CHAPTER IV

GEOLOGICAL EVOLUTION OF THE LI BASIN

Generally, the approach to facies analysis relies heavily on the reconstruction of basin morphology and bedding architecture, determination of gross lithology and reconstruction of vertical and lateral succession of facies association. The facies distribution are dependent upon a number of interrelated controlling factors, notably, sedimentary process, sedimentary supply, climate, tectonics, sea level changes, biological activity, water chemistry, and volcanism. The relative significance of these factors, however, varies between different depositional environments. Amongst these, climate and tectonics are very important in the continental environments.

It is clearly seen that the early development of a sedimentary basin, its internal structural configuration during growth and its subsequent solid geometry, following its depositional history and the period of uplifting and erosion, will be strongly influenced by movements of the basement floor underlying the basin. The structural framework of a sedimentary basin thus depends primarily on the structural patterns of basement.

All basins studies involving lithostratigraphic analysis of the entire basin logically begin at the base of the sequence and trace the development of the final record of the history. The structural evolution of the basement during this interval of time is an essential component of the basin's history and a controlling

factors in its structural frameworks.

In this chapter, an attempt is being made to define the lithostratigraphy of Tertiary sedimentary sequence of the Li basin on the informal basis, and to reconstruct the history on tectonics and sedimentation of Tertiary sediments of the Li basin.

4.1 Proposed Lithostratigraphy of the Li Basin

The informal lithostratigraphy of the area based on facies analysis previously described has defined before the discussion on the geological history of the Tertiary sedimentation and the relation of sedimentation to tectonic activity of the Li basin. The informal lithostratigraphic classification and nomenclature of the Tertiary sequence under the present investigation have been proposed for reference purpose. Previous stratigraphic classifications and nomenclatures have already been reviewed earlier under the heading 2.4.2. If the goal of the stratigraphic analysis is to predict the pattern of a specific lithology that may have economic significance, then observations relating to boundary conditions during the deposition have particular importance.

In this study, the Tertiary sedimentary sequence within the Li basin has been classified into the following lithostratigraphic levels, notably, group, formation, and member. The following discussion will be focusing upon the proposed classification, tentative nomenclature, and brief description of various lithostratigraphic units of sedimentary sequence of the Li basin. The consideration begins from the largest lithostratigraphic unit of the Tertiary sedimentary sequence of the Li basin as the "Li Group" to

serve the discussion in this context. The local lithostratigraphic subdivisions within the Li basin will fall within the "Li Group".

The Li Group overlies unconformably the highly folded pre-Tertiary rocks and underlies unconformably the unconsolidated upper succession of Quaternary age. The lithostratigraphy of the Li basin is obtained from both lithostratigraphic succession in the active mine pit and data as well as information from the boreholes. The proposed lithostratigraphy of the Li basin is characterized as Li Group which is further subdivided, based on lithology and sedimentary structure with respect to sedimentary environment, into 6 formations, 12 members.

4.1.1 Li Formation

The lowermost lithostratigraphic unit of the "Li Group" is referred to as "Li Formation" which in all cases unconformably overlies the pre-Tertiary basement rocks. The type of this unconformity is believed to be either angular unconformity or nonconformity. Due to the unexposed nature of the formation, the classification of the "Li Formation" depends entirely on subsurface data. However, at least the drill-hole data indicate that the "Li Formation" is present in the areas of Ban Pu sub-basin, Ban Hong sub-basin, Ban Mae Long sub-basin, the western and middle parts of the Li basin, while the data are not available in the remaining areas.

The lithological characteristics of the "Li Formation" is mainly gravelly sand of alluvial fan facies. For the 3 sub-basins, namely, Ban Pu, Ban Hong and Ban Mae Long, no attempt has been made to subdivide the "Li Formation" which is represented by the alluvial

fan facies into different member due to the rather homogeneous and monotonous lithological characteristics.

For the western and middle parts of the Li basin, the "Li Formation" is represented by the sedimentary unit of lacustrine facies and alluvial fan facies

The lithostratigraphy of the "Li Formation" of Ban Pu, Ban Hong, Ban Mae Long sub-basins and the western and middle parts of the Li basin are summarized in Table 4.1.1.

4.1.2 Ban Pa Kha Formation

The "Ban Pa Kha Formation" overlies conformably the "Li Formation" with abrupt change in lithological characteristics. The sedimentary succession of the "Ban Pa Kha Formation" has been recognized from the subsurface data in all areas within the Li basin. Amongst these areas, only the lithological succession at the Ban Pa Kha sub-basin is available for the subdivisiion of the "Ban Pa Kha Formation" into 2 members which will be referred to as "Ban Pa Kha-1 and Ban Pa Kha-2 Members" in ascending order.

The lithological characteristics of the "Ban Pa Kha Formation" is mainly clay intercalated with sand of lacustrine facies. However, for the Ban Pa Kha sub-basin, meandering fluviatile facies has been associated in this lithological succession.

Detailed lithostratigraphic unit of the "Ban Pa Kha Formation" in the Ban Pa Kha sub-basin can be subdivided into the "Ban Pa Kha-1 Member" of the lacustrine facies and "Ban Pa Kha-2 Member" of the meandering fluviatile facies in ascending order.

Table 4.1.1 Lithostratigraphy and sedimentary facies of the "Li Formation" of the Tertiary sequence of the Li basin

	Ban Pu sub-basin	Ban Hong sub-basin	Ban Mae Long sub-basin	Ban Pa Kha sub-basin	Ban Na Sai-Ban Mae Wang sub-basin	External sub-basinal areas
Li Fm.	Li Fm. (Alluvial fan)	Li Fm. (Alluvial fan)	Li Fm. (Alluvial fan)			Li Fm. (Lacustrine)
Pre - Tertiary rocks						

For the Ban Mae Long sub-basin, the "Ban Pa Kha Formation" is represented by the sediments of alluvial fan facies overlying the alluvial fan facies of the "Li Formation". The difference between the litholigical characteristics of the alluvial fan facies of these two formations is that the grain size of the Li Formation is generally larger than that of the Ban Pa Kha Formation.

For the remaining areas in this context, namely, Ban Pu, Ban Hong, Ban Na Sai-Ban Mae Wang sub-basins and the external sub-basinal areas, no attempt has been made to subdivide the "Ban Pa Kha Formation" which is represented by the lacustrine facies and/or the meandering fluviatile facies into different members.

The lithostratigraphy of the "Ban Pa Kha Formation" and its subdivision of Ban Pu, Ban Hong, Ban Mae Long, Ban Pa Kha, Ban Na Sai-Ban Mae Wang sub-basins and the external sub-basinal areas are summarized in Table 4.1.2.

4.1.3 Ban Hong Formation

This formation is almost exclusively characterized by thick coal bed with some clay partings of peat swamp facies. The "Ban Hong Formation" overlies conformably the "Ban Pa Kha Formation" with gradational contact in almost all parts. In Ban Mae Long sub-basin and some part of Ban Pa Kha sub-basin, the "Ban Hong Formation" overlies conformably the "Ban Pa Kha Formation" with abrupt change in lithological characteristics. The sedimentary succession of the "Ban Hong Formation" has been recognized from the subsurface data in all 5 main sub-basins. The only differences are some lithological association and thickness. However, no attempt has been made to

Table 4.1.2 Lithostratigraphy and sedimentary facies of the "Ban Pa Kha Formation" of the Tertiary sequence of the Li basin

	Ban Pu sub-basin	Ban Hong sub-basin	Ban Mae Long sub-basin	Ban Pa Kha sub-basin	Ban Na Sai-Ban Mae Wang sub-basin	External sub-basinal areas
Ban Pa Kha Fm.	Ban Pa Kha Fm. (Lacustrine)	Ban Pa Kha Fm. (Lacustrine)	Ban Pa Kha Fm. (Alluvial fan)	BPK-2 Mbr. (Meandering fluviatile) BPK-1 Mbr. (Lacustrine)	Ban Pa Kha Fm. (Lacustrine)	Ban Pa Kha Fm. (Lacustrine)
Li Fm.						

subdivide the "Ban Hong Formation" into different members due. to the rather homogenous and monotonous lithological characteristics.

For the external sub-basinal areas, the sedimentary sequence of the"Ban Hong Formation" is represented by the sediments of lacustrine facies.

The lithostratigraphy of the "Ban Hong Formation" of Ban Pu, Ban Hong, Ban Mae long, Ban Pa Kha, Ban Na Sai-Ban Mae Wang sub-basins and the external sub-basinal areas are summarized in Table 4.1.3.

4.1.4 Ban Pu Formation

The "Ban Pu Formation" overlies conformably the "Ban Hong Formation" with gradation on lithological characteristics. The sedimentary succession of the "Ban Pu-formation" has been recognized from the subsurface data and/or mine-pit observation in the Ban Pu, Ban Hong, Ban Mae Long, Ban Pa Kha, Ban Na Sai-Ban Mae Wang sub-basins and the external sub-basinal areas. Amongst these areas, only the lithological succession at the Ban Pu sub-basin is available for the subdivision of the "Ban Pu Formation" into 3 members which will be referred to as "Ban Pu-1, Ban Pu-2 and Ban Pu-3 Members" in ascending order, respectively.

The lithological characteristics of the "Ban Pu Formation" is mainly clay of lacustrine facies associated with sand of braided fluviatile facies. Detailed lithostratigraphic unit of the "Ban Pu Formation" in the Ban Pu sub-basin can be subdivided into the "Ban Pu-1 Member" of the lacustrine facies, the "Ban Pu-2 Member" of

Table 4.1.3 Lithostratigraphy and sedimentary facies of the "Ban Hong Formation" of the Tertiary sequence of the Li basin

	Ban Pu sub-basin	Ban Hong sub-basin	Ban Mae 'Long sub-basin	Ban Pa Kha sub-basin	Ban Na Sai-Ban Mae Wang sub-basin	External sub-basinal areas
Ban Hong Fm.	Ban Hong Fm. (Peat swamp)	Ban Hong Fm. (Peat swamp)	Ban Hong Fm. (Peat swamp)	Ban Hong Fm. (Peat swamp)	Ban Hong Fm. (Peat swamp)	Ban Hong Fm. (Lacustrine)
Ban Pa Kha Fm.						

braided fluviatile facies, and "Ban Pu-3 Member" of the lacustrine facies in ascending order, respectively.

For the Ban Hong sub-basin, the "Ban Pu Formation" is represented by the sediments of lacustrine and braided fluviatile environments of the "Ban Pu-1 and Ban Pu-2 Members" in ascending order, respectively.

For the remaining areas, notably, Ban Mae Long, Ban Pa Kha, Ban Na Sai-Ban Mae Wang sub-basins and the external sub-basinal areas, no attempt has been made to subdivide the "Ban Pu Formation" which is represented by the lacustrine facies into different members. It is noted that the lacustrine facies of the "Ban Pu Formation" in the Ban Mae Long and Ban Pa Kha sub-basins show the associations of marginal lacustrine character of sand layers in the fine-grained lacustrine sedimentary succession.

The lithostratigraphy of the "Ban Pu Formation" and its subdivision of Ban Pu, Ban Hong, Ban Mae Long, Ban Pa Kha, Ban Na Sai-Ban Mae Wang sub-basins and the external sub-basinal areas are summarized in Table 4.1.4.

4.1.5 Ban Mae Long Formation

The "Ban Mae Long Formation", the uppermost lithostratigraphic unit of the "Li Group", overlies conformably the "Ban Pu Formation" with gradational contact in most parts except in the Ban Hong sub-basin that relationship between these 2 formations is sharp contact. The upper contact of "Ban Mae Long Formation" is suggested to be the erosional surface.

Table 4.1.4 Lithostratigraphy and sedimentary facies of the "Ban Pu Formation" of the Tertiary sequence of the Li basin

	Ban Pu sub-basin	Ban Hong sub-basin	Ban Mae Long sub-basin	Ban Pa Kha sub-basin	Ban Na Sai-Ban Mae Wang sub-basin	External sub-basinal areas
Ban Pu Fm.	BP-3 Mbr. (Lacustrine)	BP-2 Mbr. (Braided fluviatile)	Ban Pu Fm. (Lacustrine)	Ban Pu Fm. (Lacustrine)	Ban Pu Fm. (Lacustrine)	Ban Pu Fm. (Lacustrine)
	BP-2 Mbr. (Braided fluviatile)					
	BP-1 Mbr. (Lacustrine)	BP-1 Mbr. (Lacustrine)				
Ban Hong Fm.						

The sedimentary succession of the "Ban Mae Long Formation" has been recognized from the subsurface data and/or mine pit observations in almost parts of the Li basin, notably, Ban Pu, Ban Hong, Ban Mae Long, Ban Pa Kha, Ban Na Sai-Ban Mae Wang sub-basins and the external sub-basinal areas. Amongst these areas, only the lithological succession at Ban Pu and Ban Mae Long sub-basins are available for the subdivision of the "Ban Mae Long Formation" into 4 members which will be referred to as "Ban Mae Long-1, Ban Mae Long-2, Ban Mae Long-3 and Ban Mae Long-4 Members" in ascending order, respectively.

Detailed lithostratigraphic unit of the "Ban Mae Long Formation" in the Ban Pu and Ban Mae Long sub-basins can be subdivided into the "Ban Mae Long-1 Member" of the peat swamp facies, the "Ban Mae Long-2 Member" of the lacustrine facies, the "Ban Mae Long-3 Member" of the meandering fluviatile facies and the "Ban Mae Long-4 Member" of the lacustrine facies in ascending order. It is suggested that the "Ban Mae Long-4 Member" in the Ban Mae Long sub-basin was eroded and is therefore absent.

For the Ban Hong sub-basin, the "Ban Mae Long Formation" is represented by the coal bed with partings of peat swamp facies associated with sediments of shallow lacustrine facies.

For the Ban Pa Kha sub-basin, the "Ban Mae Long Formation" is represented by the sediments of the peat swamp and lacustrine origins of the "Ban Mae Long-1 and Ban Mae Long-2 Members" in ascending order, respectively.

For the remaining areas, the "Ban Mae Long Formation" is represented by the sedimentary sequence of the lacustrine facies. No attempt is made to subdivide the "Ban Mae Long Formation" into different members in these areas due to the homogeneity and monotonous characteristics of the lithological successions.

The lithostratigraphy of the "Ban Mae Long Formation" and its subdivision of Ban Pu, Ban Hong, Ban Mae Long, Ban Pa Kha, Ban Na Sai-Ban Mae Wang sub-basins and the external sub-basinal areas are summarized in Table 4.1.5.

4.1.6 Quaternary Alluvial Deposits

The "Quaternary Alluvial Deposits" is the uppermost lithostratigraphic unit lying over the "Li Group". It overlies unconformably the "Ban Mae Long Formation" and is generally characterized by the alluvial facies. Lithologically, it is mainly medium- to coarse-grained sand with gravels of basement rocks.

Detailed subdivision of the "Quaternary Alluvial Deposits" can be clearly represented in most part of the Li basin where 3 types of deposits can be recognized. They are the "Foot-Slope Deposits, Terrace Deposits and the Active Flood Plain Deposits". The subdivision of these 3 units is based on the depositional environment which causes the differences in lithological characteristics and geomorphology.

The "Foot-Slope Deposits" are widely distributed near the basement rocks,bounded the basin of relatively high ground-surface elevation within the basin. The medium- to coarse-grained clastic

Table 4.1.5 Lithostratigraphy and sedimentary facies of the "Ban Mae Long Formation" of the Tertiary sequence of the Li basin

	Ban Pu sub-basin	Ban Hong sub-basin	Ban Mae Long sub-basin	Ban Pa Kha sub-basin	Ban Na Sai-Ban Mae Wang sub-basin	External sub-basinal areas
Ban Mae Long Fm.	BML-4 Mbr. (Lacustrine)	Ban Mae Long Fm. (Peat swamp)	BML-3 Mbr. (Meandering fluviatile)	BML-2 Mbr. (Lacustrine)		BML-2 Mbr. (Lacustrine) (Braided fluviatile)
	BML-3 Mbr. (Meandering fluviatile)		BML-2 Mbr. (Lacustrine)			
	BML-2 Mbr. (Lacustrine)		BML-1 Mbr. (Peat swamp)	BML-1 Mbr. (Peat swamp)		BML-1 Mbr. (Lacustrine)
	BML-1 Mbr. (Peat swamp)					
Ban Pu Fm.						

sediments of "Foot-Slope Deposits" are mainly gravels to cobbles of basement rocks, notably, slate, quartzite, phyllite, sandstone and quartz with sand matrix.

The "Terrace Deposits" are distributed in the areas between the "Foot-Slope Deposits" bordering the basin and the "Active Flood Plains" with relatively lower ground surface elevation was compared with the "Foot-Slope Deposits". The "Terrace Deposits" are represented by medium- to coarse-grained clastic sediments of older fluviatile deposits which have been uplifted.

The "Active Flood-Plain Deposits" are essentially distributed on both sides of the Li river and its tributaries, occupying the lowest ground-surface elevation in the Li basin. The sediments are clay, silt and sand mixtures and soils.

It is noted that the sediments of "Quaternary Alluvial Deposits" are lateritized under the influence of the ground water. It is believed that iron in water is leached from bounded basin basement rocks and redeposited in the Quaternary sediments by the seasonal fluctuation of ground water.

The lithostratigraphy of the "Quaternary Alluvial Deposits" which almost essentially, underlies all parts of the basinal areas is summarized in Table 4.1.6.1.

The lithological succession of any areas within the Li basin are correlated and presented in Figure 4.1.1 and Table 4.1.6.2.

The proposed lithological classification and nomenclature of the Li basin under the present investigation as compared with

Table 4.1.6.1 Lithostratigraphy and sedimentary facies of the "Quaternary Alluvial Deposits" of the uppermost sequence of the Li basin

	Ban Pu sub-basin	Ban Hong sub-basin	Ban Mae Long sub-basin	Ban Pa Kha sub-basin	Ban Na Sai-Ban Mae Wang sub-basin	External sub-basinal areas
Quaternary Alluvial deposits	Active Flood-plain Deposits	Active Flood-plain Deposits	Active Flood-plain Deposits	Active Flood-plain Deposits	Active Flood-plain Deposits	Active Flood-plain Deposits
	Terrace Deposits	Terrace Deposits	Terrace Deposits	Terrace Deposits	Terrace Deposits	Terrace Deposits
		Foot-Slope Deposits		Foot-Slope Deposits	Foot-Slope Deposits	Foot-Slope Deposits
Li Group						

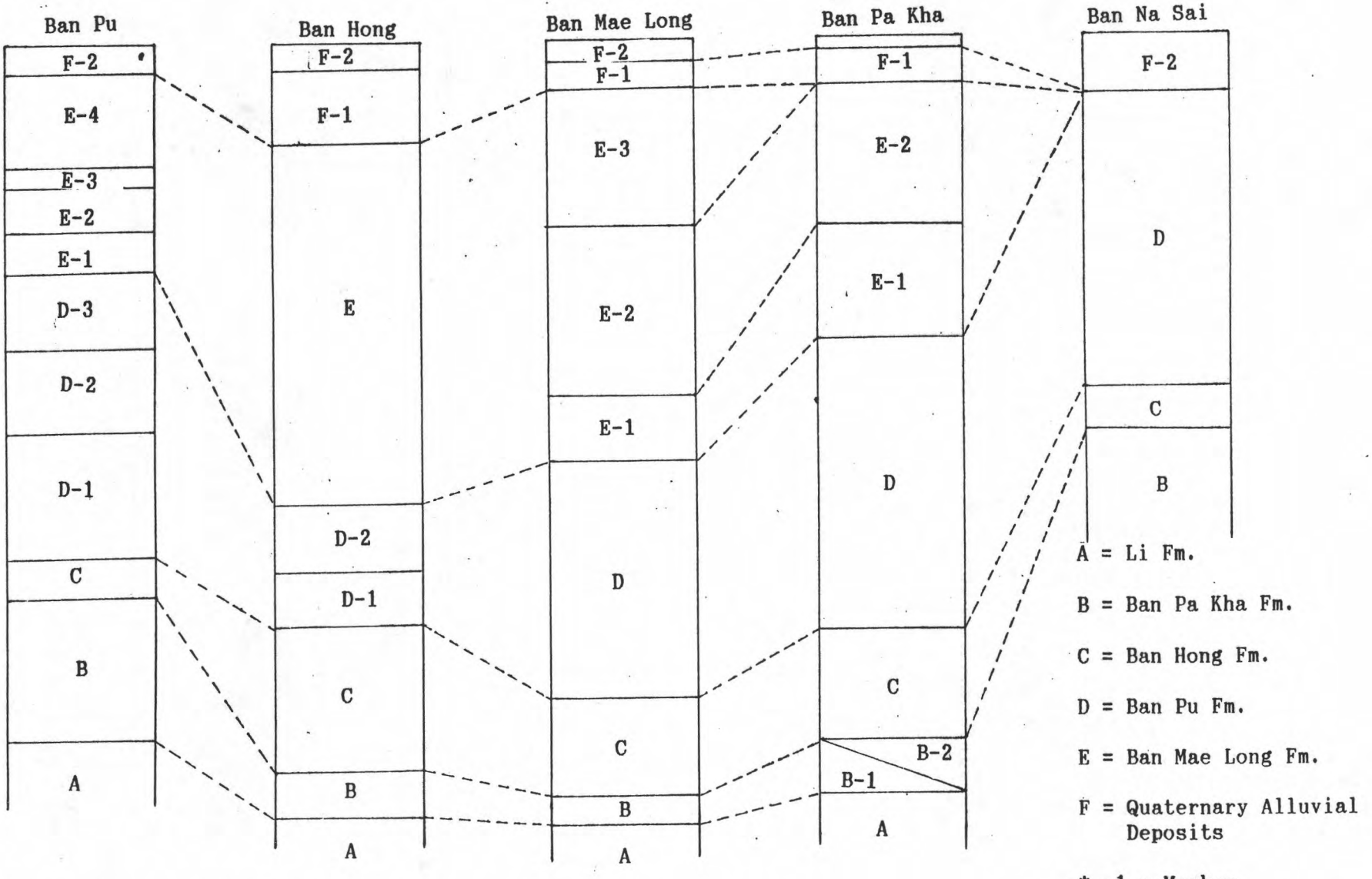


Figure 4.1.1 Lithological succession of the Li basin

Table 4.1.6.2 The lithostratigraphic succession of the Li basin

	Present Study	Ban Pu	Ban Hong	Ban Mae Long	Ban Pa Kha	Ban Na Sai-Ban Mae Wang	External sub-basinal areas
	Quaternary Alluvial deposits	Quaternary Deposits	Quaternary Deposits	Quaternary Deposits	Quaternary Deposits	Quaternary Deposits	Quaternary Deposits
Li Group	Ban Mae Long Fm.	BML-4 Mbr.	Ban Mae Long Fm.	BML-3 Mbr.	BML-2 Mbr.	Ban Mae Long Fm.	Ban Mae Long Fm.
		BML-3 Mbr.		BML-2 Mbr.			
		BML-2 Mbr.		BML-1 Mbr.	BML-1 Mbr.		
		BML-1 Mbr.					
	Ban Pu Fm.	BP-3 Mbr.	BP-2 Mbr.	Ban Pu Fm.	Ban Pu Fm.	Ban Pu Fm.	Ban Pu Fm.
		BP-2 Mbr.					
		BP-1 Mbr.	BP-1 Mbr.				
	Ban Hong Fm.	Ban Hong Fm.	Ban Hong Fm.	Ban Hong Fm.	Ban Hong Fm.	Ban Hong Fm.	Ban Hong Fm.
	Ban Pa Kha Fm.	Ban Pa Kha Fm.	Ban Pa Kha Fm.	Ban Pa Kha Fm.	BPK-2 Mbr. / BPK-1 Mbr.	Ban Pa Kha Fm.	Ban Pa Kha Fm.
	Li Fm.	Li Fm.	Li Fm.	Li Fm.	Li Fm.	Li Fm.	Li Fm.
Pre - Tertiary rocks							

previous works have been summarized and presented in Table 4.1.6.3.

4.2 Major Tectonic Framework Forming the Tertiary Li Basin

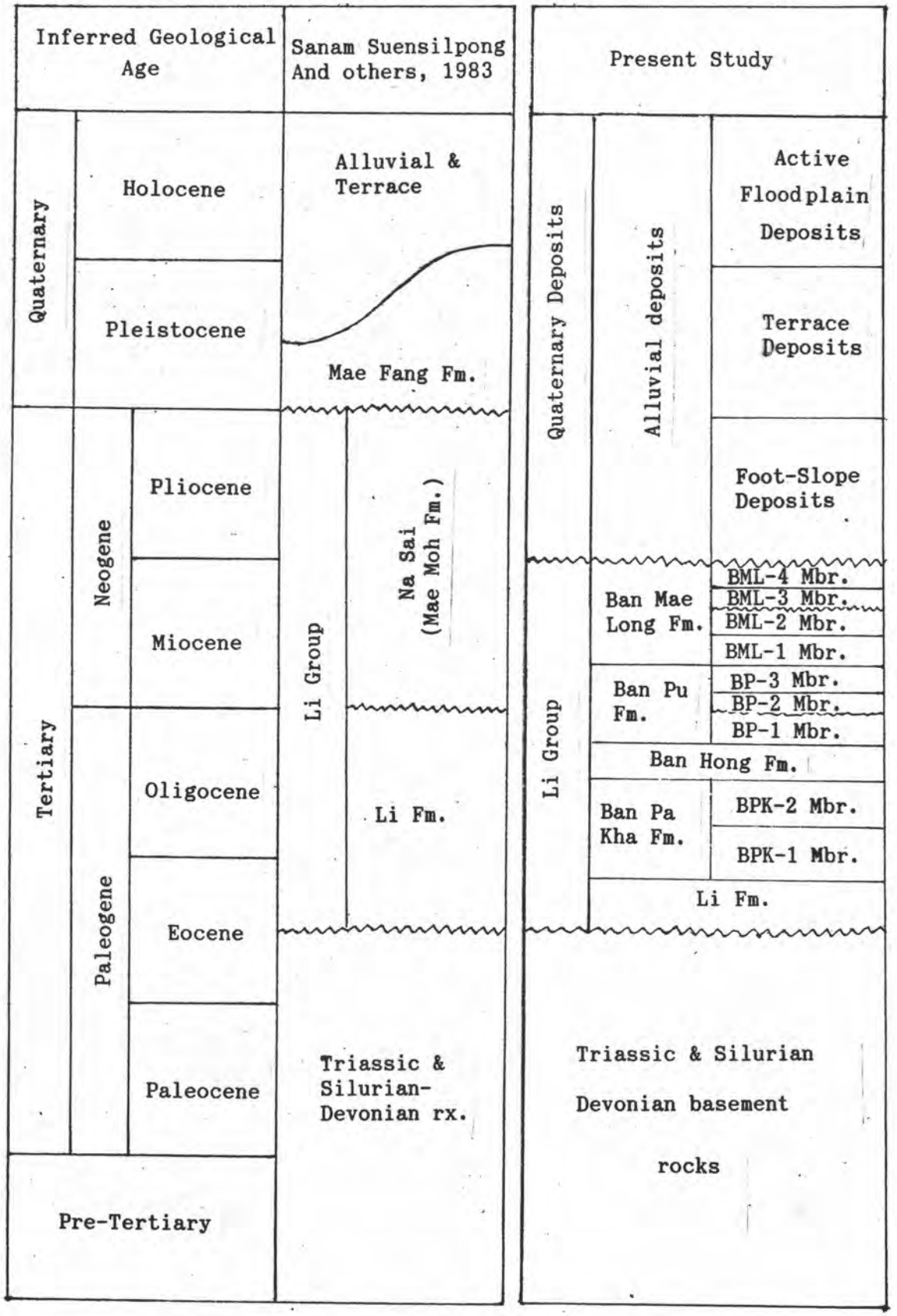
During Triassic, Shan Thai continent was collided with Indochina block and rapidly swung around clockwise to collide with South China block at the same time. Indochina Orogeny marked the termination of marine deposits in Thailand almost permanently, and the formation of 2 important foldbelts, namely, Sukho Thai and Phitsanulok of mainly thick marine Paleozoic to Triassic sediments and volcanic rocks (Sangas Bunopas, 1981 ; Sangas Bunopas and Vella , 1983).

During Jurassic and Cretaceous, the tectonism was mainly sinistral strain manifested by northwest-southeast trending of Mae Ping and Three Pagodas strike-slip faults and appears to be dextral at present (Pol Chaodumrong, 1985).

During Cretaceous to present time, the northwards drift of the Indian Plate resulted in subduction along the eastern margin of the present Bay of Bengal, opening of the Andaman Sea and Indian Ocean.

During Tertiary, a tensional regime developed and a system of north-south trending normal faults appeared. The collision of the India and Southeast Asia on Eocene, Himalayan Orogeny, is believed to created the east-west extension and north-south compression in northern Thailand. At least, three sets of faults have been recognized, they are the pre-existing north-south extensional faults originated from the weak zones prior to the collision, and the

Table 4.1.6.3 Comparative stratigraphic classification and nomenclatures of Tertiary deposits of the Li basin



conjugate strike-slip faults of northwest-southeast and north/northeast-south/southwest direction. The structural framework of Tertiary basins in northern Thailand is essentially controlled by the movement of these two conjugate strike-slip faults, and eventually the transtensional basins in this region were developed.

During Eocene, the Mae Ping Fault Zone and Uttaradit Fault Zone were the major conjugate strike-slip faults of northern Thailand. For the Li basin, it is believed that two conjugate strike-slip faults in the southern margin of present day basin with relatively movement similar to these of Mae Ping Fault Zone and Uttaradit Fault Zone, governed the formation of the Li basin in the initial stage.

Sedimentary basins have been classified according to their relationships to the present tectonic elements (Fletcher and Soeparjadi, 1976 ; Nayoan and others, 1979). The majority of the basins are of a single tectonic setting, resulting from the combination of extensional and wrench faulting. Therefore, Li basin is considered to be the intracratonic basin.

After the tectonic activities especially faulting which marked the formation of the Li basin, the area has continued to be tectonically active throughout Cenozoic Era as evidenced from the type of sediments in the basin and numerous intrabasinal faults, particularly those cross-cutting the basement ones as well as some probably basement-detached ones. There is at least one clear identifiable unconformity of presumably Mio-Pliocene wide-spreadly

present throughout the basin, representing a major episode of the uplifting, erosion followed by an influx of coarse clastics.

It is noted that north-south normal fault passing through the middle part of the basin had been active since the formation of the Li basin. It is believed that this fault had presumably subdivided the Li basin into 2 main structural basin with a half-graben configuration. It is notice that the half western structural sub-basin shows a relatively greater depth or greater thickness of the infilled sediments than that in the half eastern part. Further east towards the marginal area of the Li basin, there had been a few areas where faulting had been continuously active throughout the depositional history. These areas are referred to in this study as coal-bearing sub-basins with half-graben configuration in almost cases.

4.3 Tectonic Sedimentation and Basin Evolution

From the analyses of subsurface geological data of the Li basin in terms of lithostratigraphy, lithofacies, and environment of deposition, it is apparent that factors controlling deposition may be considered to have operated on two scales. The first one is a larger one on basinal scale, and the second one is smaller one on intrabasinal scale. On a basinal scale, sedimentation seems to have

been controlled by a combination of structurally and compactionally induced subsidence, and depositional environment. On a intrabasinal scale, the post-depositional gravity faulting seems to have been controlled by a combination and extensional tectonic regime.

The evolution of the Li depositional basin was initiated by the remnants of subtle graben style topographic low created by activation or reactivation of structural weaknesses. The two major fault zones marking the boundaries of the basin are parallel to the Mae Ping Fault Zone in the northwest-southeast direction and the Uttaradit Fault Zones in the northeast- southwest direction. These basinal faults are developed during the Middle to Late Eocene Epoch as the result of the collision of Eurasia with Indian plate. The rate of subsidence, rate of deposition, and depositional environment of the Li basin are controlled by the basinal faults. Besides, the basinal subsidence has strongly influenced on the thickness of sediments infilled.

The intrabasinal faults are analyzed in terms of syn-depositional and post-depositional faults with respect to various lithostratigraphic units concerned. The intrabasinal fault has a direct effect on local subsidence which indirectly controlled the nature of depositional environment, thickness of lithofacies, lithological characteristics.

The Li basin is believed to develop in the Late Eocene age. Sediments in the Li basin are mainly non-marine clastics of Paleogene and Neogene ages with total thickness of approximately 500 metres in the deepest part of the basin.

The Tertiary sedimentary succession of the Li basin can be subdivided into 5 main sequences. The lowermost sequence is represented by alluvial fan facies overlying unconformably the pre-Tertiary rocks. The sequence is generally characterized by the association of coarse- and medium-grained clastic sediments. Early depositional episode was restricted to the tilted fault block depression after the basin was initiated during Paleogene time. The depression zones in the northern, eastern and southern rims of the basin are appeared as the small sub-basins with difference in depth. These small sub-basins are located in the larger tilted fault block of the eastern part of the Li basin. The western part of the Li basin is the relatively deeper depression zone as compared with the other areas, while the middle part is the horst structure.

During Late Eocene to Pliocene, there was the wide spread paleo-lake developed in the Li basin. This development is believed to be associated with the increases structural activities, especially the reactivation of existing major faults which culminated a depression of limnic condition. The sedimentary sequence deposited during this period is characterized by fine-grained clastics, coal and medium-grained clastics of fluviatile facies. The overall sequence appears to be thickening westwardly with a tendency of medium-grained clastics of fluviatile facies to be influxed from the east and west. Besides, the faunal and floral assemblages in the lacustrine facies seem to be relatively more diverse and abundant.

Towards the top of the sedimentary sequence, the major change in tectonic and/or climatic conditions took place which was marked by the abrupt disappearance of the paleo-lake, the presence of basin

local unconformity as in Ban Pu sub-basin, presumably the base of Upper Miocene. It is believed that the Late Miocene unconformity, a major regional unconformity, is related to the late stage of the extensional force in this region, and the termination of tilted block-faulting. Therefore, this episode caused the younger sediments to rest unconformably on the older sequence.

The uppermost sequence overlying the unconformity is characterized by medium- to coarse-grained clastics of high energy fluviatile facies. The association of basal conglomerate above the unconformity, alluvium are well developed throughout the basin. It is interpreted that this sequence was deposited under the renewed tectonic activities which led to the expression of positive features at margin of the basin, reactivation of tilted faults. With respect to the surficial deposits of the Li basin, namely, terrace gravel deposit, and flood plain deposit, they indicate that the tectonic activity is still active throughout the Holocene Epoch.

Due to the fact that overall configuration of the Li basin is not a simple one, but complicated by different architectures of sub-basins within the basin. Therefore, sedimentation pattern and depositional environment within the Li basin vary considerably from place to place. The relation between sedimentary patterns, sedimentary facies and the tectonic activities of each area are shown in Table 4.3.1.a-f. However, it is noted that the broad pattern of sedimentary facies of the Tertiary sequence within the basin reveals that the facies are generally thickening westwardly and the influence of paleo-lake sedimentation are confined essentially to the western margin of the basin. These lines of evidence indicate that the major

Table 4.3.1.a Tectonic sedimentation of Ban Pu sub-basin

Tectonic Activities	Sedimentaion/Erosion	Facies
Slow subsidence	Sedimentation under fluviatile condition	Fluviatile
Uplift due to the reactivation of faulting in the reverse direction	Erosion	Unconformity
Moderately subsidence	Sedimentation under shallow fresh-water lake condition	Lacustrine
Slow subsidence	Sedimentation under fluviatile condition with peat accumulation in back swamp	Meandering fluviatile/ Peat swamp
Moderately subsidence	Sedimentation under shallow fresh-water lake condition	Lacustrine
Moderately subsidence	Formation of the moderately-subsiding peat swamp interrupted by shallow-lake sedimentation silting up of the lake	Peat swamp/Lacustrine
Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition	Lacustrine
Slow subsidence	Fluviatile sedimentation under braided river regime ,silting up of the lake	Braided fluviatile

Table 4.3.1.a cont.

Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition	Lacustrine
Moderately subsidence	Formation of the moderately subsiding peat swamp silting up of the lake	Peat swamp
Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition	Lacustrine
Block faulting and the formation of the sub-basin	Alluvial sedimentation	Alluvial fan

Table 4.3.1.b Tectonic sedimentation of Ban Hong sub-basin

Tectonic Activities	Sedimentaion/Erosion	Facies
Slow subsidence	Sedimentation under fluviatile condition	Fluviatile
uplifting due to the reactivation of faulting in the reverse direction	Erosion	Unconformity
Moderately subsidence	Formation of the moderately-subsiding peat swamp with shallow lake sedimentation	Peat swamp with shallow lacustrine association
Slow subsidence	Fluviatile sedimentation under fluviatile river regime, silting up of the lake	Braided fluviatile
Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition	Lacustrine
Moderately subsidence	Formation of moderately-subsiding peat swamp silting up of the lake	Peat swamp
Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition	Lacustrine
Slow subsidence	Alluvial sedimentation	Alluvial fan

Table 4.3.1.c Tectonic sedimentation of Ban Mae Long sub-basin

Tectonic activities	Sedimentation/Erosion	Facies
Slow subsidence	Sedimentation under fluviatile condition	Fluviatile
Slow subsidence	Alluvial sedimentation	Alluvial fan
Uplifting due to the reactivation of faulting in the reverse direction	Erosion	Unconformity
Slow subsidence	Fluviatile sedimentation under meandering river regime, silting up of the lake	Meandering fluviatile
Rapid subsidence due to faulting	Sedimentation under fresh water lake condition	Lacustrine
Moderately subsidence	Formation of the moderately-subsiding peat swamp silting up of the lake	Peat swamp
Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition with association of marginal lacustrine character of sand layers	Lacustrine
Moderately subsidence	Formation of the moderately-subsiding peat swamp	Peat swamp
Block-faulting and the formation of sub-basin	Erosion of basement rocks/Alluvial sedimentation	Unconformity/Alluvial fan

Table 4.3.1.d Tectonic sedimentation of Ban Pa Kha sub-basin

Tectonic activities	Sedimentation/Erosion	Facies
Slow subsidence	Fluviatile sedimentation	Fluviatile
Uplifting due to the reactivation of faulting in the reverse direction	Erosion	Unconformity
Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition	Lacustrine
Moderate subsidence	Formation of the moderately-subsiding peat swamp silting up of the lake	Peat swamp
Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition	Lacustrine
Moderate subsidence	Moderately-subsiding peat swamp	Peat swamp
Block faulting and the formation of the sub-basin	Fluviatile sedimentation under meandering river regime/ lacustrine sedimentation in low-lying areas	Fluviatile/Lacustrine

Table 4.3.1.e Tectonic sedimentation of Ban Na Sai-Ban Mae Wang sub-basin

Tectonic activities	Sedimentation/Erosion	Facies
Slow subsidence	Sedimentation under fluviatile condition	Fluviatile
Uplifting due to the reactivation of faulting in the reverse direction	Erosion	Unconformity
Rapid subsidence due to faulting	Sedimentation under freah-water lake condition	Lacustrine
Moderately subsidence	Formation of moderately-subsiding peat swamp silting up of the lake	Peat swamp
Rapid subsidence due to faulting	Sedimentation under freah-water lake condition	Lacustrine

Table 4.3.1.f Tectonic sedimentation of External sub-basinal areas of the Li basin

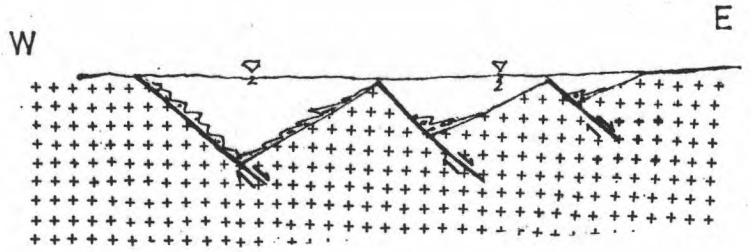
Tectonic activities	Sedimentation/Erosion	Facies
Slow subsidence	Sedimentation under fluviatile condition	Fluviatile
Slow subsidence	Fluviatile sedimentation under meandering river regime	Meandering fluviatile
Uplifting due to the reactivation of faulting in the reverse direction	Erosion	Unconformity
Rapid subsidence due to faulting	Sedimentation under fresh-water lake condition with the association of marginal lacustrine character of sand layers	Lacustrine
Rapid subsidence due to faulting	Sedimentation under freah-water lake condition	Lacustrine
Block faulting and the formation of sub-basin	Erosion of basement rocks/Alluvial sedimentation	Unconformity/Alluvial fan

faults in the western margin have been intermittenly reactivated throughout the basin-filled history.

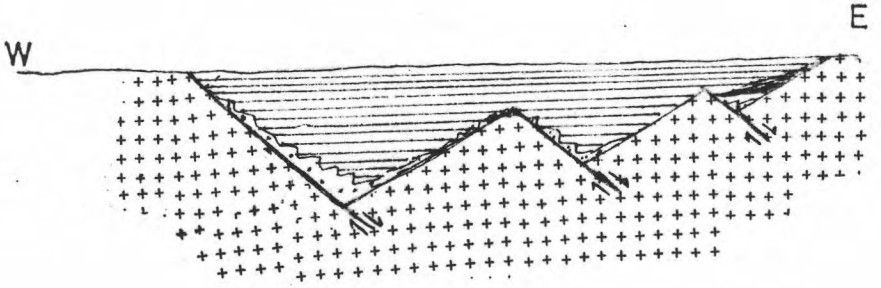
Local subsidence and uplifting within the Li basin are also recognized from the pattern vertical and lateral facies changes which are believed to be partially responsible by the differential, post depositional, compactional induced subsidence, and tectonic faulting.

In conclusion, the nature and characteristics of Tertiary sediments in the basin, namely, depositional environment, lithology, thickness and lateral continuity of sedimentary unit are controlled by subsidence which may be caused by faulting or combination of both. The tectonic regime and the load of sediments infilled are, however, believed to be the major factors that controlled faulting and compaction. The schematic model of the Li basin development and depositional history is shown in Figure 4.3.1.

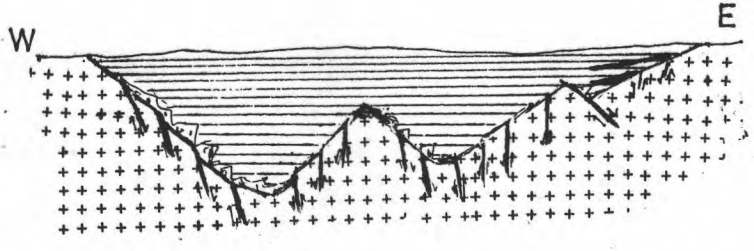
Detailed information regarding the tectonic activities of 5 main sub-basin of the Li basin are presented in Figure 4.3.2.



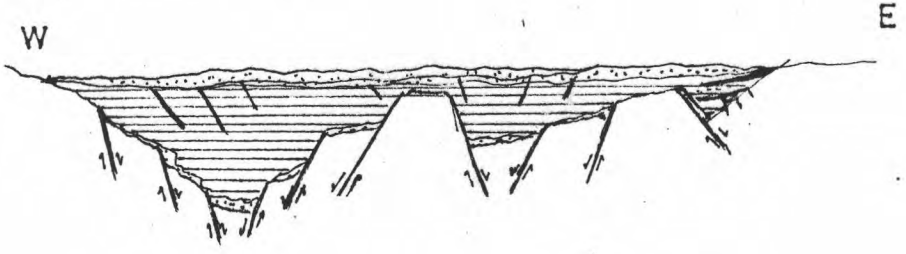
a) Initial Stage of Li graben and deposition of Li Fm.



b) Early middle stage of Li basin development with the deposition of Ban Pa Kha and Ban Hong Fm.



c) Late middle stage of Li basin development with the deposition of Ban Pu and Ban Mae Long Fm.



d) Late stage of Li basin development with Late Miocene unconformity and deposition of Quaternary deposits

Figure 4.3.1 The schematic model of the Li basin development and depositional history.

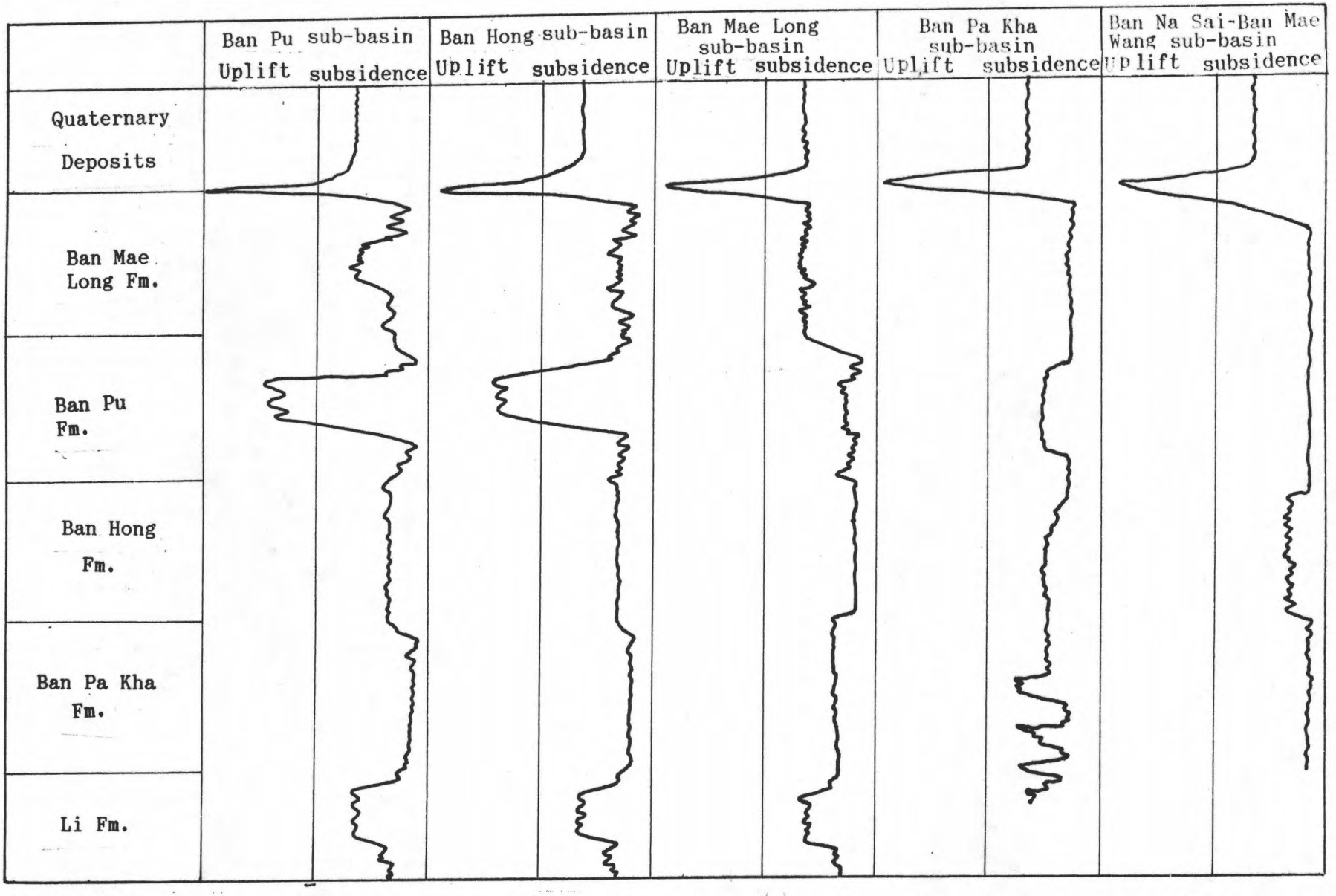


Figure 4.3.2 Detailed information regarding the tectonic activities of 5 main sub-basin of the Li basin.