# CHAPTER 4

# DEPOSITIONAL ENVIRONMENT

The lithofacies is the characteristics of sedimentary rock which indicate depositional environment. It is generally characterised by lithology, geometry, sedimentary structure, and fossil. The facies sequence and association are groups of facies that occur together and are considered to be genetically and environmentally related. Besides, the facies and facies association represent the depositional environment and depositional system, respectively.

In the Thung Yai-Khlong Thom area, the Trang group is believed to be deposited under the fluvio-lacustrine with occasional marine influxes of lagoonal to fluviatile environments. According to the analysis and interpretation of the geology and lithofacies. The different lithostratigraphic units are considered in terms of lithofacies for further uses in the reconstruction of depositional environments.

## 4.1 Facies analysis

The lithostratigraphic units of the Trang group in the Thung Yai-Khlong Thom area includes 4 formations and 9 lithofacies; namely, the Khlong Min formation, Lam Thap formation, Sam Chom formation, and Phun Phin formation, respectively, in ascending order. The Khlong Min formation consists of 4 lithofacies; mudstone intercalated with fossiliferous limestone, siltstone, calcareous sandstone, and fossiliferous limestone lithofacies, respectively, in ascending order. The Lam Thap formation contains of 2 lithofacies; thick-bedded arkosic sandstone, and siltstone interbedded with mudstone lithofacies. The Sam Chom formation consists mainly of conglomerate, and conglomeratic sandstone with poorly cemented coarse-grained sandstone. Finally, the Phun Phin formation predominantly consists of 2 lithofacies; fine-grained sandstone and fanglomerate lithofacies.

The lowest unit of the Khlong Min formation within the Thung Yai-Khlong Thom area is the mudstone intercalated with fossiliferous limestone lithofacies(I). The formation unconformably overlies the Sai Bon formation of Triassic rocks indicated by the basal conglomerate at Khao Khom in the western part of Thung Song. This lithofacies is commonly characterised by grayish brown to gray mudstone with thin-bedded fossiliferous limestone and bituminous jets. The limestone is microscopically designated as biomicrite and biosparite. This lithofacies composes of abundant fossils such as estheria, ostracods, sporepollens, and vertebrates etc., (Table 4.1) graded bedding, hummocky, load casts, and liminated structures. The overall geometry of this lithofacies is confined only in the central to southwest part as tabular (Table 4.2). The graded bedding (Figure 3.23) shows the gradual change in grain size from medium-grained sand to clay with maximum thickness 3-5 metres. This lithofacies underlies the siltstone lithofacies with gradational contact. The characteristics of the mudstone intercalated fossiliferous lithofacies is summarised and presented in Table 4.2.

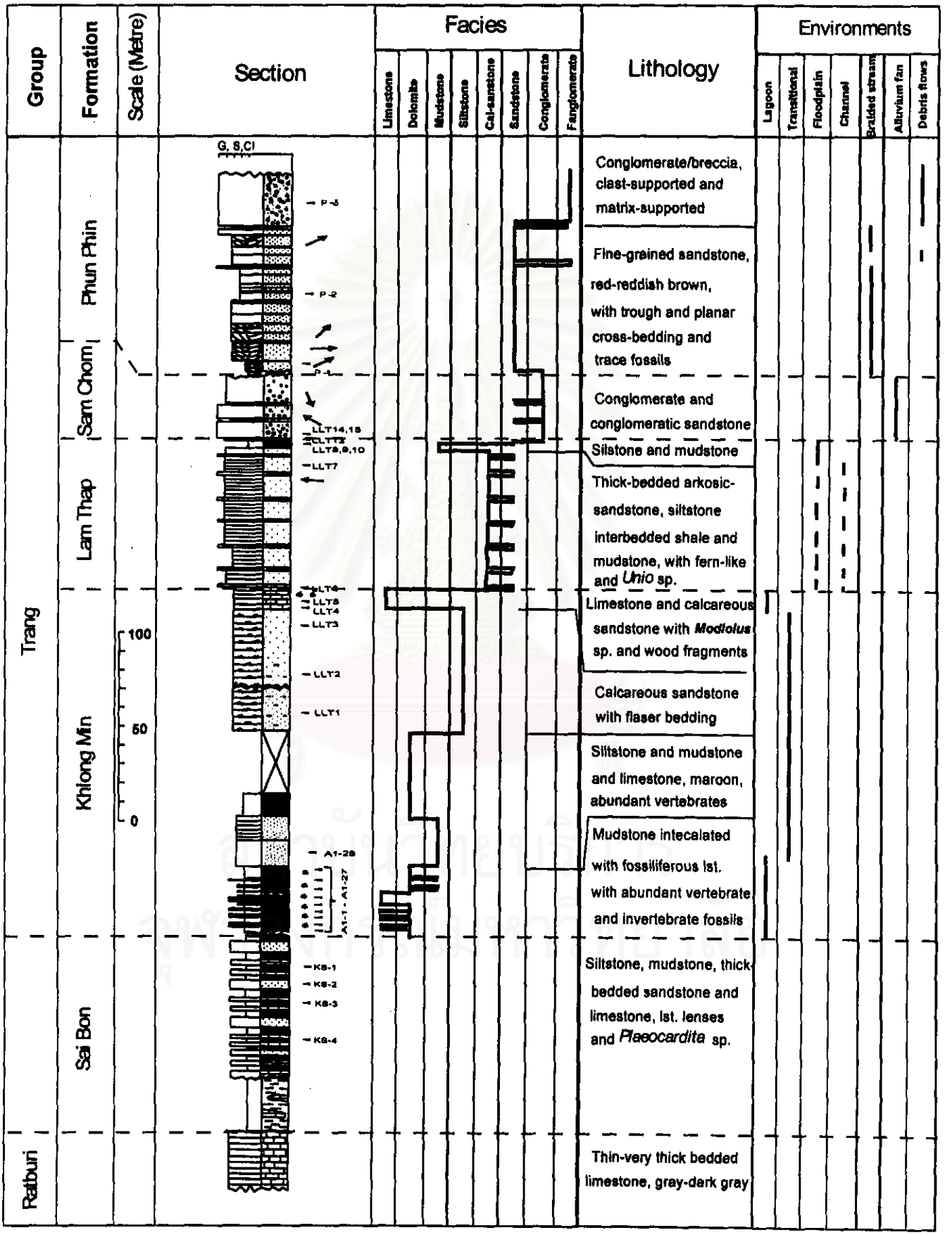
The siltstone lithofacies (II) of totally 51-67 metres thick is mainly characterised by the association of thick-to very thick-bedded reddish-brown to maroon siltstone. The lowest part of this lithofacies is represented by thick-bedded reddish-brown to maroon siltstone interbedded with thin-bedded limestone with abundant fossils, particularly vertebrates of hybodont shark, *Lepidotes*-like actinopterygians, and lungfishes etc. Petrographically, biomicrite is confined as thin-bedded limestone with abundant ostracods, and gradually passing upward to mudstone and siltstone in the upper part. The overall geometry is widely distributed only in the central part of the study area as tabular.

About 15-60 metres thick of the sandstone lithofacies (III) is generally characterised by yellowish-brown medium-grained sandstone, well sorted, with calcareous cement. The overall geometry is distributed only central part of the study area as tabular. This lithofacies overlies siltstone lithofacies (II) with transitional contact. The sedimentary structures are predominantly flaser bedding and small-scale

Table 4.1 Summarised interpretation of depositional environments of the Trang group

| Formation | Litho-facies | Lithology | | Geometry | | Sedimentary structure | Fossil |
|---|---|---|---|---|---|---|---|
| | | Colour | Lithological characteristics | Thickness (metre) | Distribution | | |
| Phun Phin | IX | Red to reddish brown | Conglomerate/ breccia | 19.5-25 | Local | Sandstone lenses | - |
| | VIII | Red to reddish brown | Fine-grained sandstone | 77-750 | Only central and southwest | Planar and trough cross-bedding, graded-bedding | Trace fossils |
| Sam Chom | VII | Yellowish brown | Conglomerate, conglomeratic sandstone and sandstone | 8-100 | Local | Graded-bedding, finning upword sequence | - |
| Lam Thap | VI | Reddish brown | Siltstone interbedded sandstone and mudstone | 2-20 | Cover the areas | Laminated, finning upward sequence, load casts | *Unio* sp., fern-like leaves |
| | V | Yellowish brown | Arkosic sandstone | 5-8 | Cover the areas | Planar cross-bedding, graded-bedding, load casts | - |
| Khlong Min | IV | Gray | Limestone and cal-sandstone | 7-10 | Only central tabular/prism | Laminated | *Modiolus* sp. |
| | III | Yellowish brown | Calcareous sandstone | 15-60 | Only central as tabular | Flaser bedding | - |
| | II | Maroon | Siltstone and limestone | 51-67 | Only central as tabular | Limestone lenses | |
| | I | Gray to grayish brown | Mudstone intercalated with fossiliferous limestone | 27-52 | Only central to southwest as tabular | Hummocky, load casts, lamination, graded bedding | Pollens, invertebrates, vertebrates |

Table 4.2 The characteristics of the Trang group and facies analysis



cross strata. The upper part of this lithofacies is represented by thin-bedded fine-grained sandstone, commonly laminated.

Overlying the sandstone lithofacies (III) is the upper bed fossiliferous limestone lithofacies (IV). It is characterised by the association of light gray to gray fossiliferous limestone interbedded with yellowish brown medium-grained sandstone, well-sorted with common flaser bedding, of totally 7-10 metres thick. The overall geometry of this lithofacies is prism and distributed only in the central part of the study area. The interbedded sandstone is well laminated with calcareous cement. The fossiliferous limestone contains abundant bivalves of *Modiolus* sp. and wood fragments. The lithofacies (IV) underlies the Lam Thap formation with sharp contact. The characteristics of the facies association of Khlong Min formation are summarised in Table 4.2.

The Lam Thap formation, with the thickness ranges from 30 to 197 metres, is generally characterised by alternating beds of siltstone, shale interbedded with thin-to medium-bedded sandstone, and very thick-bedded arkosic sandstone with common planar cross-bedding and graded bedding. The lateral facies changes are very common. The Lam Thap formation consists of two lithofacies; the thick-bedded arkosic sandstone (V) and siltstone interbedded mudstone lithofacies (VI).

The arkosic sandstone lithofacies (V) is characterised by thick-to very thick-bedded, yellowish brown to brown with graded bedding, planar cross-bedding and load casts. The fining upward sequences show the gradual change in grain size from sand to clay with maximum thickness of each cycle of less than 5-8 metres. The overall geometry of this lithofacies is tabular over the study area. The lithofacies (V) underlies the siltstone interbedded mudstone lithofacies (II) with sharp contact.

The siltstone interbedded mudstone lithofacies (VI) is represented by fining upward sequences of sandstone and mudstone alternating with sandstone mudstone

thinly interbedding. At least 6 cycles of fining upward units and sandstone to mudstone thinly interbedding have been recongnized. The overall geometry of this lithofacies is tabular covering over the study area. The maximum thickness of each cycle is approximately 2-20 metres. The characteristics of the facies association of the Lam Thap formation are summarised at Table 4.2.

Overlying the Lam Thap formation is the conglomerate and conglomeratic sandstone of the Sam Chom formation of lithofacies (VIII). It is characterised by series of conglomerate, conglomeratic sandstone and thin-to medium-bedded sandstone with predominantly graded bedding. The conglomerate is matrix-supported and clasts are made up mainly of quartz, chert, sandstone and fragments of volcanic rocks. The upperpart of the Sam Chom formation is mostly very loose medium-coarse sandstone, well sorted with angular to subangular. The lower part of this formation is marked locally by medium-bedded, medium-grained sandstone. The overall geometry is lense-type with maximum thickness of the lithofacies (VII) is about 8-100 metres.

The lowermost Phun Phin formation conformably overlies the Sam Chom formation and unconformably underlies the Tertiary rocks. It is characterised by red to reddish brown fine-grained sandstone and conglomerate/breccia. This formation consists of 2 lithofacies; the fine-grained sandstone (VIII) and fanglomerate (IX).

The lower part of the Phun Phin formation is the red to reddish brown fine-grained sandstone lithofacies (VIII), thin-to very thick-bedded with planar and trough cross-bedding. The upper part of this lithofacies of about 20 metres thick consists of reddish-brown thin-to medium-bedded sandstone interlayer with conglomerate. The boundary between fine-grained sandstone lithofacies (VIII) and the overlying lithofacies (IX) is a sharp contact.

Overlying the fine-grained sandstone lithofacies (VIII) is the fanglomerate lithofacies (IX) of about 28 metres thick. It is characterised by conglomerate/breccia

with both clast and matrix-supported. Clasts are made up of quartz, chert, quartzite, sandstone and rock fragments. Generally, this lithofacies unconformably underlies the Tertiary rocks indicated by basal conglomerate in a few places of the study area.

## 4.2 Deposition environments

The interpretation of the depositonal environments of the lithofacies is essentially based on lithology, geometry, sedimentary structure and fossils and compare with the facies models concerned.

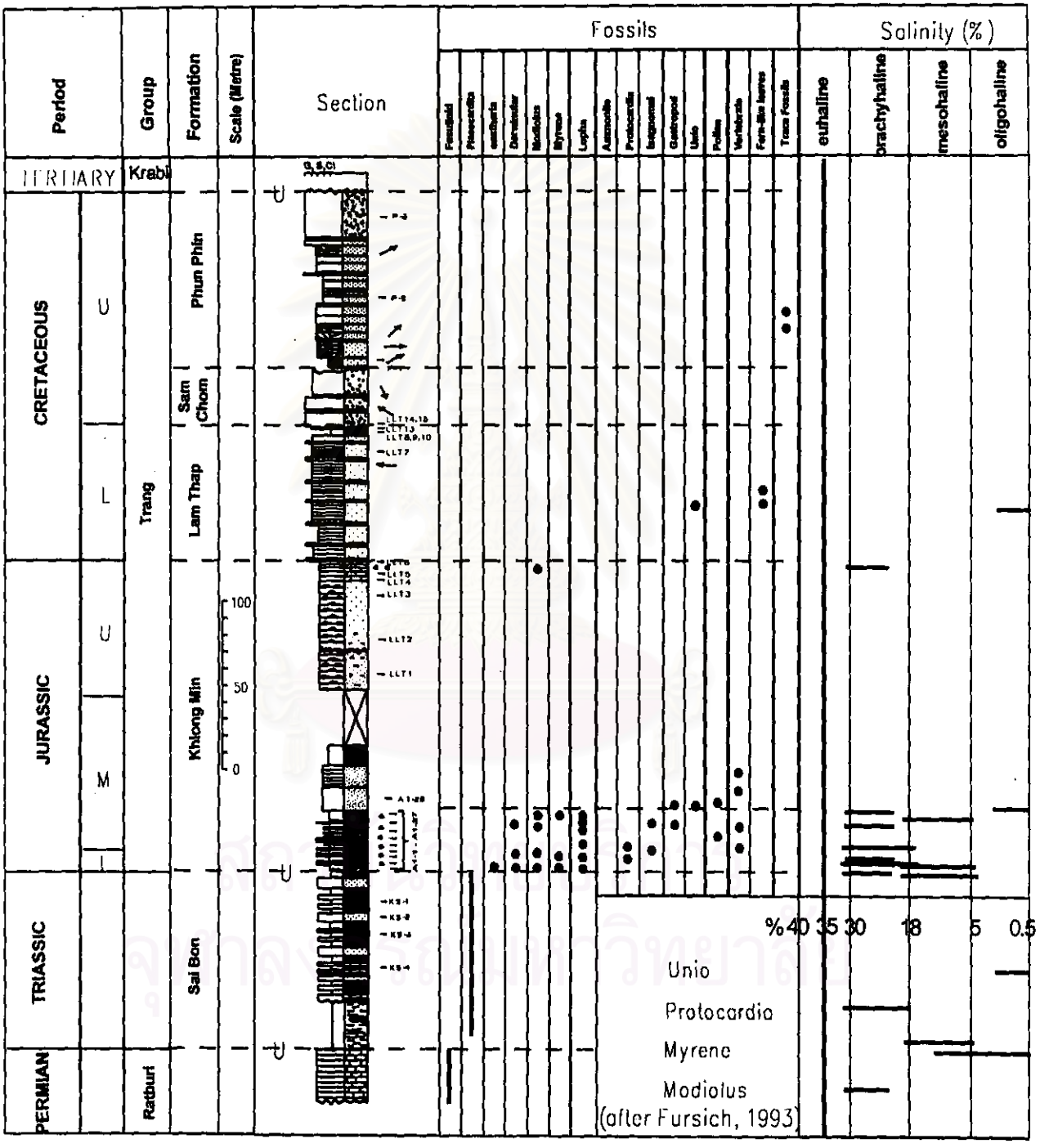
For the reconstruction of all possible depositional environment as summarised from the detailed facies analysis are shown in Table 4.1.

### 4.2.1 Depositional environment of the Khlong Min formation

Under the present investigation, the Khlong Min formation in Thung Yai-Khlong Thom area is believed to be deposited in the transitional to fluviatile environment with marine influxes of lagoonal environment. The lowest part, the mudstone intercalated with fossiliferous limestone lithofacies (I) consists of abundant vertebrate and invertebrate fossils, and flaser bedding, lamination and graded bedding sequences. This lithofacies (I) as compared with the studies of Fursich and Werner (1986), Fursich (1993), Raksaskulwong et al. (1989), Chonglakmani (1990), Suwanpredit et al. (1990), Zuoqi (1993), Meesook and Grant-Mackie (1994), and Jumnongthai (pers. comm., 1999) can be conclusively determined to deposit under the gently subsiding lagoonal environment. According to Fursich and Werner (1986), and Fursich (1993), the salinity-controlled benthic macroinvertebrate association indicates salinity-range from brachyhaline to mesohaline (Table 4.3).

After the mudstone intercalated with fossiliferous limestone of lithofacies (I) were deposited, the environment is believed to be gradually changed from transitional

Table 4.3 The fossils of the Trang group and locality



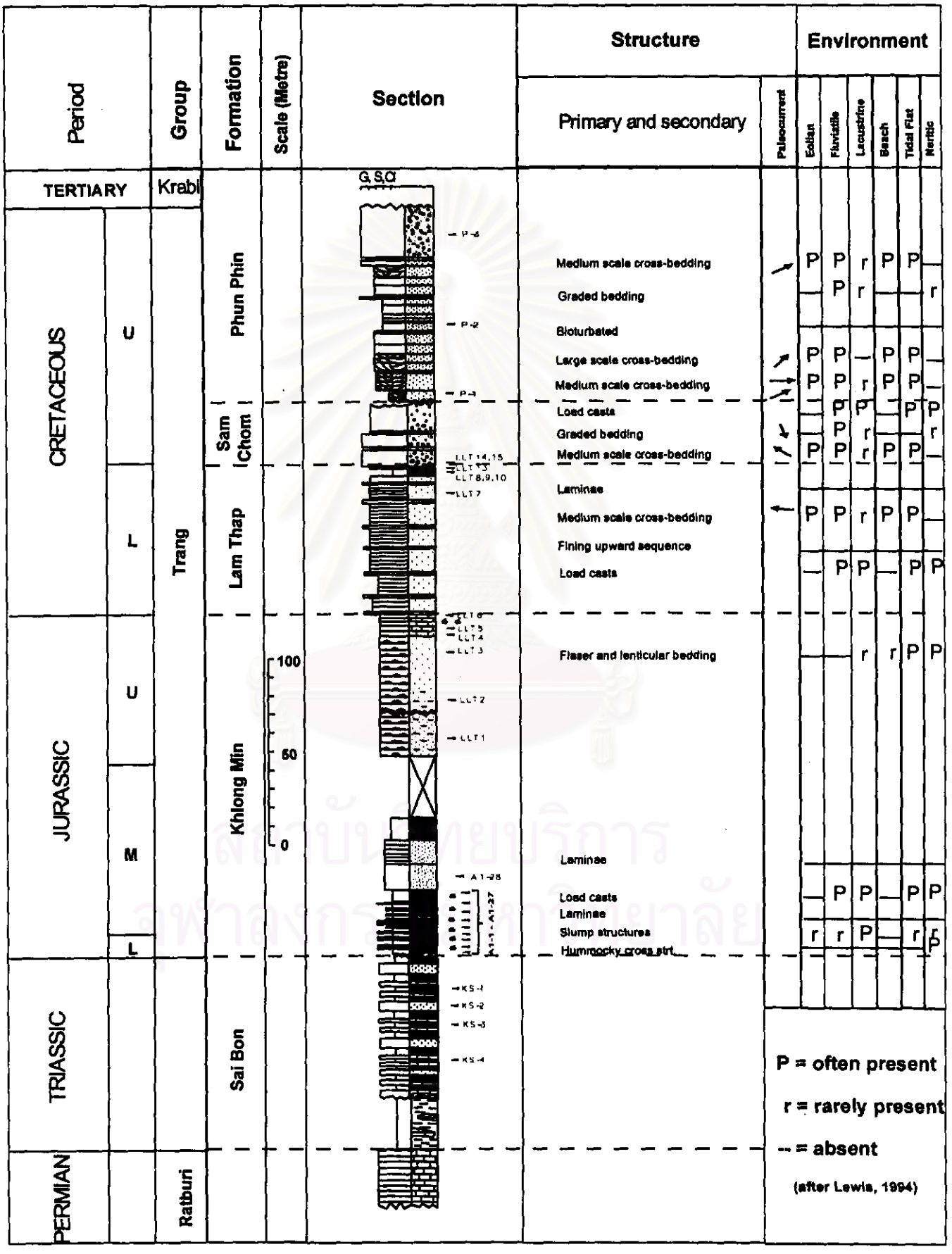
to continental origin due to uplifting or marine regression during the Jurassic to Cretaceous times. Besides, the siltstone lithofacies (II), contains abundant invertebrate of ostracods-*Darwinulla* sp., smaller foraminifera-*Classopolis* sp., *Aggerella circumtexta* sp., and vertebrate-hybodont shark, *Lepidotes*-like actinopterygians and lungfishs etc., also suggests the fresh water lacustrine environment in the coastal plain with occasional marine influx. In conclusion, this lithofacies (II), as compared with Lewis and McConchie (1994) indicate sedimentation under the gently subsiding fresh water lacustrine environment with occasional marine influx. The thickness of siltstone lithofacies is approximately 51-67 metres.

After the lacustrine sedimentation of siltstone and limestone of lithofacies (II), the Thung Yai-Khlong Thom area was prograding southwestly. With continuous uplifting and occasional marine trangression, the depositional environment have changed from fluviatile environment in lower part and gradually passing upward to transitional marine environment again in the upper part, indicate by sedimentary structures of flaser bedding in the calcareous sandstone lithofacies (III)(Table 4.4).

Finally, the uppermost part of the Khlong Min formation is fossiliferous limestone lithofacies (IV), the depositional environment have changed to lagoonal environment. The thick sequence of fossiliferous limestone interbedded with yellowish-brown calcareous sandstone with flaser bedding and abundant bivalve of *Modiolus* sp. (Table 4.3). Petrographically, the presence of fine-grained quartz in matrix of fossiliferous limestone indicates the infuence of terrigenus sediments in the carbonate lagoonal sequences. The depositional environment of fossiliferous limestone lithofacies (IV), as compared with the studies by Fursich and Werner (1986), and Fursich (1993), is deposited under the lagoonal environment.

Therefore, the sedimentary sequences of Khlong Min formation is analysed in terms of lithofacies association of lithofacies (I) to (IV) representing the transitional to fluviatile environment with occasional marine influxs of lagoonal environment. The

Figure 4.4 Sedimentary structures of the Trang group



facies association of the Khlong Min formation and environmental interpretation are summarised and presented in Table 4.5.

### 4.2.2 Depositional environment of the Lam Thap formation

After the deposition of the Khlong Min formation the area of Thung Yai-Khlong Thom was entirely under the influence of continental environment of fluviatile sedimentation of approximately 30 to 197 metres thick. The least 6 fining upward sequences indicate typical fluviatile of meandering stream origin.

At the lowest part, the thick-bedded arkosic sandstone lithofies (V) is characterised by thick-to very thick-bedded arkosic sandstone interbedded with maroon laminated siltstone with common planar cross-bedding, graded bedding of fining upward sequences. The depositional environment is interpreted to be fluviatile of meandering stream origin.

The Lam Thap formation commonly exhibits lateral facies change from the thick-bedded arkosic sandstone of lithofies (V) mainly in the north and northeast to siltstone interbedded with mustone of lithofacies (VI) mainly in the west to southwest of the study area. The paleocurrent of this formation is mainly from the east to west direction (285 direction, Table 4.2 ). Besides, the presence of fern-like leaves and bivalve of *Unio* sp., as compared with the studies by Asama et al. (1983), Fursich and Werner (1986), Raksaskulwong (1994), Walker (1984), Miall (1984), and Lewis and McConchie (1994) also indicates the fluviatile environment of presumably meandering stream origin.

The characteristics of facies association of the Lam Thap formation and their environmental interpretation are summarised and presented in Table 4.5.

Table 4.5 Summarised interpretation of depositional environments of the Trang group

| Formation | Litho-facies | Lithology | | Geometry | | Sedimentary structure | Fossil | Proposed Depositional Environment | ←Transgression Regression→ |
|---|---|---|---|---|---|---|---|---|---|
| | | Colour | Lithological characteristics | Thickness (metre) | Distribution | | | | |
| Phun Phin | IX | Red to reddish brown | Conglomerate/ breccia | 19.5-25 | Local | Sandstone lenses | - | Debris flows | |
| | VIII | Red to reddish brown | Fine-grained sandstone | 77-750 | Only central and southwest | Planar and trough cross-bedding, graded bedding | Trace fossils | Fluviatile (Braided) | |
| Sam Chom | VII | Yellowish brown | Conglomerate, conglomeratic sandstone and sandstone | 8-100 | Local | Graded bedding, finning upword sequence | - | Alluvial fan | |
| Lam Thap | VI | Reddish brown | Siltstone interbedded sandstone and mudstone | 2-20 | West & southeast of the areas | Laminated, finning upward sequence, load casts | *Unio* sp., fern-like leaves | Fluviatile (meandering) | |
| | V | Yellowish brown | Arkosic sandstone | 5-8 | North & northeast of the area | Planar cross-bedding, graded bedding, load casts | - | | |
| Khlong Min | IV | Gray | Limestone and cal-sandstone | 7-10 | Only central part tabular/prism | Laminated | *Modiolus* sp. | Lagoonal | |
| | III | Yellowish brown | Calcareous sandstone | 15-60 | Only central part as tabular | Flaser bedding | - | Fluviatile to transitional marine | |
| | II | Maroon | Siltstone and limestone | 51-67 | Only central part as tabular | Limestone lenses | | Lacustrine with marine influx | |
| | I | Gray to grayish brown | Mudstone intercalated fossiliferous limestone | 27-52 | Only central to southwest as tabular | Hummocky, load casts, laminating, graded bedding | Pollens, invertebrates, vertebrates | Lagoonal | |

### 4.2.3 Depositional environment of the Sam Chom formation

The lowest part of the Sam Chom formation is characterised by medium-bedded, medium-grained sandstone with planar cross-bedding and sharp contact with the underlying arkosic sandstone of the Lam Thap formation. The study by Bunopas (1981) reveals that the tectonic events was very strong during the Lower Cretaceous and consequently caused the uplifting in this area, especially in the northern and northeastern parts. The sedimentary sequences and geometry are isolated lense deposits, indicated by diversified type/size of clasts of conglomerate. From field evidences of fining upward sequence, graded bedding and random pattern of paleocurrents, northwest (330 direction) and southwest (178 direction), as compared with the study of Raksaskulwang (1994). These strongly suggest that the sediments were deposited under the alluvium fan environment (Reading, 1978 and Miall, 1984). In conclusion, the Sam Chom formation represents the alluvial fan deposits.

The characteristics of facies of the Sam Chom formation and their environmental interpretation are summarised and presented in Table 4.5.

### 4.2.4 Depositional environment of the Phun Phin formation

After the deposition of fluviatile sediments of the Lam Thap and Sam Chom formations, the northwestern and northeastern parts of the Thung Yai-Khlong Thom area have been abruptly uplifted, this is believed to be controlled by a series of faulting and granite emplacement in Late Cretaceous to Tertiary (Charusiri, 1989 and Kosuwan, 1996).

The lower part of the sedimentary sequence, represented the fine-grained sandstone lithofacies (VIII), is characterised by medium to very thick-bedded, parallel bed type, graded bedding with common planar, trough cross-bedding, and rip-up clasts, As compared with the studies by Raksaskulwong (1994), Miall (1984), and

Lewis and McConchie (1994), this lithofacies suggests that it was deposited under the fluviatile environment of presumably braided stream with the eastward paleocurrent in the lower part and gradually change over to the northeastward in the upper part.

The upper part of the fine-grained sandstone of lithofacies (VIII) is overlain by the the fanglomerate lithofacies (IX) with sharp contact and characterised by conglomerate/breccia with both clasts-and matrix-supported. As compared with Raksaskulwong (1994), the sediments of lithofacies (IX) were deposited under the fluviatile environment of presumably debris flows origin (Miall, 1984). In conclusion, the fanglomerate lithofacies (IX) indicates debris flows deposits.

4.3 Geological evolution and reconstruction

In the present investigation, an attempt has been made to analyse the sedimentary sequences, tectonism and facies model of the Thung Yai-Khlong Thom area. The Trang group mainly characterised by associations of mudstone, fossiliferous limestone, sandstone and conglomerate are believed to be deposited in the transitional to fluviatile environment with occasional marine influxes of nearshore lagoonal environment in the lower part and gradually passing upward change to fluviatile environment of presumably meandering stream, braided stream and debris flow origins.

During the Carboniferous through Permian periods, there was the deposition of shallow marine limestone of the Ratburi Group. It is also evident that deposition under the shallow marine environment of carbonate sediments began over the the wide area during Lower or Middle Permian. The Permian carbonate sediments of totally less than 800 metres thick conformably overly the clastic rocks of the Kaeng Krachan Group (Tantiwanit et al., 1983).

The sedimentary basin became shallow marine during the Permian to Triassic period. Therefore, the sediments were gradually deposited under shallow marine to continental environments.

During the Upper Triassic period, the long episode of continent-continent collision of Shan-Thai/Indochina came to an end leading to the culmination of marine sedimentary basins and commencing of the continental deposition. There was a transitional environment of marine facies grading upward to fluviatile facies toward the Jurassic-Cretaceous of the Trang group.

During the Triassic-Lower Jurassic time (Figure 4.5, stage I), the marine regression was represented by the deposition of limestone and shale with overlying sandstone of the Sai Bon formation.

After the deposition of the Sai Bon formation, the study area was under the short interval of marine influence for the deposition of the lithofacies I of the Khlong Min formation under the lagoonal environment. After that, the area was uplifted for the deposition of lithofacies II, III of the Khlong Min formation during the Middle Jurassic to Lower Cretaceous under the fluvio-lacustrine environment. Towards the end of the Lower Cretaceous, there was another marine incursion to deposit the lithofacies IV of the Khlong Min formation under the lagoonal environment.

During the Late Jurassic to Cretaceous, emplacement of the Khao Phanom granites followed by the accumulation of sandstone, mudstone and shale of the Lam Thap formation; conglomerate and conglomeratic sandstone of the Sam Chom formation and fine-grained sandstone of the Phun Phin formation, respectively, under the non-marine environment.

After the deposition of the Phun Phin formation, the area had undergone tectonic deformation of the Himalayan orogeny followed by the erosion of pre-

existing rocks towards the end of the Mesozoic and probably the Lower Tertiary. From the Middle Tertiary onward, sediments of fluvio-lacustrine origins were deposited in the fault-block or depression area forming the Krabi Group.

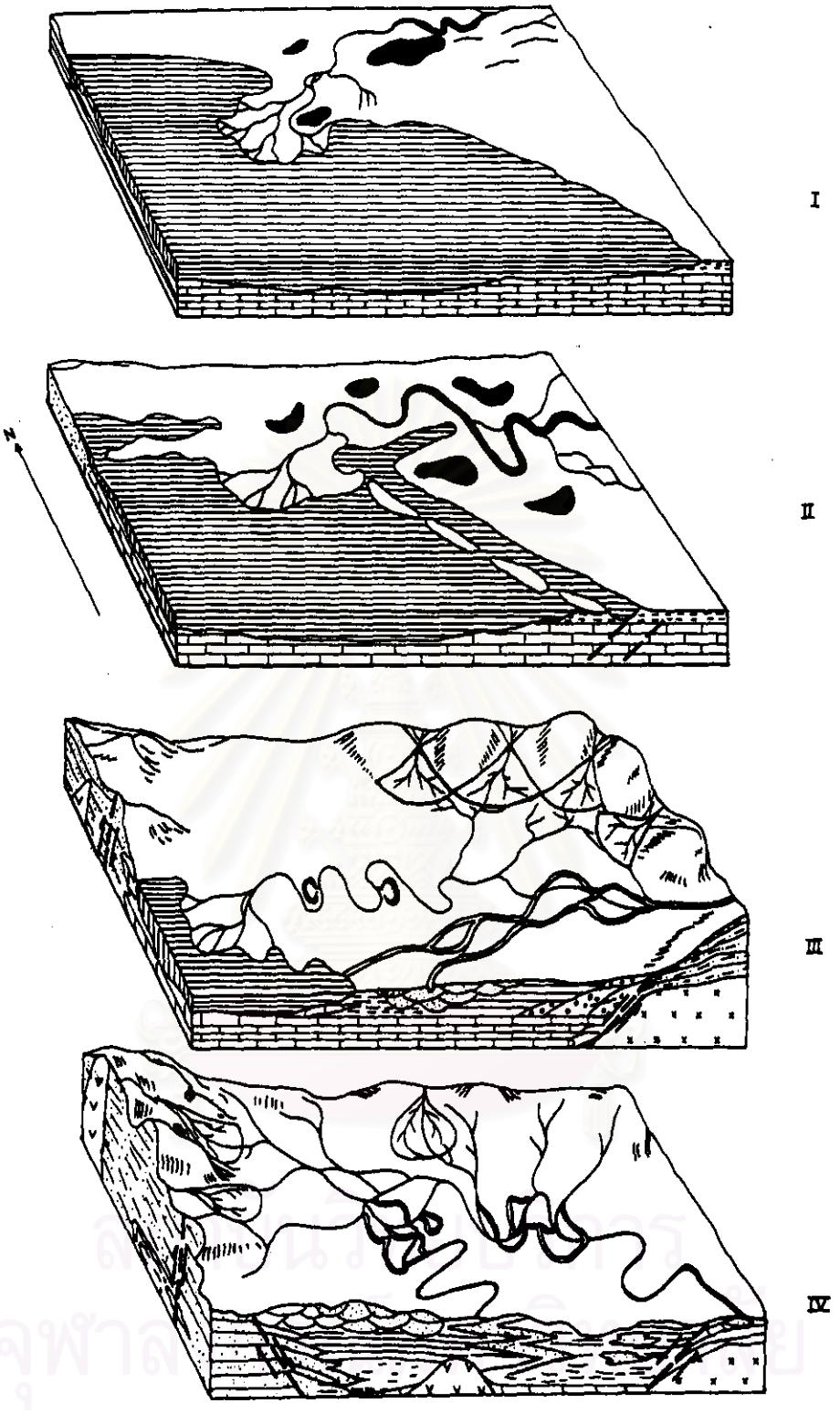



Figure 4.1 Schematic models illustrating of depositional environment of the study area, I=During Triassic-Lower Jurassic, II=Middle Jurassic-Lower Cretaceous, and III to IV=Lower Cretaceous-Upper Cretaceous