

CHAPTER 2

REGIONAL GEOLOGY

2.1 LOCATION AND EXTENT OF THE STUDY AREA

The study area located between latitude 8 : 52 : 21.7 and 9 : 8 : 15.3 and longitude 101 : 15 : 43.2 and 101 : 41 : 24.2 covers 10 fields approximately 1370 sq. km, both in the east and west flank of Pattani Basin. From north to south, in the east flank, are 1).Trat field, 2).Jakrawan field, 3).Funan field, 4).Gomin field, and in the west flank consist of 1).Kaphong field 2).Platong field, 3).Surat field, 4).Satun field, 5).Erawan field, and 6).Baanpot field (Figure 1.1).

The Pattani Basin is the most petroliferous basin in Thailand, accounting for more than 80% of present-day hydrocarbon production in the country and is the largest of a series of Tertiary-age north-south trending rift basin in the Gulf of Thailand. It is located in the central portion of the Gulf (Figure 2.1). The basin is bounded on the west by Ko Kra Ridge, the basement high feature. To the east, it is bounded by Narathiwat Ridge, and to the south by Narathiwat high, the major Cretaceous complex. To the southeast, it opens out into the northwestern Malay Basin. The basin contains up to 8,000 m of Tertiary sediments, which spectacularly thin eastwards to the Khmer Shelf and to less than 1,000 m westwards. The sediments consist of fluvial, marsh swamp, delta plain, and the occasional marine facies, with rapid facies variations. Until now, no sedimentary rocks older than the Late Oligocene has been encountered in drilled wells. However, pre-Late Oligocene rocks are expected to be present in the deeper parts of the basin. The pre-Tertiary basement in this area consists of a varied suite of sedimentary rocks,

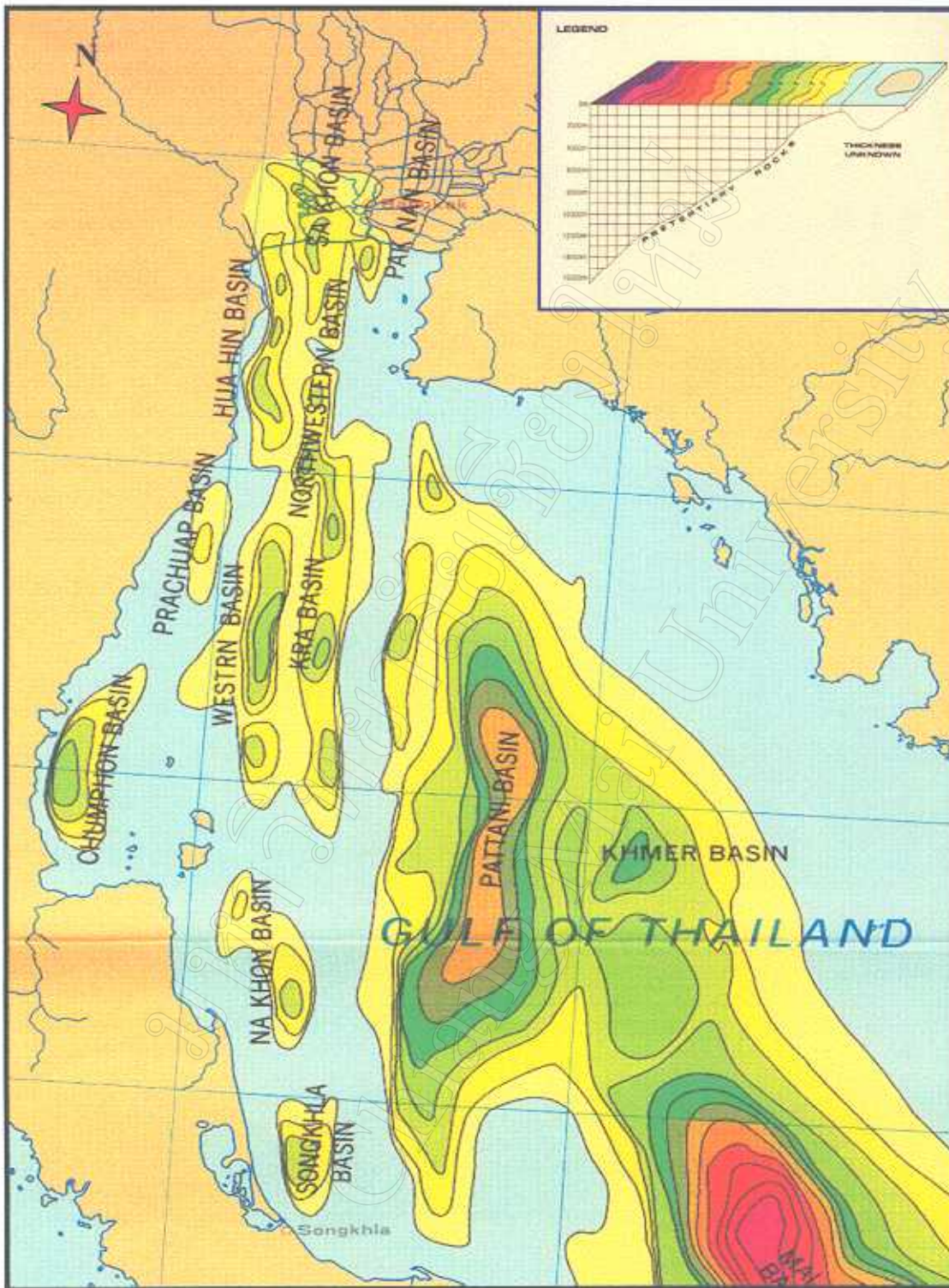


Figure 2.1 : Isopach map of Tertiary basins in the Gulf of Thailand showing location of the Pattani and other major basins (after CCOP's working group on resource assessment (WGRA), 1991).

meta-sedimentary rocks, and intrusion as well as extrusive igneous rocks. This area was chosen for study in order to strengthen our knowledge of paleoenvironment, deposition and sedimentation of hydrocarbon origin that become important hydrocarbon sequences.

2.2 TYPE OF SAMPLES AND DATA SOURCE

The data and cutting samples used in this study were provided by UNOCAL (THAILAND). The cutting samples comprise claystone, sandstone, shale and coal from 10 wells of 10 petroleum fields including 1).Trat field, 2).Jakrawan field, 3).Funan field, 4).Gomin field in the east flank and 1).Kaphong field 2).Platong field, 3).Surat field, 4).Satun field, 5).Erawan field, and 6).Baanpot field in the west flank (Figure 1.1). The data include wireline logs and general geological information. List of well's name and its detail are shown in Table 2.1(Figure 2.2).

2.3 DEVELOPMENT OF PATTANI BASIN

Packham (1993) summarized sequence of events associated with the development of basins in Thailand as follows :

- 1) Early Oligocene (or possibly older) : commencement of rifting and basin formation induced by dextral shear,
- 2) Early Oligocene to Middle Miocene : relative tectonic quiescence but with continued extension, progressive expansion of deposition outwards from the initial rifting sites,
- 3) Late Middle Miocene : possibly increase in dextral shear with local basin inversion and erosion, concurrent with sea level fall,

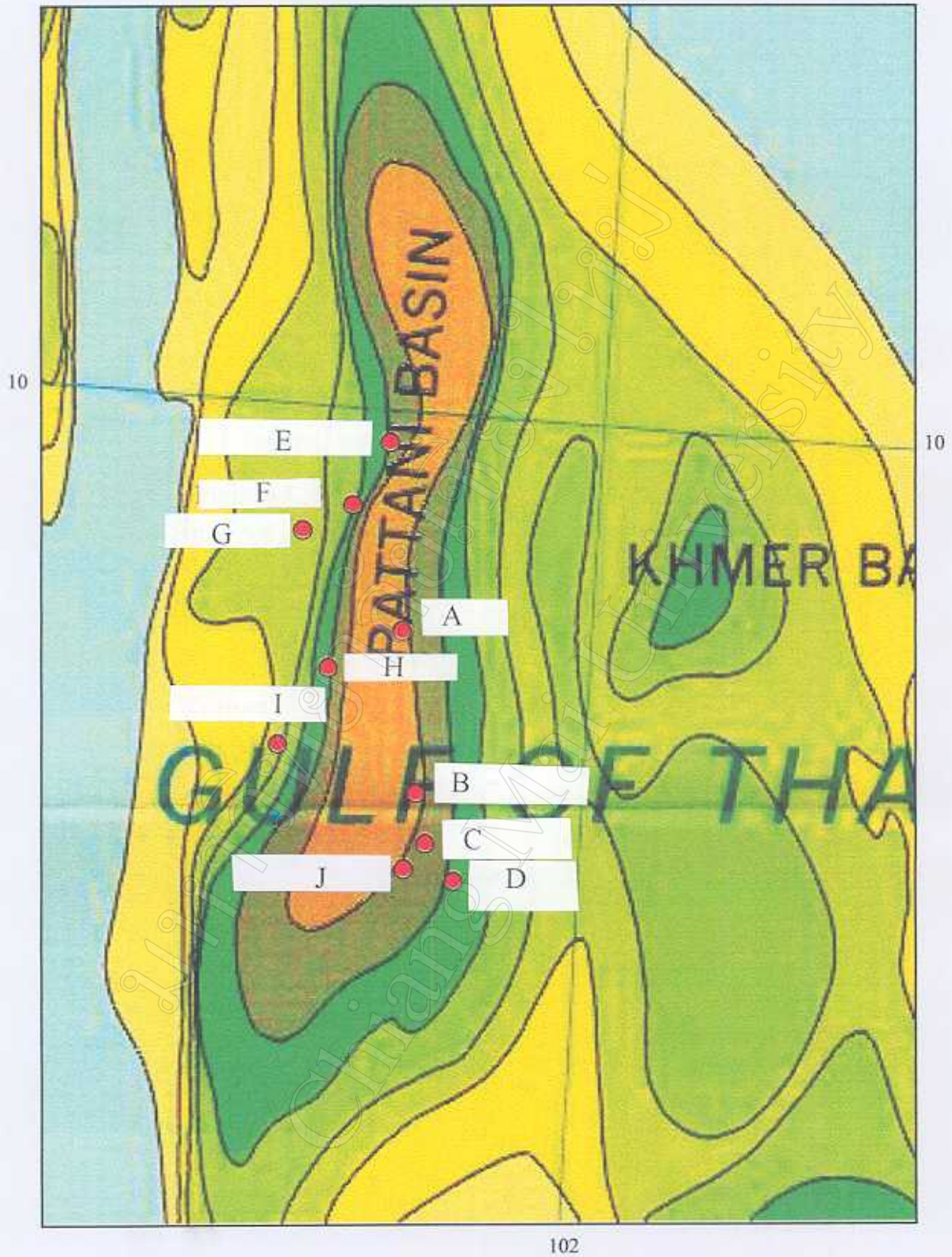


Figure 2.2 : Study area and location of wells used in this study.

Table 2.1 List of well's name, position grid, total cutting depth and wireline log depth.

Well's name	Position Surface Grid	Total Cutting Depth (ft)	Wireline Log Depth (ft)
East flank			
1. A	775916 E 1045989 N	3000' -11917'	-4260 - -9331
2. B	782348 E 1003480 N	4100' -13572'	-4199 - -8886
3. C	789089 E 987294 N	3000' -12872'	-3901 - -8694
4. D	795843 E 981772 N	3000' -10663'	-3908 - -9008
West flank			
1. E	768055 E 1087518 N	3000' -11740'	-3190--10014
2. F	761116 E 1071522 N	3000' -10470'	-3163 - -8595
3. G	753775 E 1070424 N	4000' -10891'	-3267 - -7790
4. H	759236 E 1038066 N	4100' -11931'	-4006 - -9061
5. I	748559 E 1010763 N	3135' -12289'	-3425 - -7666
6. J	761112 E 984051 N	1090' -10393'	-4098 - -9530

- 4) Late Middle Miocene : inception of Burma plate and switching off of regional lithospheric strain except near active strike-slip faults,
- 5) Late Miocene to Quaternary : decrease in tectonism, lithospheric cooling, and marine transgression in the Gulf of Thailand.

Jardine (1997) subdivided the structural evolution of the Pattani Basin into 7 main stages as follows :

- 1) Pre-rift folding and uplift of Pre-Tertiary accreted basement terranes from the Cretaceous to the Eocene,
- 2) initial uplift and creation of localized sub-basin (half-graben) from Late Eocene to Late Oligocene time,
- 3) structural inversion and erosion at the end of the Oligocene,
- 4) rifting and basin formation in the Lower Miocene,
- 5) post-rift collapse and basin subsidence in the Middle Miocene,
- 6) widespread erosion in the latest Middle to Early Middle Miocene,
- 7) continued basin subsidence from the Upper Miocene to the present.

2.4 STRATIGRAPHY AND SEDIMENTATION IN PATTANI BASIN

Stratigraphy and sedimentation of the Pattani Basin have been reported by many workers follows :

Woollands and Haw (1976) divided the Tertiary succession in the Gulf of Thailand into three cycles of sedimentation which are particularly well developed in the main basinal areas of the Pattani and Malay Basins

as follows Cycle 1 : Oligocene to Early Miocene, representing a regressive from paralic coal measures and deltaic continental redbed, Cycle 2 : from Early Miocene to Late Middle Miocene, Cycle 3 : from Late Middle Miocene transgressing through to recent.

Lian and Bradley (1986) have divided the Tertiary sediment in the Pattani Basin into 4 stratigraphic units (Figure 2.3);

Unit I : Late Oligocene to Early Miocene, 5,000 m thick, composed of shales and sandstones in brown – gray color. Sandstones show fine to coarse grained, fining upward and channel characteristics.

Unit II : Early Miocene to Middle Mid-Miocene, 800 m thick, composed of organic rich gray shales and brown-gray sandstones with very fine to medium grained, average thickness 4.5 m, significant lateral extent.

Unit III : Middle Miocene to Late Mid-Miocene, 1,200 m thick, composed of shales, claystones and sandstones. Shales and claystones show varicolored or redbrown, silty or sandy. Sandstones display varicolored or brown, fine to coarse grained, average thickness 5 m, significant restricted lateral extent.

Unit IV : Late Miocene to Recent, 1,700 m thick, composed of gray clays/shales, and gray silty sand (stone) which display fine to very coarse grained, channel characteristics.

Praditjan and others (1990) used the unconformity to suggest two stratigraphic groups for the Tertiary sequence; post-rift and syn-rift sequences. The syn-rift sequence was formed during Late Oligocene to Late middle Miocene and bounded by 2 major unconformities. Internally,

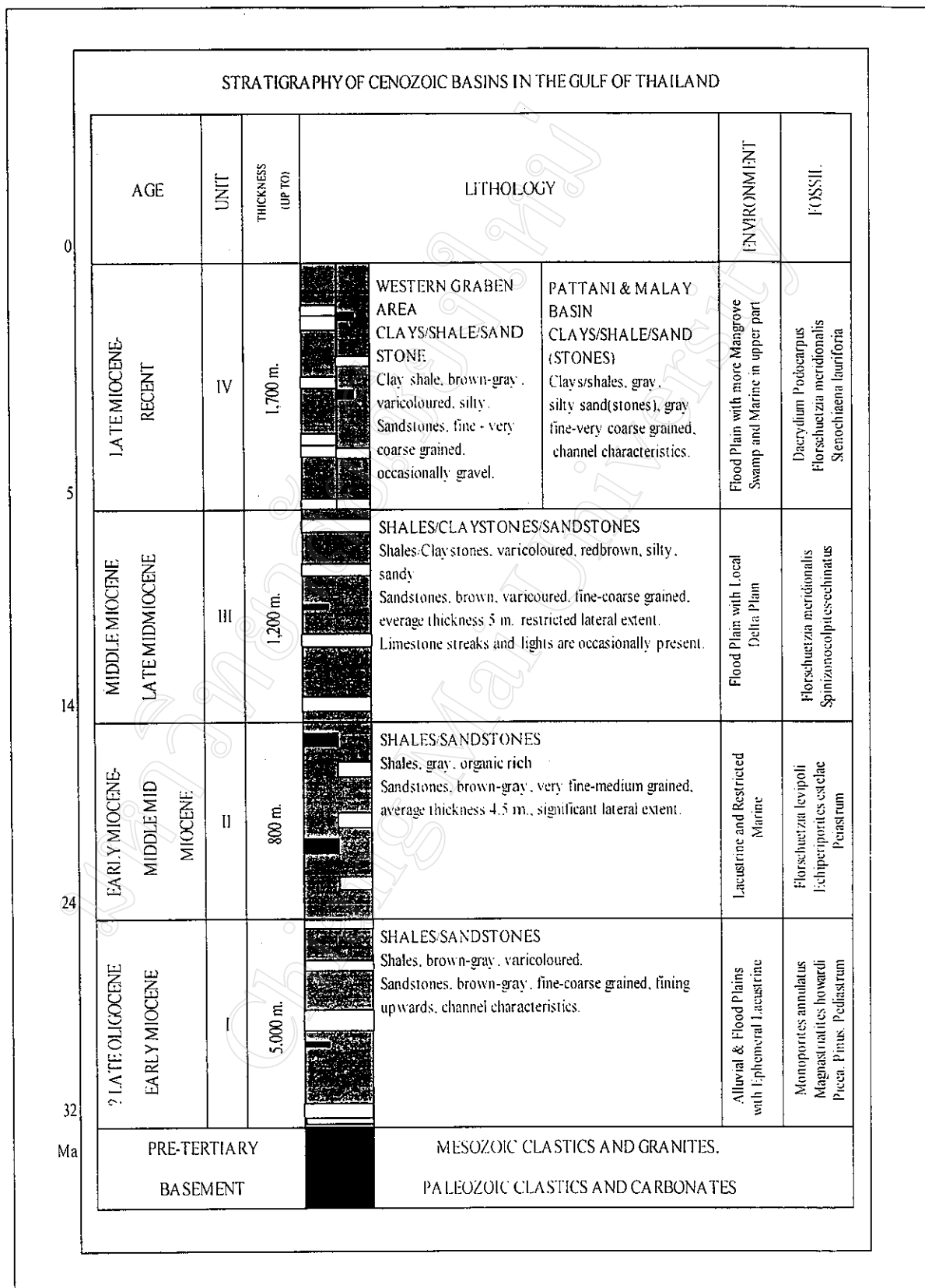


Figure 2.3 : Gulf of Thailand stratigraphic sequence (after Lian and Bradley, 1986).

the syn-rift sequence can be subdivided into 3 units; lower, middle, and upper units. The syn-rift sequence consists primarily of flood plain, fluvial, fluvio-lacustrine and lacustrine sediment. The upper unit, the post-rift sequence unconformably overlies the syn-rift sequence, and contains up to 1,700 m thick of sediments, during Late Miocene to Quaternary. This sequence consists of high-energy, fluvial coarse sand with some interbedded varicolored organic-rich clay and thin coal bed but immature.

Bustin and Chonchawalit (1997) have subdivided Tertiary strata in the Pattani Basin based on lithology and palynomorph assemblages into six informal stratigraphic units (Table 2.2 and 2.3). The stratigraphy and sedimentology of strata started from syn-rift sediments (Unit 6 and 5) and a shallow-marine to non-marine regressive succession (Unit 4). The post-rift sediments comprise a shallow-marine to non-marine, regressive sequence (Unit 3) and two non-marine to shallow-marine, transgressive successions (Unit 2 and 1).

Lockhart and others (1997) studied Early Tertiary deposition in the southern Pattani Trough by using Mayura-1 exploration well data as a reference suggested that stratigraphic intervals within the Pattani Trough include five major sequence divisions. Jardine (1997) identified 5 major sequence packages of Tertiary sediment in the Pattani Basin relation to the evolution of the deposition environment as follows :

Sequence 1 : began with initial localized lacustrine and alluvial deposition in the Oligocene,

Table 2.2 : Stratigraphy and depositional environments of Tertiary synrift strata, Pattani Basin (after Bustin and Chonchawalit, 1997).

Unit	Subunit	Depositional Environment	Sedimentary Sequence	lithology	Relative Sea-Level	
					+	-
4	Upper	Upper delta plain and flood plain	Generally fine grained with fining-upward sequences	Claystone and sandstone		↘
4	Middle	Distributary mouth bar and beach ridge complex	Coarsening-upward sequences	White sandstone and minor claystone		
4	Lower	Prodelta and shallow marine	Generally fine grained	Brownish claystone with coal partings		↘
5	Upper	Nonmarine meandering channel	Fining-upward sequences	Brownish sandstone		
5	Lower	Meandering channels and flood plain	Generally fine grained with fining-upward sequences	Red claystone and sandstone		
6	Upper	Flood plain and channel	Fining-upward sequences and fine grained	Sandstone and grayish brown claystone		↘
6	Lower	Alluvial fan and braided stream	Coarse grained and poorly sorted	Conglomerate and coarse grained		

Table 2.3 : Stratigraphy and depositional environments of Tertiary postrift strata, Pattani Basin (after Bustin and Chonchawalit, 1997).

Unit	Subunit	Depositional Environment	Sedimentary Sequence	lithology	Relative Sea-Level	
					+	-
1	Upper	Shallow marine	Fine grained	Not available		↖
1	Middle	Interdistributary bay or crevasse splay	Generally fine grained	Dark gray claystone		
1	Lower	Distributary channel in a coastal plain	Fining-upward sequences	Reddish brown claystone and sandstone		↘
2	Upper	Brackish swamp and marginal marine	Generally fine grained with some fining-upward sequences	Brownish gray claystone and sandstone		↖
2	Lower	Distributary channels and flood plain	Fining-upward sequences and fine grained	Sandstone and claystone		↘
3	Upper	Nonmarine meandering channel	Fining-upward sequences and fine grained	Sandstone and minor claystone		
3	Middle	Distributary mouth bar and beach ridge complex	Coarsening-upward sequences	Sandstone and claystone		
3	Lower	Prodelta and shallow marine	Generally fine grained	Claystone and minor sandstone		

Sequence 2 : changing to mostly fluvial and alluvial deposition in the lower Miocene,

Sequence 3 : transgressive fluvial and marginal marine deposition in the Lower Middle Miocene,

Sequence 4 : overall regressive fluvial and alluvial deposition in the Upper Middle Miocene,

Sequence 5 : predominantly transgressive marginal marine deposition in the Late Miocene (Figure 2.4).

2.5 ORGANIC CHARACTERISTIC IN PATTANI BASIN

Bustin and Chonchawalit (1997) suggest that the dispersed organic matter in the Pattani Basin is mainly detrital and continental origin, as is evident from the predominance of type III and minor type II kerogen and the present of vitrinite and liptinite derived from vascular plants. The detrital organic matter was supplied by river systems. Autochthonous and hypautochthonous origins are also evident from interbedded coals and carbonaceous partings in many stratigraphic units.

Jardine (1997) suggested that there are dual petroleum systems in the Pattani Basin. First is gas and condensate, the majority of the hydrocarbon reserves in the Pattani basin, from the correlation of hydrocarbon and source rock chemistries strongly suggest that coals and coally shales in sequence 2, 3, and 4 are the primary source of gas and condensate in the region. Optical and chemical kerogen of well cuttings and core samples show that the remains of terrestrial vascular plant material (Type III kerogen) is the dominant organic matter type making up the coals and coally shales. The organic matter is hydrogen poor but vitrinite rich, and is prone to gas/condensate generation. Sequence 5

GULF OF THAILAND
 PATTANI TROUGH
 STRATIGRAPHIC SUMMARY

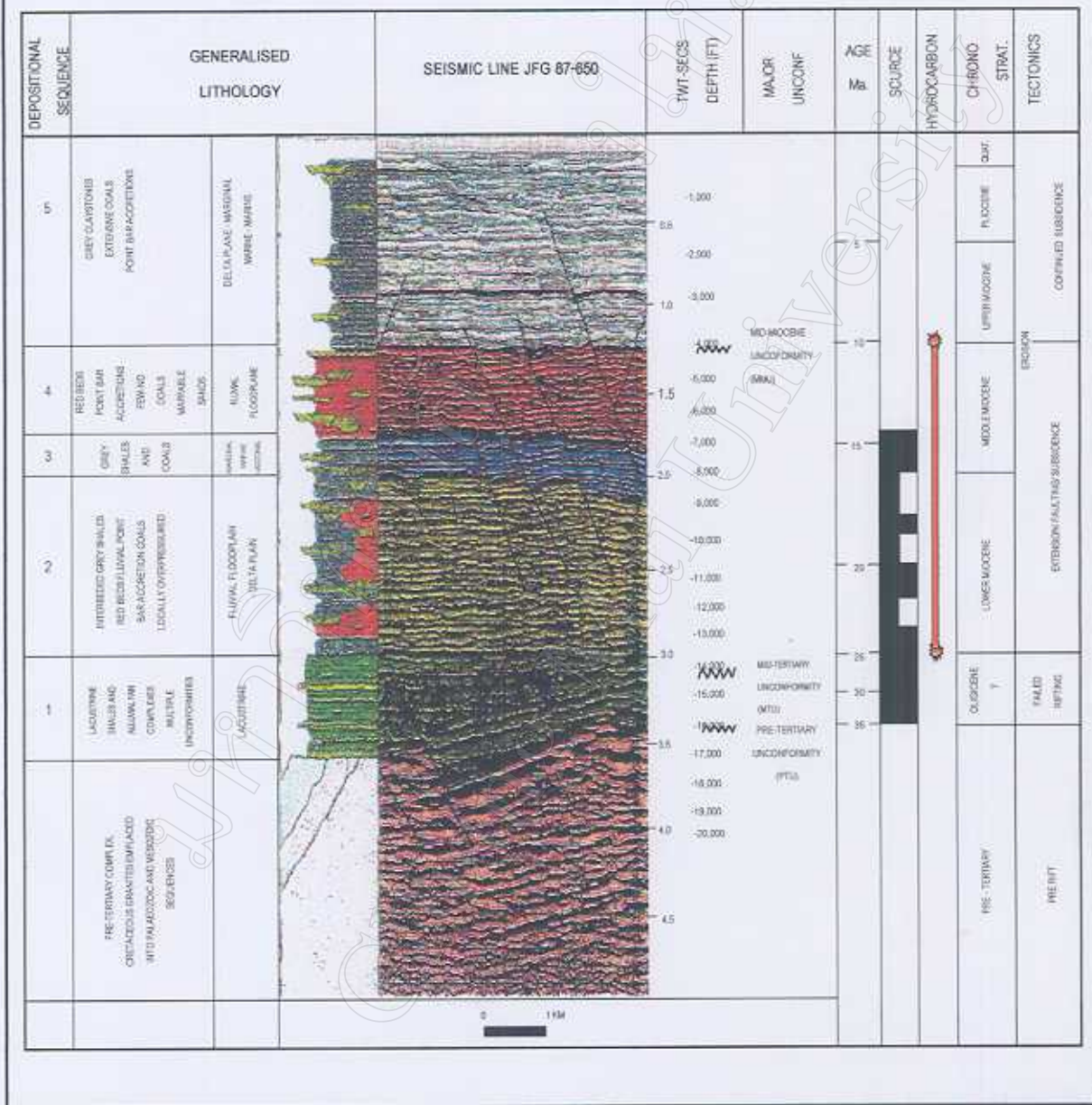


Figure 2.4 : Stratigraphic summary of the major depositional sequences within the Pattani Basin (after Unocal (Thailand), 1998).

section contain Type III and Type II kerogen (terrestrial and marginal marine) and shows the potential for gas/condensate and oil generation, but is presently immature across the basin. Second is oil-dominated that have primary source from lacustrine shales in sequence 1 and lower sequence 2.