derived from alginite of sample 14700 from Mae Sot basin in cross polarize light (A); in fluorescence-inducing blue light (B).

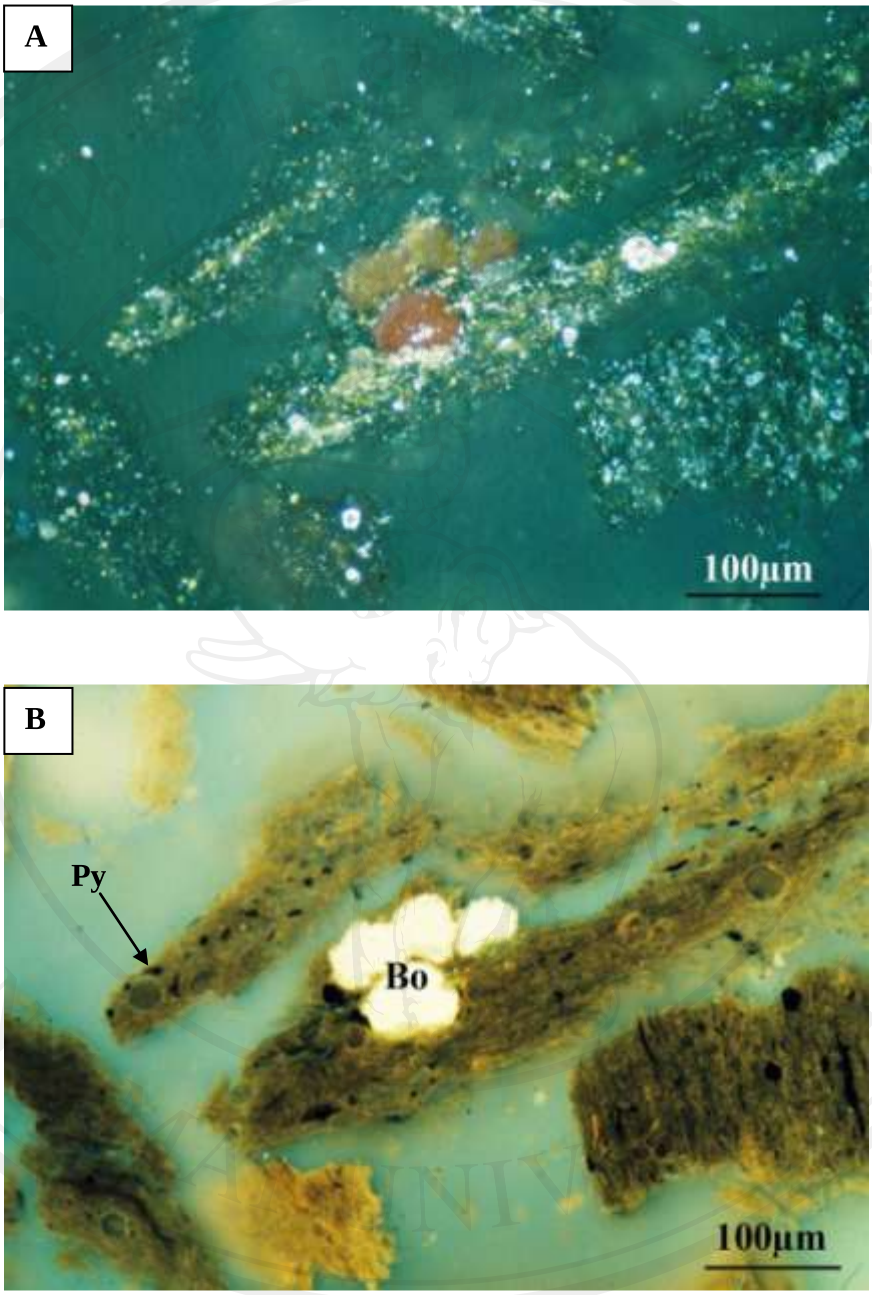

Figure 4.32 Photomicrographs of disc-shaped *Botryococcus*-type telalginite (Bo) in pyrite (Py) rich liptodetrinite groundmass of sample 14702 from Mae Sot basin in cross polarize light (A) in fluorescence-inducing blue light (B).

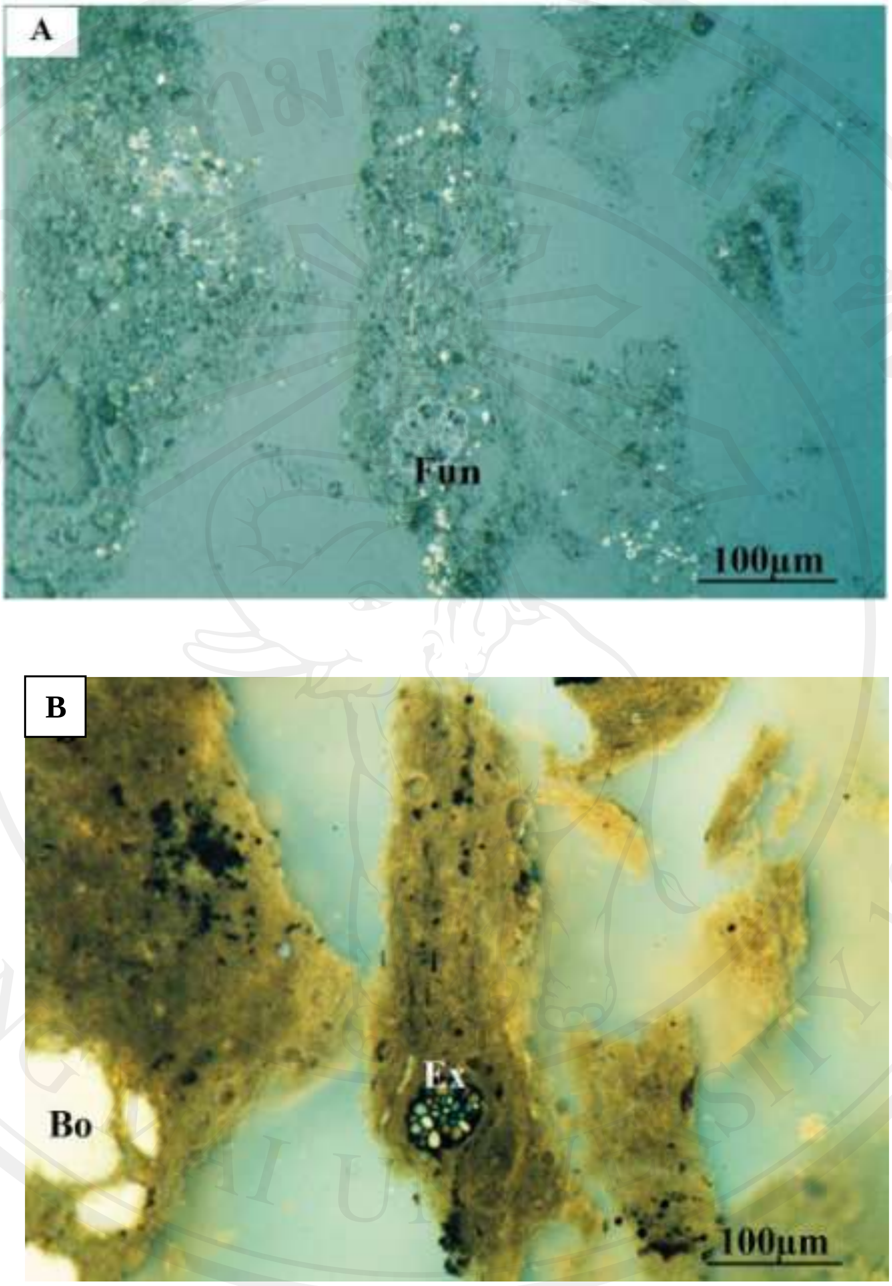

Figure 4.33 Photomicrographs of disc-shaped *Botryococcus*-type telalginite (B) in liptodetrinite groundmass and exsudatinite (Ex) filled in pore of funginite (Fun) of sample 14702 from Mae Sot basin in white light (A); in fluorescence-inducing blue light (B).

composed of laminated lamalginite, liptodetrinite, fluorescing amorphous organic matter, exsudatinite, telalginite, predominantly with morphology similar to theextant

Random reflectance data (% R_o) determined from two samples from Mae Sot samples are 0.35% and 0.37% R_o (Table 4.11).

4.4.5 P-SK well, Phitsanulok basin

The macerals of samples from the P-SK well are given in Table 4.12. The liptinite content ranges from 45.30 to 79.40 percent. The liptinitic material is principally composed of exsudatinite, fluorescing amorphous organic matter, liptodetrinite, laminated lamalginite, telalginite, predominantly with morphology similar to the extant algae *Botryococcus,* resinite, and sporinite (Figures 4.34, 4.35 4.36 and 4.37). The huminite content ranges from 4.9 to 9.4 percent (Figures 4.38, 4.39 and 4.40). The inertinite content is absent (Figure 4.41). The non-fluorescing mineral matter content ranges from 14.4 to 43.70 percent. Pyrite content is from 2.1 to 3.5 percent (Figure 4.42). In sample 14728, 14732 and 14737 show high proportion of exsudationite content (~ 30 %) and followed by fluorescing AOM and resinite. The lamalginite, telalginite and liptodetrinite are absent.

Other samples show high proportion of liptodetrinite, laminated and filamentous morphology lamalginite, fluorescing AOM and followed by telalginite. Resinite presents in some samples. The sporinite is only present in sample 14755. Cutinite is absent. Under fluorescence-inducing blue light, the exsudatinite displays pale yellow to yellowish orange color. The fluorescing AOM and liptodetrinite display yellowish brown color. The lamalginite displays yellowish orange color and telalginite displays yellow color in blue light. The resinite displays yellowish brown while sporinite displays yellow to yellowish orange color.

4.4.6 Suphanburi basin

SP1 well

Random reflectance data (% R_o) determined from ten samples from P-SK range from 0.40% and 0.66% R_o (Table 4.13).

Table 4.12: Organic composition and vitrinite reflectance of the samples from P-SK well, Phitsanulok basin.

Sample	Depth (m)	Liptinite								Lipt	Hum	Inert	Non-fl	Py	VR
		Telalg	Lamalg	Fl. AOM	Lipto	Sp	Cu	Ex	Re						(%R_o)
		Vol.%								Vol. %			Vol.%		
14728	1,250-1,300	0	0	14.2	0	0	0	30.2	0.9	45.3	9.4	0	43.2	2.1	0.4
14732	1,450-1,500	0	0	16.1	0	0	0	29.1	0.5	45.7	7.9	0	43.7	2.7	0.42
14737	1,700-1,750	0	0	18.2	0	0	0	29.7	0.1	48	8.2	0	40.3	3.5	0.47
14742	1,950-2,000	2.7	13.3	14.2	27.4	0	0	15.4	0	73	7.5	0	17.2	2.3	0.49
14745	2,100-2,150	2.5	18.3	13.5	30.4	0	0	11.2	0	75.9	6.4	0	15.6	2.1	0.52
14748	2,250-2,300	0.8	22.3	13.2	30.1	0	0	12.5	0.5	79.4	8.1	0	14.4	3.5	0.54
14755	2,600-2,650	2.1	19.4	14.3	28.1	0.2	0	9.4	0	73.5	7.8	1.1	15.3	2.9	0.57
14759	2,800-2,850	1.9	16.5	16.9	32.7	0	0	6.3	0	74.3	7.1	0	15.5	3.1	0.6
14761	2,900-2,950	0.6	18.2	15.7	33.1	0	0	3.7	0	71.3	6.3	0	19.2	3.2	0.62
14763	3,000-3,050	0.6	16.1	17.2	33.2	0	0	4.1	0	71.2	4.9	0	21.1	2.8	0.66

Telalg: telalginite; Lamalg: lamalginite; Fl. AOM: fluorescing amorphous organic matter; Lipto: liptodetrinite; Sp: sporinite; Cu: cutinite; Ex: exsudatinite; Re: resenite; Lipt: liptinite; Hum: huminite; Inert: inertinite; Non-fl: non-fluoresencing mineral matter; Py: pyrite; VR: vitrinite reflectance

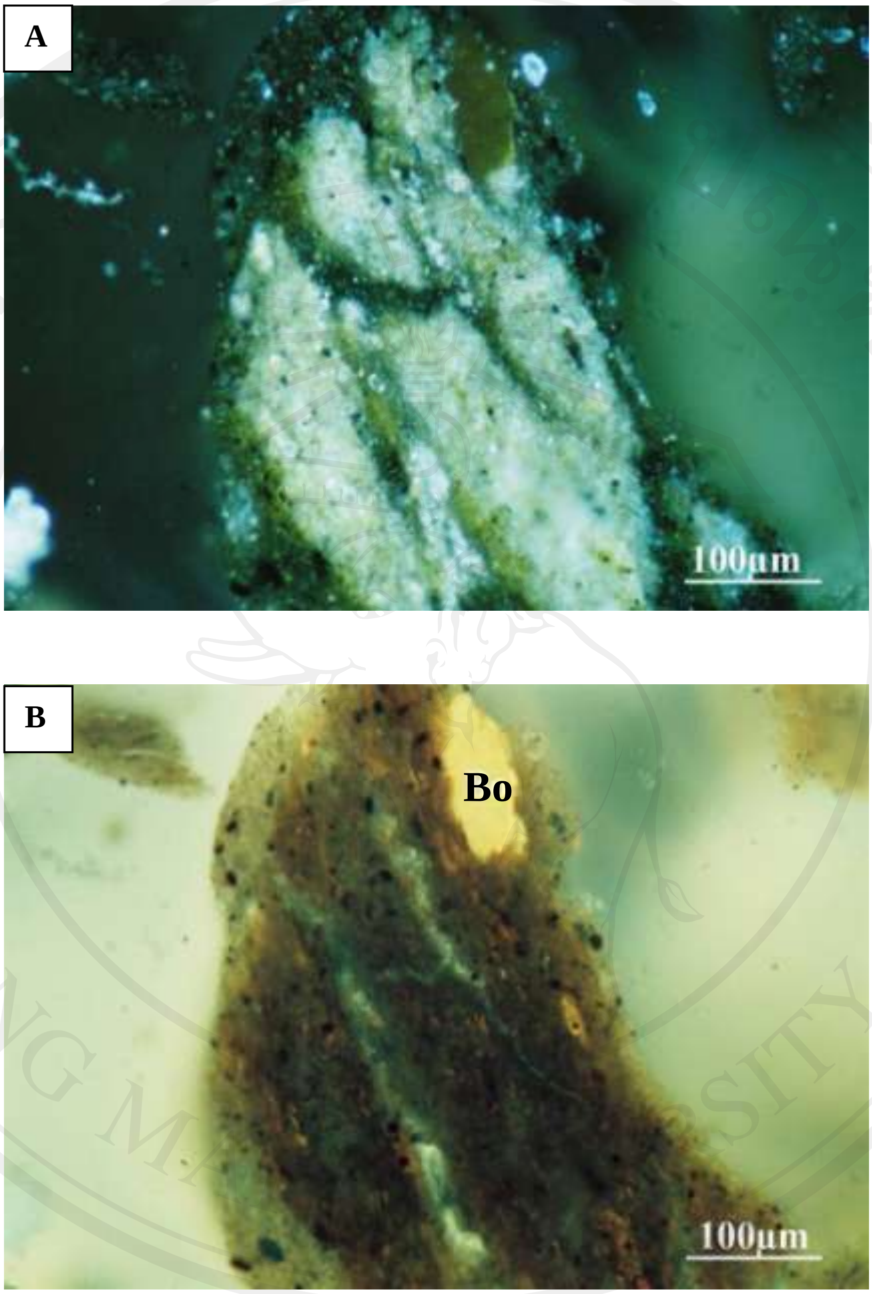

Figure 4.34 Photomicrographs of disc-shaped *Botryococcus*-type telalginite (Bo) in liptodetrinite and fluorescing amorphous organic matter groundmass of sample 14742 from P-SK well in cross polarize light (A); in fluorescence-inducing blue light (B).

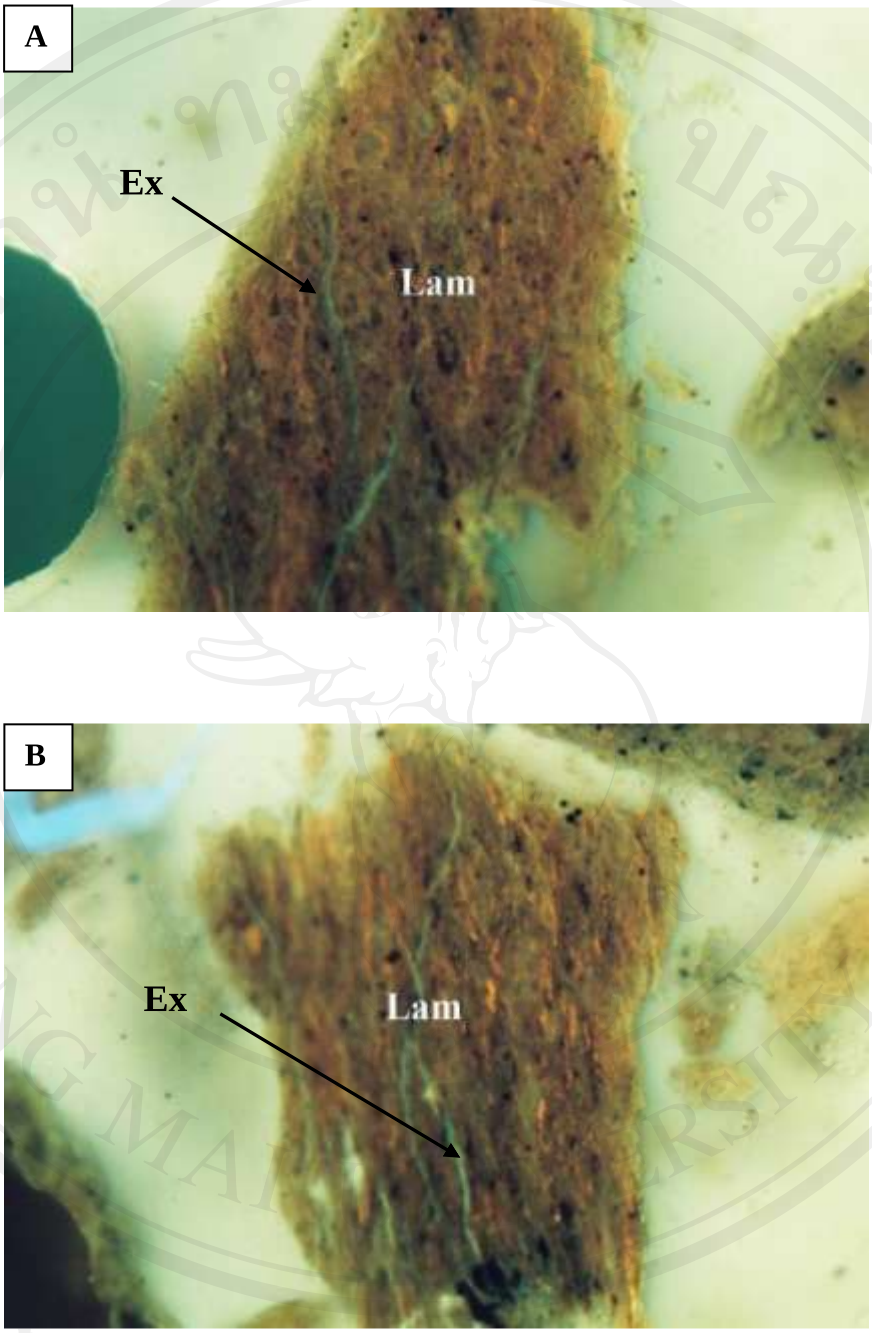

Figure 4.35 Photomicrographs of filamentous lamalginite (Lam) in liptodetrinite and fluorescing amorphous organic matter groundmass of sample 14745 from from P-SK well in fluorescence-inducing blue light (A and B). Greenish fluorescing lines are exsudationite (Ex) of low number carbon chain.

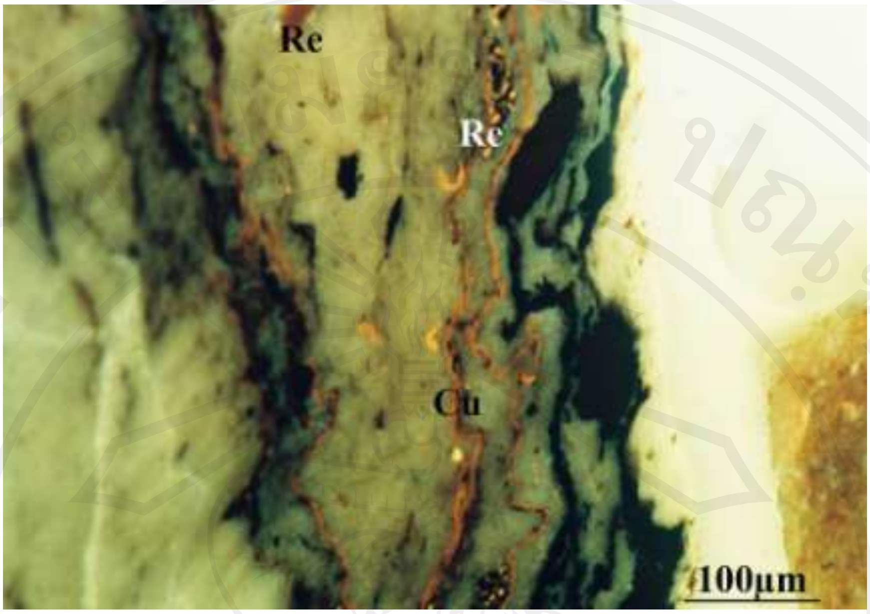

Figure 4.36 Photomicrograph of cutinite (Cu) and resinite (Re) in the groundmass of *Botryococcus* algae of sample 14755 from P-SK well in fluorescence-inducing blue light.

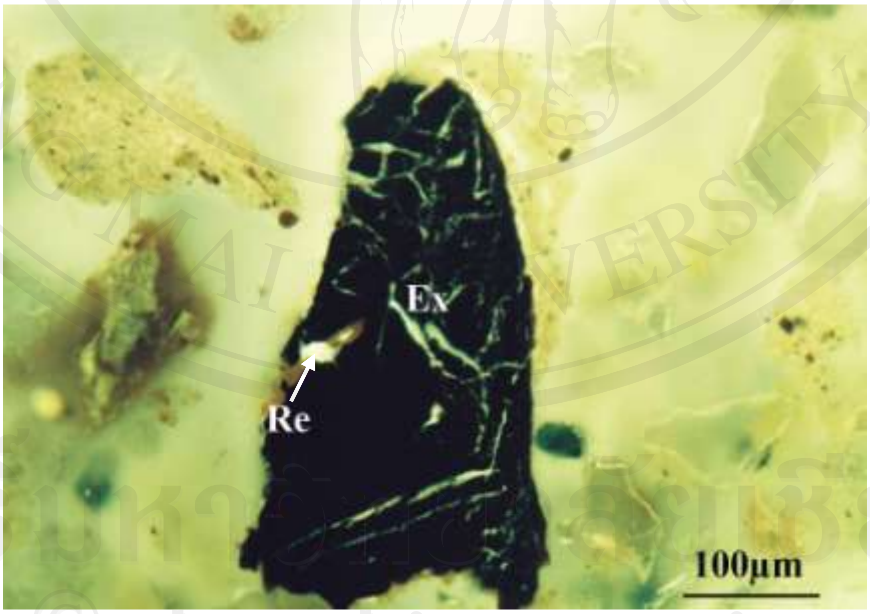

Figure 4.37 Photomicrograph of resinite (Re) and exsudatinite (Ex) expelled into cleats of huminite of sample 14737 from P-SK well in fluorescence-inducing blue light.

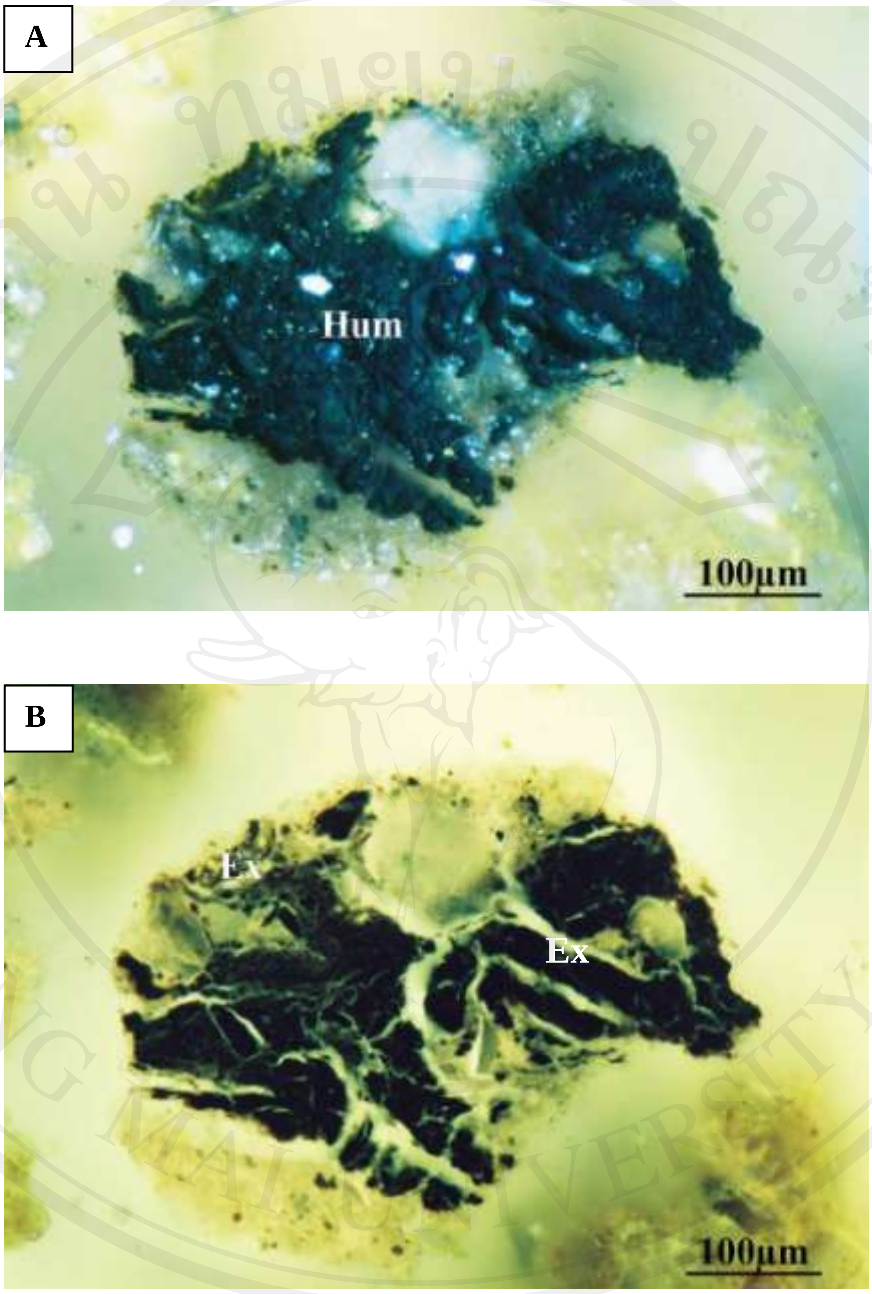

Figure 4.38 Photomicrographs of exsudatinite (Ex) intruded into cleats of huminite of sample 14728 from P-SK well in cross polarize light (A); in fluorescence-inducing blue light (B).

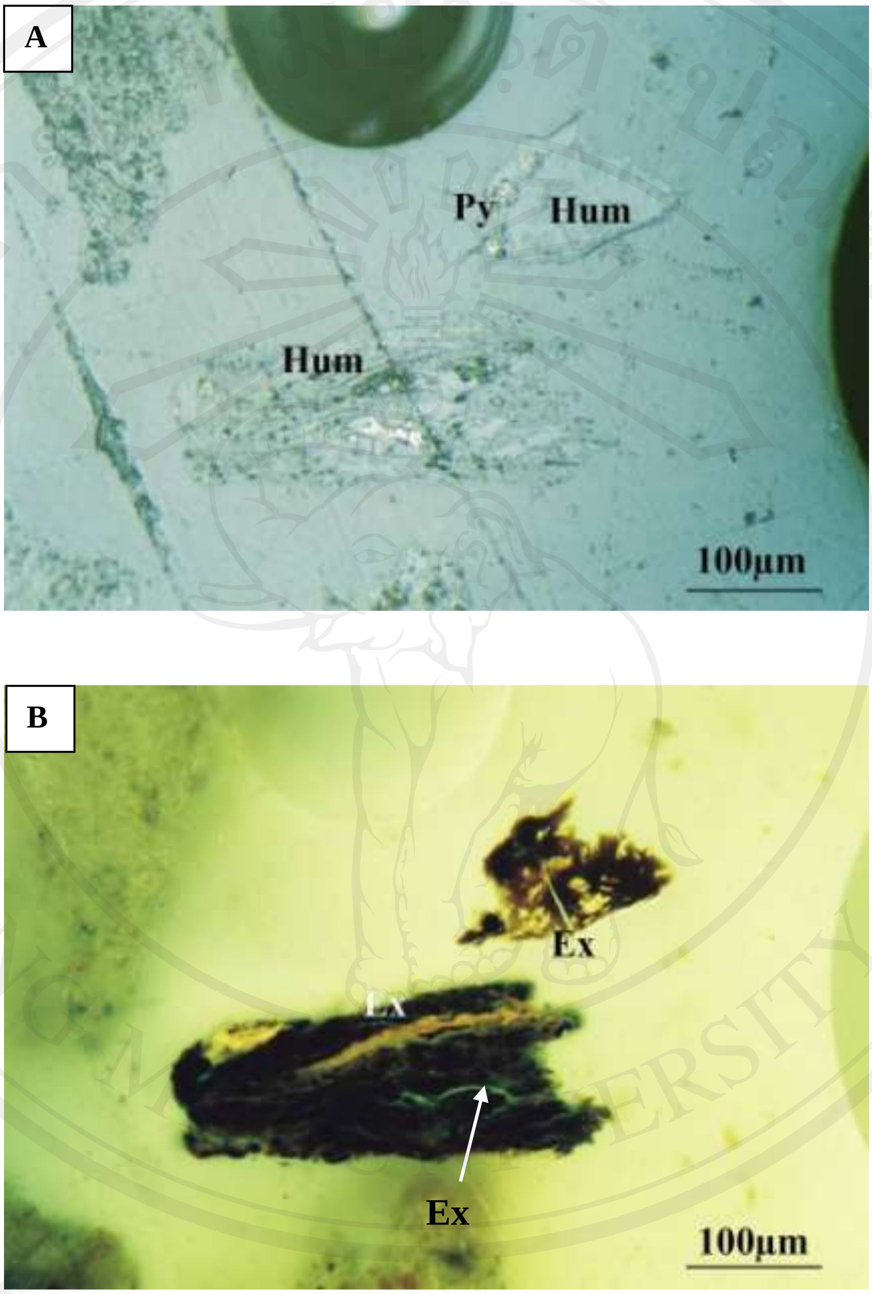

Figure 4.39 Photomicrographs of exsudatinite (Ex) intruded into cleats of huminite, and pyrite (Py) of sample 14748 from P-SK well in white light (A); in fluorescence-inducing blue light (B).

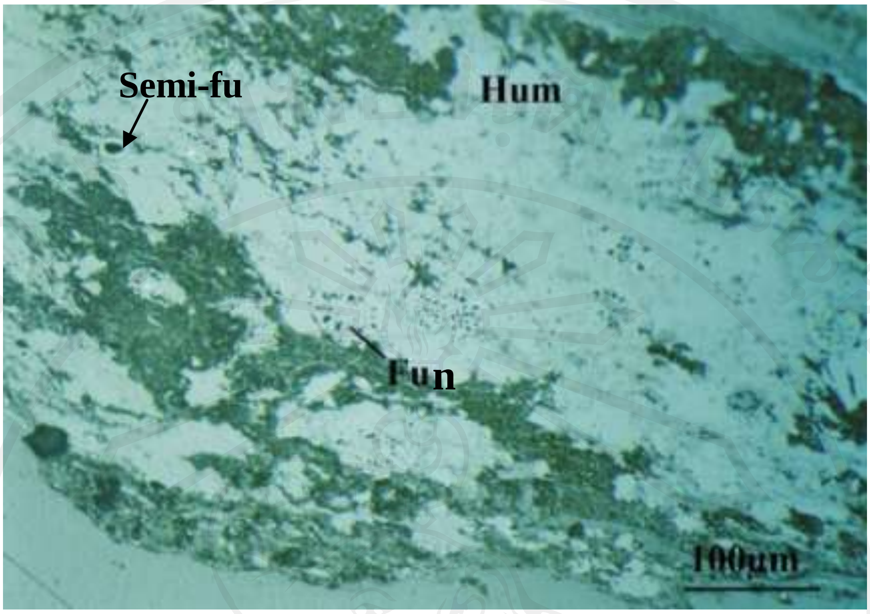

Figure 4.40 Photomicrograph of huminite (Hum), funginite (Fun) and semifusinite (Semi-fu) in groundmass of Liptodetrinite sample 14755 from P-SK well in white light.

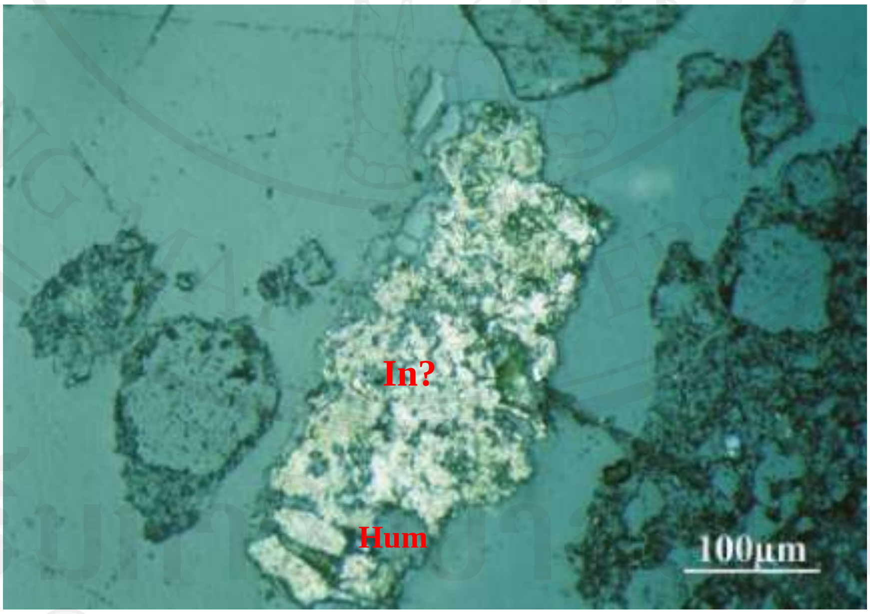

Figure 4.41 Photomicrograph of inertinite? (In?) and huminite (Hum) of sample 14737 from P-SK well in white light.

Table 4.13: Organic composition and vitrinite reflectance of the samples from SP1 well, Suphanburi basin.

Sample	Depth (m)	Liptinite								Lipt	Hum	Inert	Non-fl	Py	VR ($\%R_o$)
		Telalg	Lamalg	Fl. AOM	Lipto	Sp	Cu	Ex	Re						
		Vol.%								Vol. %			Vol.%		
11725	1,440-1,450	11.4	28.3	6.6	12.4	0	0	7.1	4.2	70	10.8	0.9	15.4	2.9	0.59
11726	1,455-1,465	10.2	30.3	6.5	12.2	0	0	6.2	4.6	70	11.4	0.8	15.1	2.7	0.61
11731	1,530-1,545	9.7	36.8	6.7	12.5	0	0	5.3	2.3	73.3	9.7	0	14.7	2.3	0.65
11743	1,710-1,725	10.6	35.7	6.3	12.6	0.4	0	8.4	3.5	77.5	6.3	0	13.6	2.6	0.61
11746	1,755-1,770	7.1	33.6	9.2	14.9	1.1	0	7.2	2.5	75.6	7.1	0	15.1	2.2	0.75
11753	1,945-1,960	5.3	33.7	11.3	18.7	1.3	0	6.9	1.2	78.4	6.9	0	12.2	2.5	-
11754	1,960-1,975	4.1	33.6	14.7	19.3	0	0	7.3	2.6	81.6	7.5	0	8.1	2.8	0.76
11761	2,135-2,150	3.4	28	13.9	11.5	0	0	9.6	6.4	72.8	7.4	1.2	14.7	3.9	0.78
11763	2,165-2,180	2.3	22.7	11.4	15.4	0	0	10.9	8.2	70.9	10.9	0.7	15.3	2.2	0.77
11767	2,225-2,240	2.7	28.4	12.8	10.5	0	0	10.5	5.6	70.5	12.7	1.4	13.3	2.1	-
11770	2,480-2,485	4.9	29.4	13.6	8.4	0	0	9.8	4.7	70.8	12.3	0.7	13.5	2.7	0.92
11776	2,575-2,590	3.3	30.6	14.4	9.5	0	0	12.6	3.6	74	12.2	1.3	10.1	2.4	1.23
11781	2,655-2,670	2.6	28.4	9.7	14.1	0	0	11.5	2.3	68.6	14.8	0.6	13.8	2.2	-
11783	2,705-2,720	3.6	26.5	10.3	17.9	0.8	0	7.3	3.1	69.5	13.3	0.3	14.2	2.7	1.35

Telalg: telalginite; Lamalg: lamalginite; Fl. AOM: fluorescing amorphous organic matter; Lipto: liptodetrinite; Sp: sporinite; Cu: cutinite; Ex: exsudatinite; Re: resenite; Lipt: liptinite; Hum: huminite; Inert: inertinite; Non-fl: non-fluorescing mineral matter; Py: pyrite; VR: vitrinite reflectance, -: non measurement.

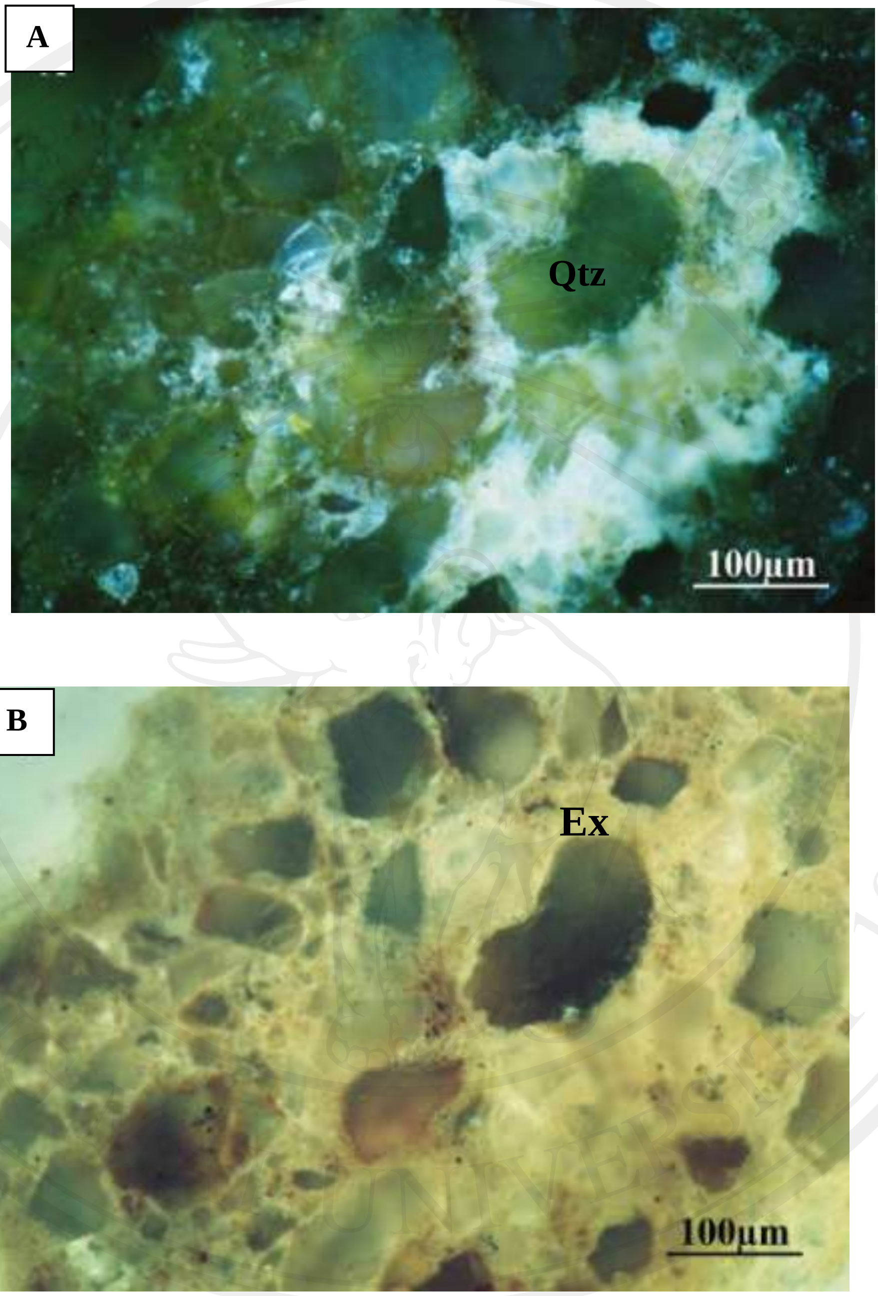

Figure 4.42 Photomicrographs of exsudatinite (Ex) surrounded of quartz grains (Qtz) of sample 14728 from P-SK well in cross polarize light (A); in fluorescence-inducing blue light (B).

The macerals of samples from the SP1 well are given in Table 4.13. The liptinite content ranges from 68.6 to 81.6 percent. The liptinitic material is principallyalgae *Botryococcus*, resinite and sporinie (Figures 4.43, 4.44 and 4.45). The huminite group is 6.3 to 14.8 percent (Figure 4.46). The inertinite content ranges from 0 to 1.4 persent. The non-fluorescing mineral matter content ranges from 8.1 to 15.4 percent (Figures 4.47 and 4.48). Pyrite content ranges from 2.1 to 3.9 percent (Figure 4.49).

In all samples, the fluorescence properties of liptrinite showed a range of yellowish orange to yellowish brown. The lamalginites show laminated and filamentous morphology. Telalginites generally show sheet-like and disc-shaped forms. Under fluorescence-inducing blue light, they display yellow to yellowish brown color. In groundmass of all samples, the fluorescing AOM are found associated with liptodetrinite and non fluorescing mineral matter. The fluorescing AOM displays orange to orange brown color. The liptodetrinites display dark yellow to yellowish brown colour. The sporinite generally displays yellow color and presents in some of the samples. The exsudatinite displays yellow to yellowish brown color and presents in all samples. The resinite displays yellowish orange color and presents in all samples.

Random reflectance data (% R_o) determined from eleven samples from SP1 range from 0.59% and 1.35% R_o (Table 4.13).

SP2 well

The macerals of samples from the SP2 well are given in Table 4.14. The liptinite content ranges from 59.6 to 81.3 percent. The liptinitic material is principally composed of laminated lamalginite, liptodetrinite, telalginite, predominantly with morphology similar to the extant algae *Botryococcus*, fluorescing amorphous organic matter, exsudatinite, resinite followed by sporinite and cutinite (Figures 4.50, 4.51, 4.52 and 4.53). The huminite ranges from 8.1 to 15.7 percent (Figure 4.54). The inertinite content is ranging from 0 to 5.2 percent. The non fluorescing mineral matter is from 6.3 to 16.8 percent. Pyrite content ranges from 2.1 to 4.1 percent.

In all samples, the fluorescence properties of liptinite showed a range of yellowish orange to yellowish brown. The lamalginites show laminated and filamentous morphology. Telalginite generally show sheet-like and disc-shaped forms.

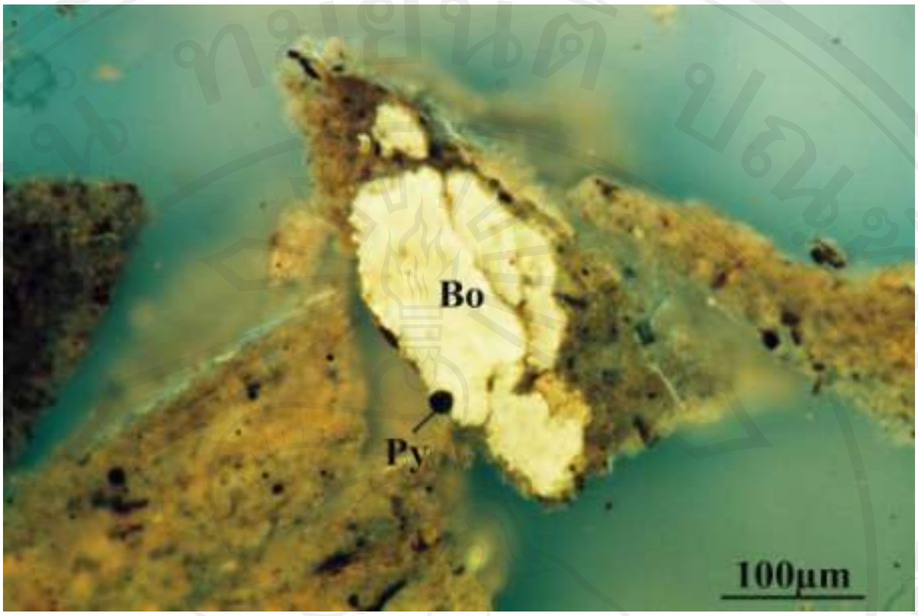

Figure 4.43 Photomicrograph of disc-shaped *Botryococcus*-type telalginite (Bo) and pyrite (Py) in liptodetrinite (Lip) and fluorescing amorphous organic matter groundmass of sample 11725 from SP1 well in fluorescence-inducing blue light.

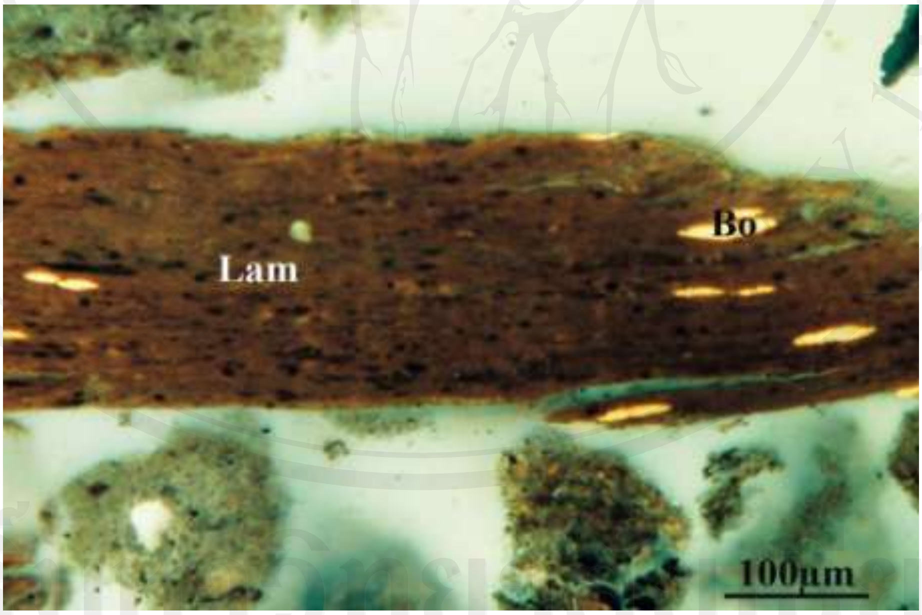

Figure 4.44 Photomicrograph of compacted lamalginite (Lam) and disc-shaped *Botryococcus*-type telalginite (Bo) in groundmass of fluorescing amorphous organic matter and liptodetrinite of sample 11753 from SP1 well in fluorescence-inducing blue light. The brown color of lamaginite indicated the partially expelled of hydrocarbon.

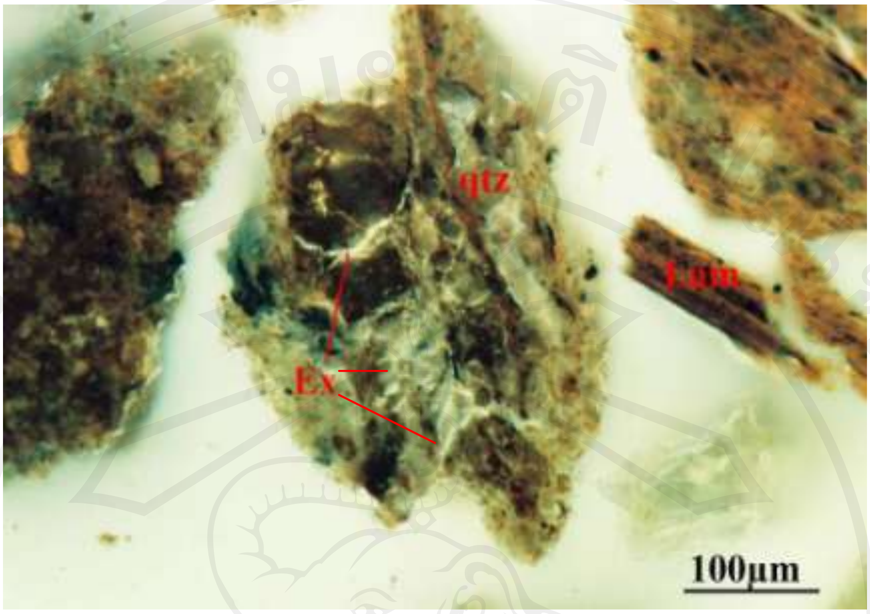

Figure 4.45 Photomicrograph of lamalginite (Lam) and exsudatinite (Ex) surrounded quartz grains (Qtz) of sample 11753 from SP1 well in fluorescence-inducing blue light.

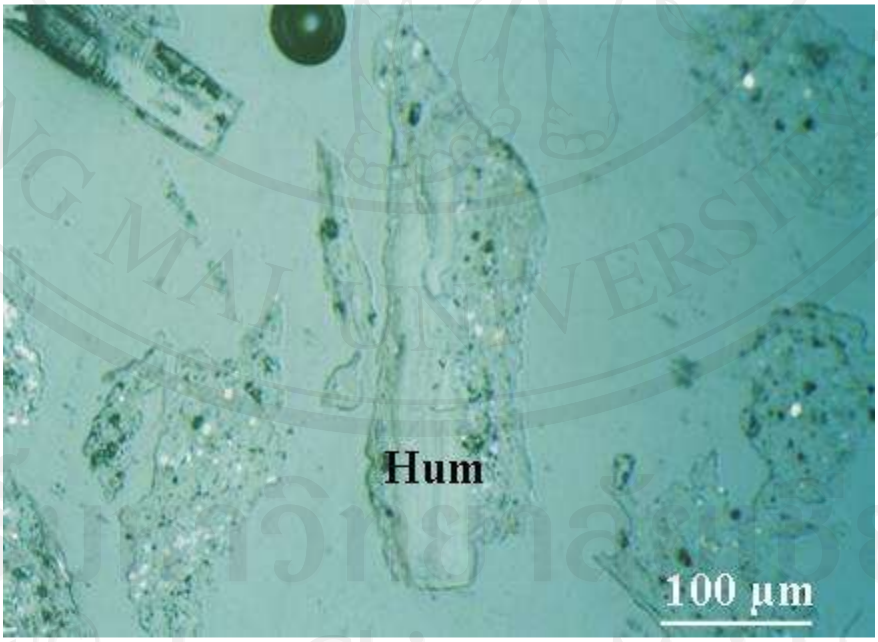

Figure 4.46 Photomicrographs of huminite (Hum) of sample 11726 from SP1 well in white light.

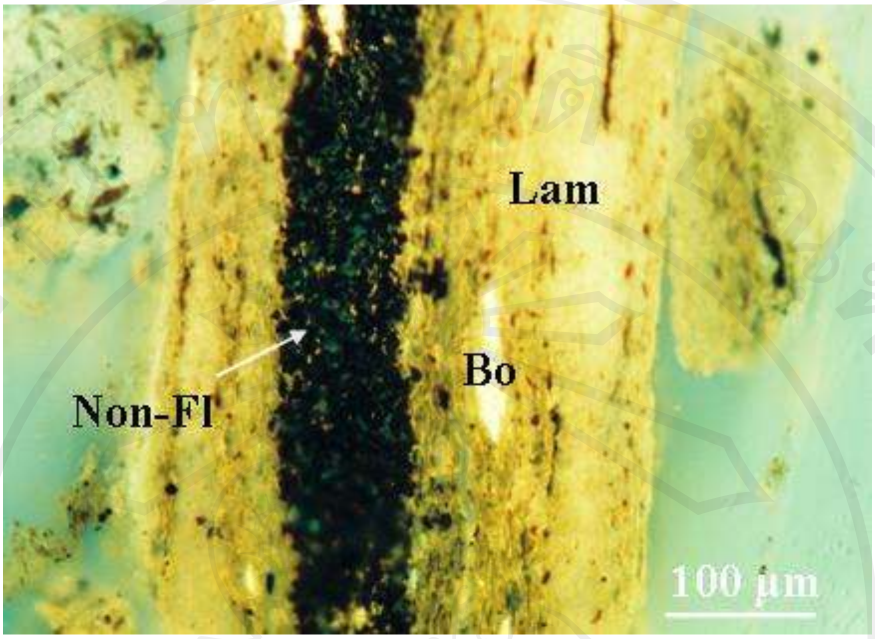

Figure 4.47 Photomicrographs of non-fluorescing mineral matter (Non-fl) and association of disc-shaped *Botryococcus*-type telalginite (Bo) and lamalginite (Lam) in groundmass of fluorescing amorphous organic matter and liptodetrinite of sample 11725 from SP1 well in fluorescence-inducing blue light.

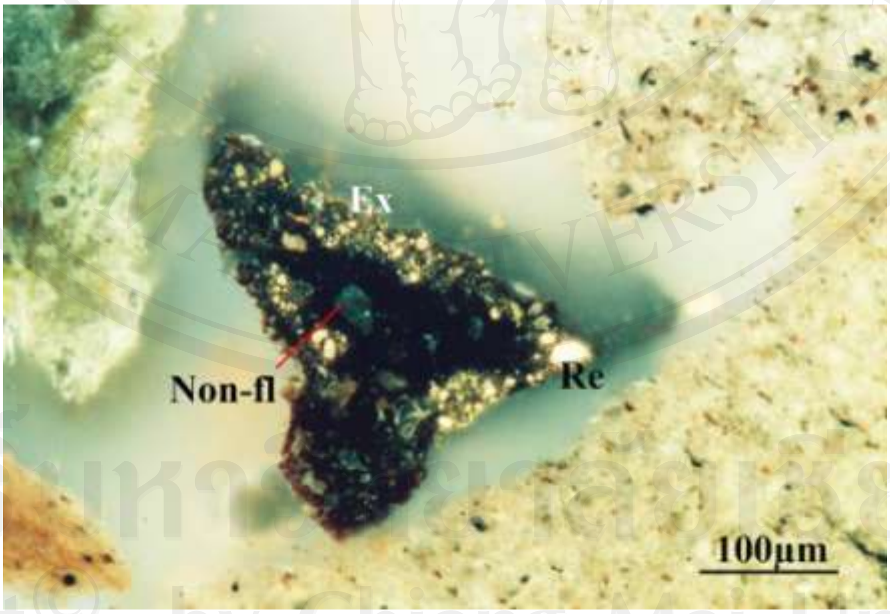

Figure 4.48 Photomicrograph of exsudatinite (Ex), resinite (Re) and non-fluorescing mineral matter (Non-fl) of sample 11743 from SP1 well in fluorescence-inducing blue light.

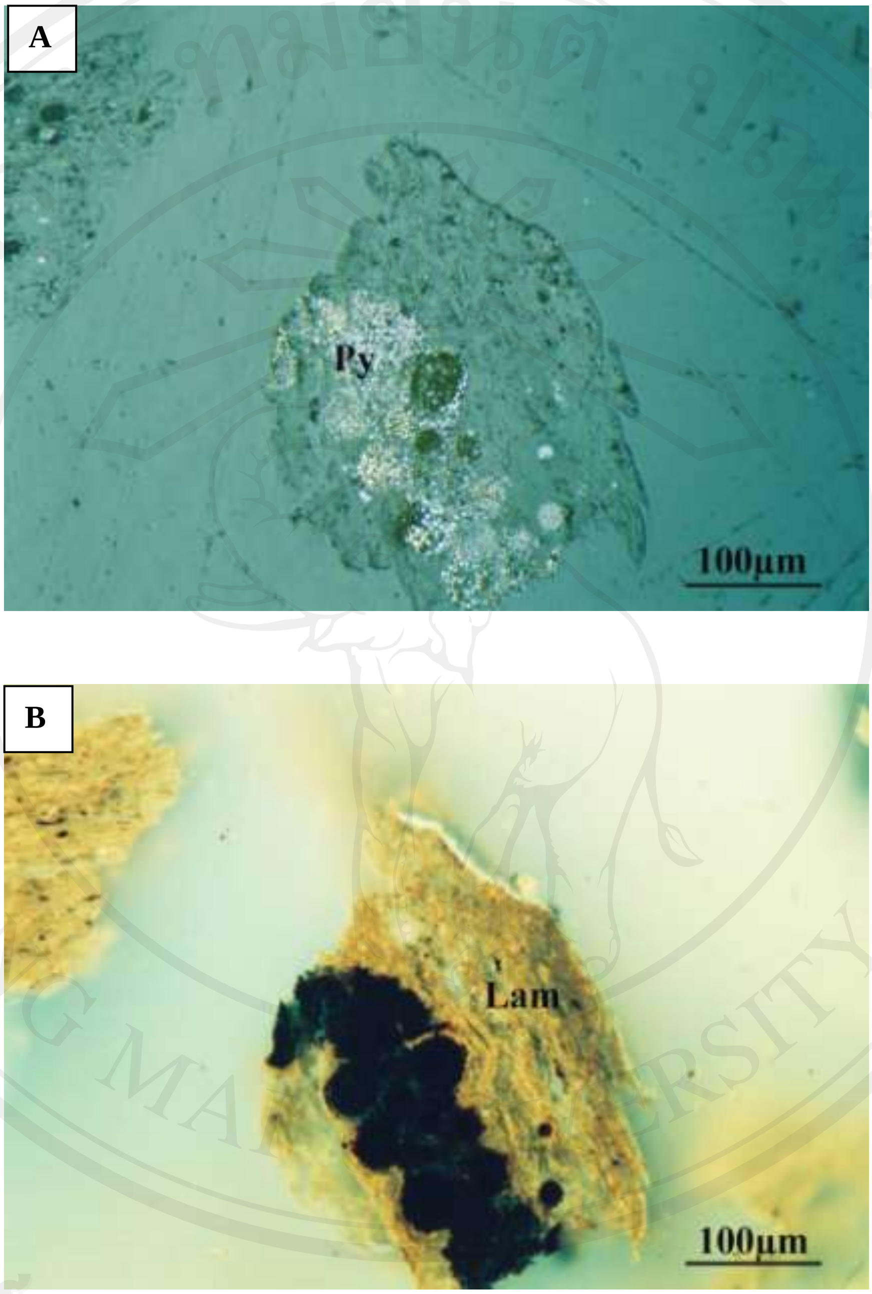

Figure 4.49 Photomicrographs of lamalginite (Lam) and framboidal pyrite (Py) of sample 11726 from SP1 well in white light (A); in fluorescence-inducing blue light (B).

Table 4.14: Organic composition and vitrinite reflectance of the samples from SP2 well, Suphanburi basin.

Sample	Depth (m)	Liptinite								Lipt	Hum	Inert	Non-fl	Py	VR
		Telalg	Lamalg	Fl. AOM	Lipto	Sp	Cu	Ex	Re						(%R_o)
		Vol.%								Vol. %			Vol.%		
11799	1,185.67-1,200.91	13.5	32.2	7.9	18.7	0.7	0	2.7	0.5	76.2	10.8	1.7	9.1	2.2	0.46
11800	1,200.91-1216.15	13.7	33.4	9.8	17.5	0	0	0	0	74.4	11.2	0	11.5	2.9	0.45
11802	1,237.49-1,249.68	12.5	34.5	9.8	19.3	1.3	0	3.9	0	81.3	9.4	0.8	6.3	2.2	0.48
11810	1,359.41-1,371.60	11.9	32.8	12.2	17.6	0	0	2.8	1.2	78.5	8.1	0.3	10.7	2.4	0.53
11817	1,466.09-1,478.28	10.3	34.6	10.1	16.3	0	0	3.7	0	75	9.1	1.4	11.7	2.8	0.54
11820	1,511.81-1,524.00	10.2	37.5	10.6	13.3	0	0	2.9	1.7	76.2	10.7	0.8	9.4	2.9	0.55
11823	1,557.53-1,569.72	11.4	37.6	4.6	12.4	4.2	0	1.1	3.6	74.9	9.1	0.6	10.2	4.2	0.55
11825	1,642.87-1,645.92	9.6	33.9	10.2	11.1	4.1	0.5	0.9	1.3	71.6	9.1	1.1	15.7	2.5	0.58
11829	1,697.74-1,703.83	10.6	30.9	11.4	7.3	2.3	0	0	5.1	67.6	11.9	2.4	15.5	2.6	0.62
11832	1,740.41-1,752.60	13.8	29.7	10.5	12.6	0	0	2.4	2.8	71.8	10.8	1.5	13.6	2.3	0.68
11835	1,819.66-1,828.80	12.6	27.1	10.1	11.8	2.3	0	3.8	3.3	71	11.8	2.8	10.3	4.1	0.66
11839	1,880.62-1,889.76	9.7	25.8	9.9	14.6	0.9	0	4.7	1.8	67.4	11.3	2.7	14.8	3.8	-
11840	1,908.05-1,917.19	8.4	25.3	7.1	10.2	0	0	8.6	0	59.6	15.7	5.2	16.8	2.7	0.72
11843	1,959.86-1,972.06	5.2	22.6	11.7	12.8	0	0	9.3	2.3	63.9	14.2	4.2	15.6	2.1	-

Telalg: telalginite; Lamalg: lamalginite; Fl. AOM: fluorescing amorphous organic matter; Lipto: liptodetrinite; Sp: sporinite; Cu: cutinite; Ex: exsudatinite; Re: resenite; Lipt: liptinite; Hum: huminite; Inert: inertinite; Non-fl: non-fluorescing mineral matter; Py: pyrite; VR: vitrinite reflectance, -: non measurement, -: non measurement.

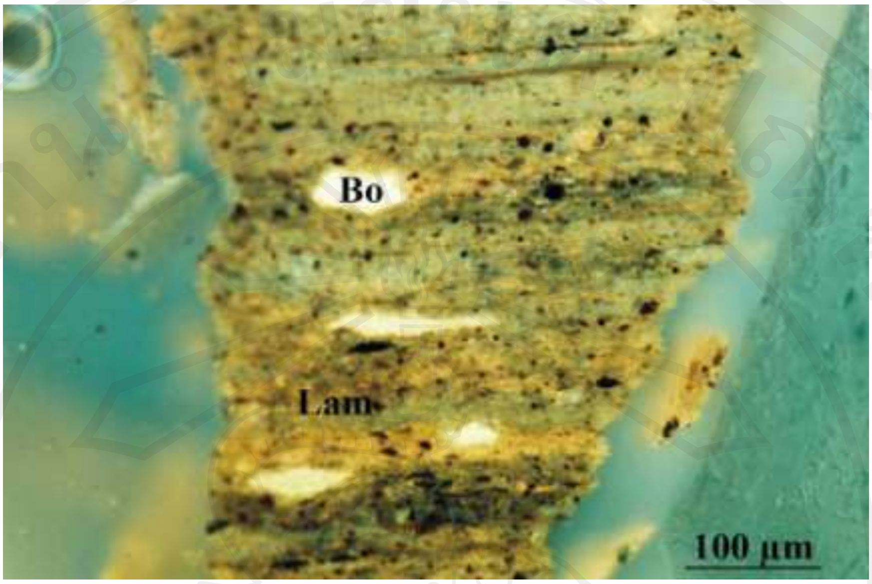

Figure 4.50 Photomicrograph of association of disc-shaped *Botryococcus*-type telalginite (B) and lamalginite (Lam) in groundmass of fluorescing amorphous organic matter and liptodetrinite of sample 11799 from SP2 well in fluorescence-inducing blue light.

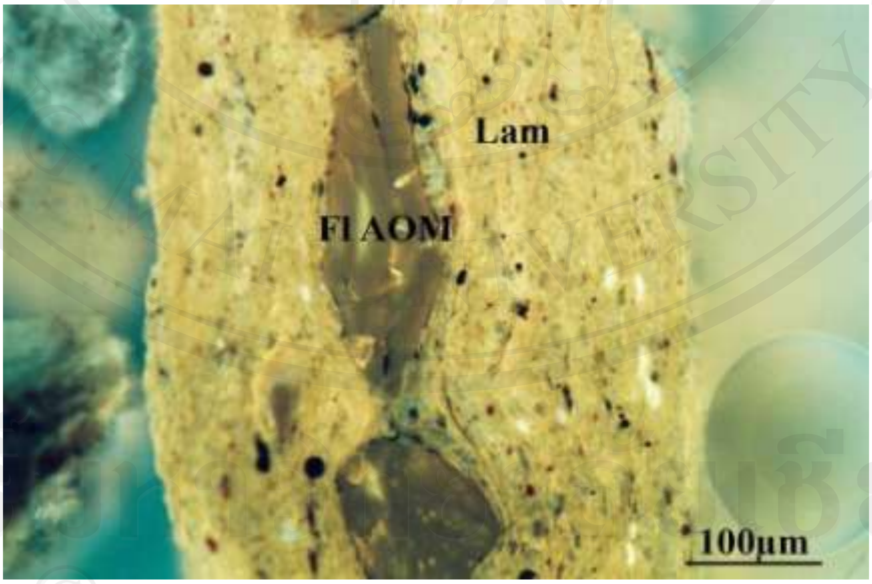

Figure 4.51 Photomicrograph of lamalginite (Lam) and fluorescing amorphous organic matter (Fl AOM) of sample 11802 from SP2 well in fluorescence-inducing blue light.

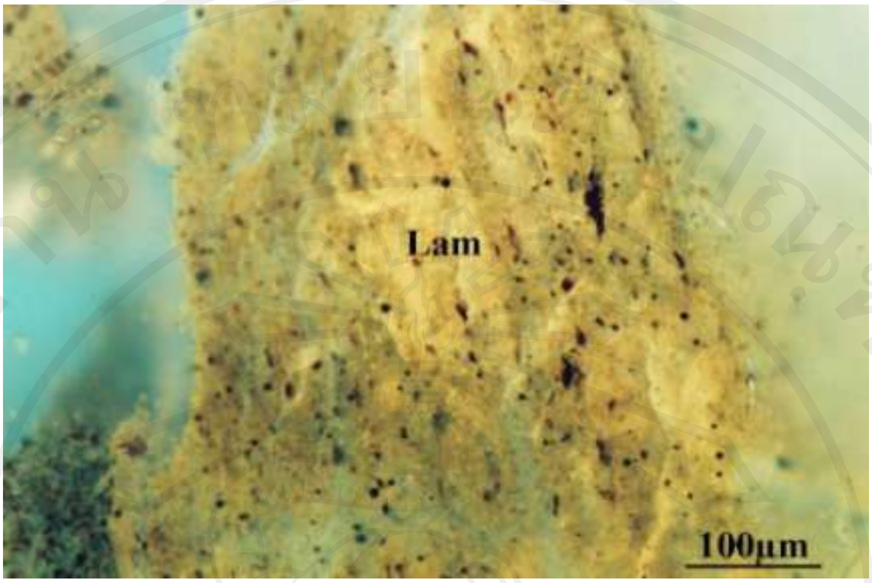

Figure 4.52 Photomicrograph of lamalginite (Lam) in groundmass of liptodetrinite and pyrite (black) of sample 11820 from SP2 well in fluorescence-inducing blue light.

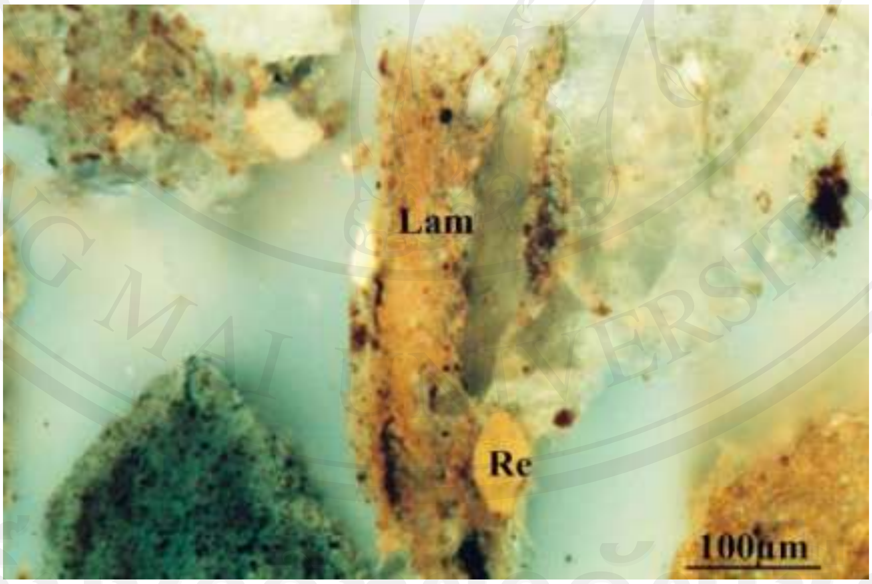

Figure 4.53 Photomicrograph of resinite (Re) and lamalginite (Lam) of sample 11829 from SP2 well in fluorescence-inducing blue light.

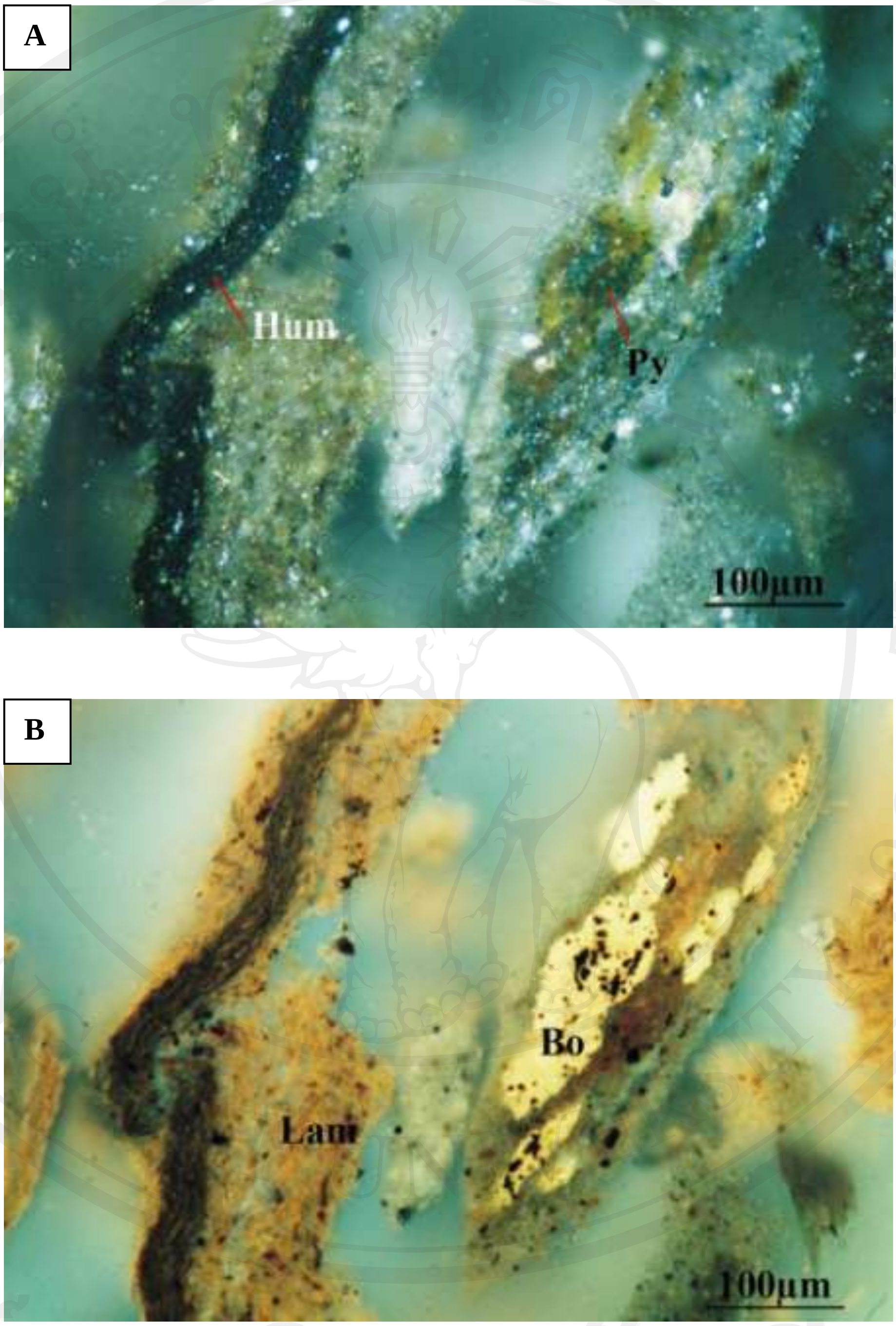

Figure 4.54 Photomicrographs of disc-shaped *Botryococcus*-type telalginite (B), lamalginite (Lam), huminite (Hum) and framboidal pyrite (Py) of sample 11825 from SP2 well in cross polarize light (A) and in fluorescence-inducing blue light (B).

Under fluorescence-inducing blue light, they display yellow to yellowish brown. In groundmass of all samples, the fluorescing AOM displays orange to orange brown color. The liptodetrinites display dark yellow to yellowish brown color. The exsudatintes display yellow to yellowish brown color and present in all samples. The resinite display yellowish orange colour and present in all samples. The sporinites generally display yellow color and present in some of samples.

Random reflectance data (% R_o) determined from twelve samples from SP2 range from 0.45% and 0.72% R_o (Table 4.14).