CHAPTER 7

SUMMARY AND CONCLUSION

The Fang Basin, situated in northern Thailand, is an intracratonic basin, and owes its origin to tilted block faulting closely related to the Chiang Saen and Mae Tha Fault Zones. The main basin was initiated in response to extensional rifting during Early Tertiary period. Carboniferous and Triassic granites; Paleozoic, Permian and Ordovician metamorphic rocks; Carboniferous clastics and Permian limestones are well exposed in the vicinity of the basin. Three main sedimentary successions characterise the Cenozoic sequence. Alluvial fans, fluviatile and localised ephemeral lake sediments represent the earliest phase of sedimentation (Lower succession). This phase of sedimentation was essentially restricted to fault block depressions. Wide spread paleolake development took place during Oligocene to Middle Miocene. Sedimentation during this phase included thick sequence of fluvio-lacustrine and lacustrine sediments (Middle succession). Climatic and tectonic changes during late Miocene led to the disappearance of the paleolake. High energy fluviatile sediments characterise this period (Upper succession). High-low energy fluviatile deposits form the main surfacial deposits. Organic rich lacustrine strata are contained within the lower and middle parts of the sedimentary succession.

The present work involves a preliminary assessment of the organic rich sediments based on a set of sedimentological, petrological and geochemical data. Palynology of the sedimentary succession is also studied.

Through stratigraphic and sedimentological studies, six broad units, designated 1-6, and six facies states were recognised. Units 1 and 3 are

defined by a rather uniform lithology, predominantly of shales/claystones. Volumetrically insignificant sandstone and siltstone beds are found in association. Distinct laminations, abundant pyrite and siderite as well as locally well preserved alginites of unit 1 (Lower lacustrine facies) suggest deposition in a stratified fresh-water lake. Unit 3 (the upper lacustrine facies) which lacks the above features is presumed to have been deposited in a shallow oxygenated lake condition. Deposits of units 4 and 6 are almost exclusively characterised by texturally and minerallogically immature sandstones. The coarse overall texture, poorly developed upward profiles, high sand to shale ratio and the quantitatively minor clays collectively suggest deposition in a braided fluviatile complex. Unit 2 (fluvio-lacustrine facies) contains sandstones, siltstones and shales. Part of the unit occurs in fining upward sequence. It is interpreted as to have been deposited in a fluvio-lacustrine setting, where the lake sediments were largely influenced by meandering river deposits. An alternating strata of clay, sand and silt form unit 5 (meandering fluviatile facies). Some clay strata may be thick enough and few upward fining sequences may be associated. It is interpreted as a meandering fluviatile facies which is deposited in a meandering river, overbank, flood plain and/or floodplain lakes.

Two distinct microfloral assemblages referred to as palyno-assemblages 1 and 2 were estabilished through palynologic studies. Palyno-assemblage 1 represents the lower lacustrine facies. Framework components include rare *Magnastriatites, Picea, Pinaceae, Alnipollenites versus, Zonocostites*

ramonae fairly abundant *Quericoidites, Polypodiaceae, Spinizonocolpites echinatus,* abundant *Ephiphyllous* and *Microthyriaceous* fungi and other angiosperms. The microfloral assemblage is characteristics of a humid tropical and sub-tropical type climate and is apparently typical of a pre-Neogene aspect (Possibly Oligocene). Palyno-assemblage 2.1 characterises the fluvio-lacustrine and upper lacustrine facies. Typical association diagonising this assemblage include *Floreschuetzia trilobata, Floreschuetzia semilobata, Zonocostites ramonae, Spinozonocolpites echinatus, Hypoxylonites suleskii* ect. The *Sonneratia (Floreschuetzia trilobata* and *Floreschuetzia semilobata*) and the *Rhizophora-Zonocostites ramanoe* are considered to be characteristics of coastal swamp deposits of Middle Tertiary age (Germeraad and others, 1968). In particular, *Floreschuetzia semilobata* has in many cases been cited as the best stratigraphic marker for late Oligocene to Lower Miocene whereas *F. trilobata* has been cited from Oligocene. Based on these a late Oligocene - Lower Miocene age is inferred for this part of the succession. Palyno-assemblage 2.2 is characterised by *Quericoidites, Tiliaceae, Polypodiaceae, Pinaceae, Betulaceae, Nyssaceae, Jungladaceae, Faguceae, Osmundaceae* and *Compositae.* The micro-floral assemblage is suggestive of a Neogene aspect. The temperate varieties are most likely to have been transported from a coeval upland vegetation. Core and back mangrove taxa may not belong to the pollen site but rather would represent authochthonus pollens belonging to a hinterland vegetation such as a mangrove swamp and/or deltaic environments as suggested by the presence of *Nypa* pollens. The lack of Middle Miocene key pollen, *F. levipoli,* and the overal palynomorphic assemblage (1 + 2),

is therefore indicative of late Oligocene to Lower Miocene age. Based on the palynological findings, the deposit as a whole can be correlated in age to some deposits in the Li Basin (eg. Ban Pa Kha subbasin) which are of Oligocene to lower Miocene age and its upper part can be correlated with the Wiang Haeng deposit (lower Miocene). The palynologic assemblage is characteristic of humid, tropical to subtropical climate with trace amounts of temperate taxa. The presence of temperate taxa at the lower part of the deposit could indicate the gradual change from sub-tropical climate to tropical climiate during the upper lacustrine deposit, and then to the sub-tropical climate in the upper part.

Results of the geochemical analysis show that the organic matter can be classified as Type II and III kerogenes. All the samples have total organic carbon (TOC) values greater than the critical limit suggested for source rocks. The pyrolysis data shows that kerogen type varies along the vertical. Kerogens type trend from predominantly Type III at the top (upper lacustrine facies) to Type II at the bottom (Lower part of the fluvio-lacustrine and lower lacustrine facies) and lower lacustrine facies). TOC and HI values also tend to increase in a similar fashion. These facts coupled with the corresponding increase in potential yield and extract chemistry perhaps suggest an increase towards a better source rock potential with depth. Although there were no fully mature source rocks, as demonstrated by the maturity parameters (Tmax, PI, % Ro values), the deeper samples were very close to the point where oil generation becomes

significant. More mature sections and liquid hydrocarbon generation in laterally equivalent facies is possible. The lower part of the fluvio-lacustrine and lower lacustrine shales are considered to be potential source rocks. Most shales of the upper part of the section are either lean shales or could at most be sources for gas.

As estabilished from the organic petrographic studies, the organic matter appears to have been derived from a number of precursor materials such as higher plant liptinites (liptodetrinites, resinite/bitumen), algal organic matter (alginite) and terresterial higher plant detritus (vitrinites and minor inertinites). The distribution of organic matter is such that there is a relatively higher algal material input into the lower lacustrine shales. The bulk algal material occurs as *Botroyococcus* related telalginite. Lamalginite may also be present but is too rare to be easily seen even under fluorescence. The maceral composition of the upper part of the fluvio-lacustrine shales is of higher plant source. Vitrinite is typically the most abundant maceral and inertinites are also found in association. Petrographic and geochemical evidences, therefore suggest a better source rock potential with depth. Maturation studies based on optical parameters suggest an early mature state of the samples. Clay minerals in the samples are represented by abundant kaolinite and minor illite. The non-clay minerals include, quartz, plagioclase feldspar, and could indicate a terrestrial detrital origin of the sediments. Reducing conditions were more widespread in the lower part of the succession as demostrated by the presence of abundant pyrite and siderite.

Combining the results of this study (with all the limitated nature of the data) and data from previous works the following recommendations can be made

(1) Further source rock studies (on a basin wide scale) are necessary. Priority should be given to the deepest part of the basin and perhaps to the western side where higher geothermal gradients are recorded. The studies should include geochemical analyses on oils and organic extracts, and also use other complementary geochemical methods such as carbon isotope, biomarker studies, burial history etc. Based on previous works mature source strata can possibly be in excess of 300 m.

(2) Potential reservior rocks are found within the lower and middle Mae Sot members or the fluvio-lacustrine facies (Unit 2 in this study, and sand lens in Unit 3) in Mae Soon, Pong Nok, and Nong Yao sub-basins. The upper Mae Sot member or the upper lacustrine facies (this study) can act as a regional seal.