CHAPTER IV
LITHOSTRATIGRPHY

The objective of this chapter is to synthesis various lithofacies sequences encountered in the studied carbonate sediments into lithostratigraphic member for subsequent use in the interpretation of their depositional environments.

4.1 Stratigraphic Keys and Stratigraphic Correlation.

The establishment of lithostratigraphic sequence and correlation of Khao Lamphean carbonate sediments is based on the distribution of various distinctive microfacies as well as occurrence important faunas such as corals, fusulinids and giant bivalve.

4.1.1 Distinctive microlithofacies keys.

Since 9 distinctive microlithofacies are already described in the preceding chapter, their distributions are used as the stratigraphic key as follows:

The microfacies II is rare and found only in the middle part of measured section A (A12/2, A15/2), measured section B (B24/2, B29), measured section C (C9/2, C14) and measured section D (D7, D15, D36).

The microfacies III is found only in the horizons B12 and C2.

The microfacies IV is found only in the top of the section E (E3).

The sparry calcite cement, which is the characteristic of microfacies VII (Biosparite) and microfacies VIII (Biopelsparite), occurred only in the top part of measured section A, B and C including the lower part of the measured section E (E15).

4.1.2 Paleontological keys.

The occurrence of distinctive faunas such as corals, fusulinids and giant bivalves, will be also used as the stratigraphic keys as follows:

The fusulinids *Conodofusiella* sp. are first appeared in the top of section B and not be discovered in the section A, C, and D.

In the section E fusulinids are not abundant and *Sumatrina* sp. are not present.

The massive rugose corals, Genus *Multimurinus* sp. and *Ipciphyllum* sp. are abundantly accumulated as the biostrome especially in the lower part of the measured section A, B, C and D. In elsewhere , they are scattered as small fragmental colonies.

The tabulate corals *Sinopora* sp. are found in abundance only in the measured section E.

The fasciculate corals *Waagenophyllum* sp. found only in the lower part of the section D and not present in every sections.

The Alatoconchids giant bivalves are obviously discovered in the middle part of the measured section A (A12/2, A15/2), measured section B (B24/2 B29), measured section C (C9/2, C14) and measured section D (D7).

Accordingly, the correlative lithostratigraphic sequence of Khao Lamphean carbonate sediments from 5 measured rock sections can be established as illustrated in Figure 4.1.

In addition, the representative composite section of lithostratigraphic sequence of Khao Lam Phean is shown in Figure 4.2. The composite sequence is subdivided into 4 lithostratigraphic units in ascending order as, Wat Khao Lamphean Member (WKL), Ban Chon Muang I Member (BCM1), Ban Chon Muang II Member (BCM2) and Ban Phu Noi Member (BPN) respectively, and their comparative characteristic are summarized in Table 4.1.

4.2 Lithostratigraphic Units

4.2.1 Wat Khao Lamphean Member (WKL).

This member is named in accordance with the name of Wat Khao Lamphean which is located in the northern part of the study area. This member is thickly to very thickly bedded micritic limestone containing some nodular and elongated chert.

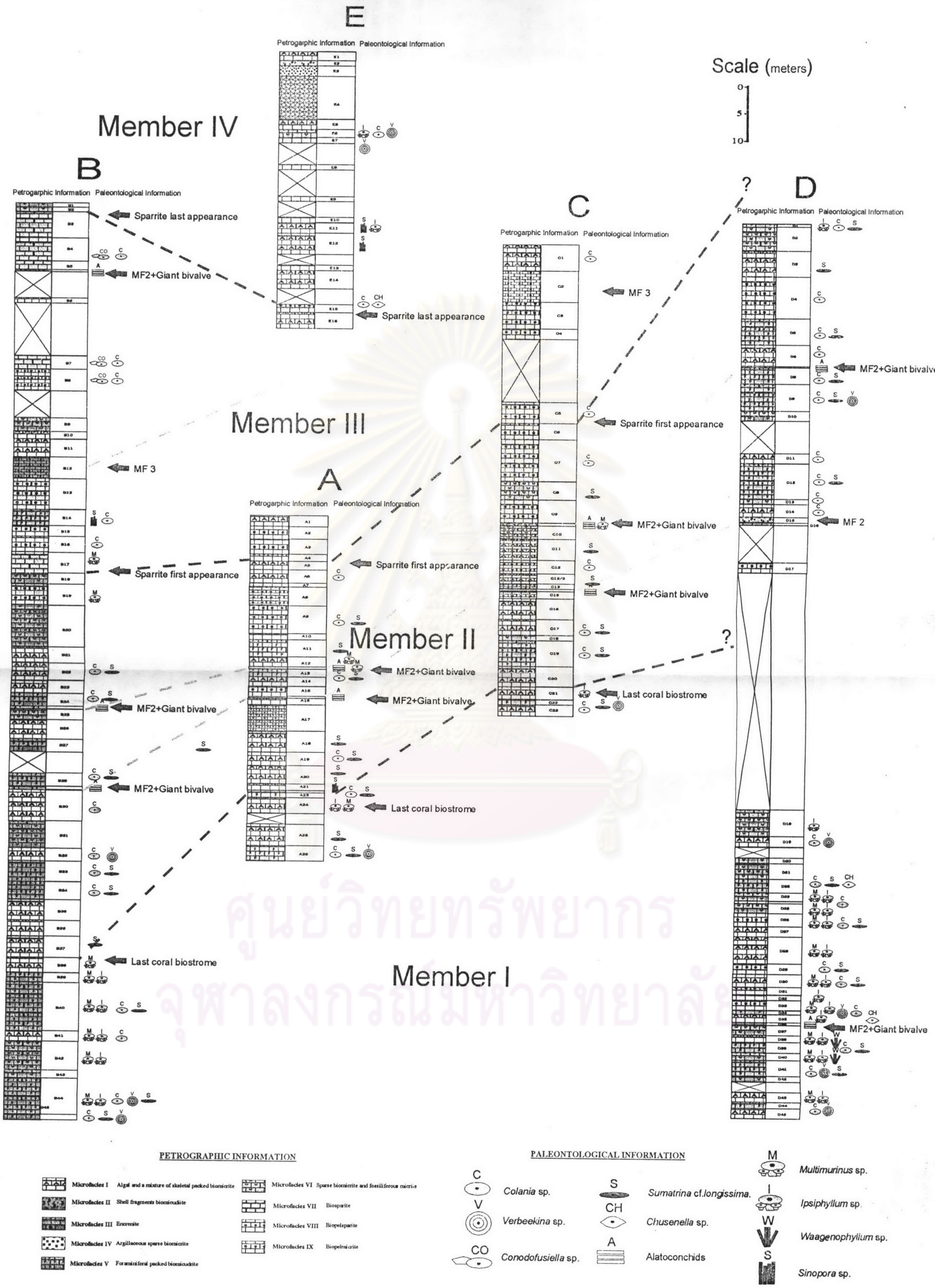

Figure 4.1 The correlative lithostratigraphic sequence from 5 measured rock sections of Khao Lamphean area.

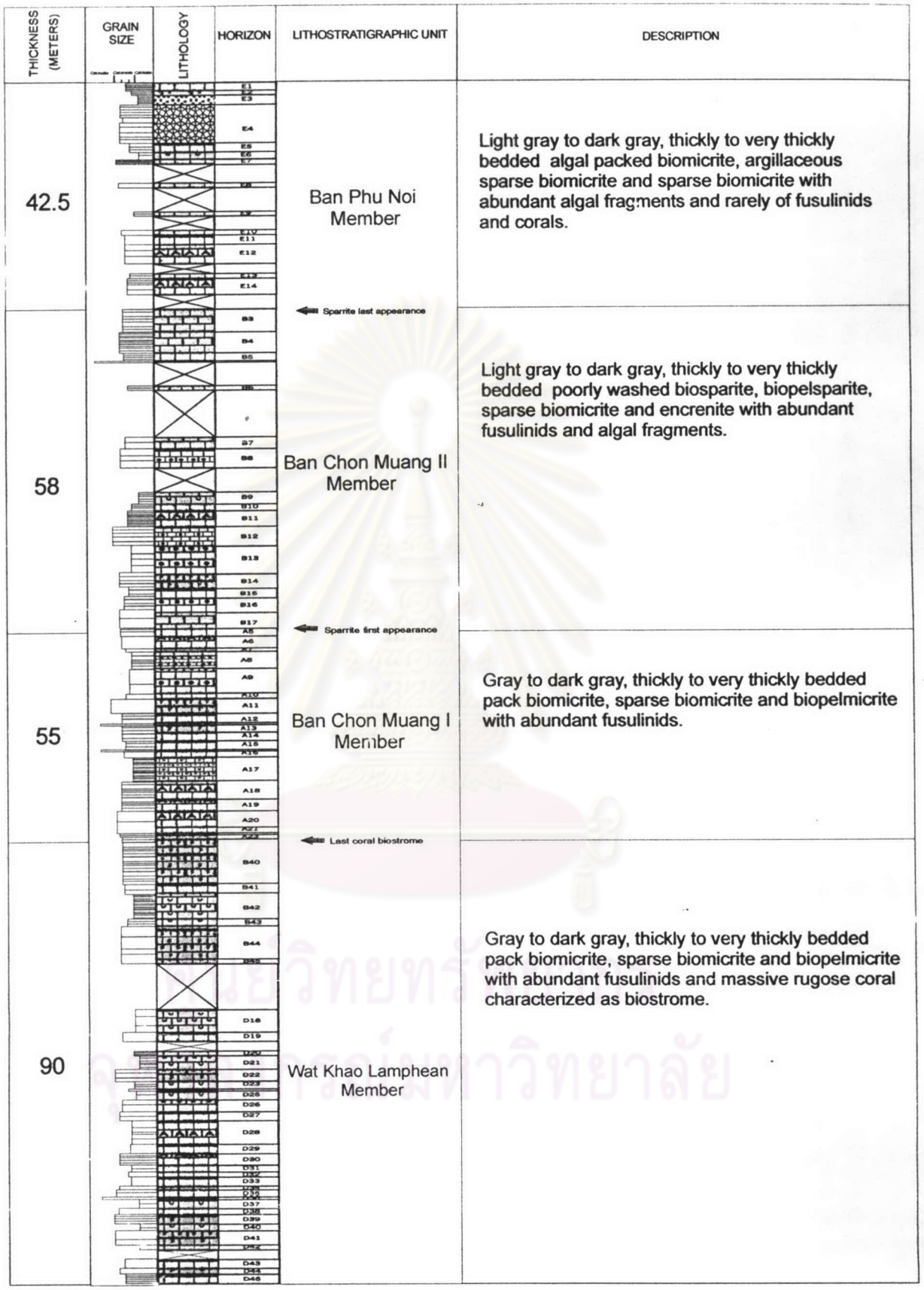

Figure 4.2 The representative composite section showing the lithostratigraphic sequence of the Permian Khao Lamphean carbonate sediments.

Table 4.1 A subdivision of lithostratigraphic unit of Khao Lamphean carbonate Sediments and their comparative characteristics.

Rock Unit A: Wat Khao Lamphean Member (WKL)	***Rock Unit B:*** Ban Chon Muang I Member (BCM1)	***Rock Unit C:*** Ban Chon Muang II Member (BCM2)	***Rock Unit D:*** Ban Phu Noi Member (BPN)
Thickness 90 meters	55 meters	58 meters	42.5 meter
Stratigraphic positions Lower Unit	Lower middle unit	Upper middle unit	Upper unit
Distinctive characteristics Massive coral appeared in biostrome	Fusulinids in abundant but rare corals	Sparry calcite cement	Algal in abundant but rare fusulinids
Lower boundaries Uncertain because the lowest part of the section D is not exposed	Last appearance of the coral biostrome	First appearance of sparry calcite cement	Last appearance of sparry calcite cement
Upper boundaries Last appearance of the coral biostrome	First appearance of sparry calcite cement	Last appearance of sparry calcite cement	Uncertain because the upper most part of the section E is not exposed
Microfacies *I,V,VI and IX*	*I,V and IX*	*I,III,V,VI,VII,VIII and IX*	*I,IV,VI*

The fossils are very abundant consisting of colonial rugose coral, fusulinids and algal fragments. Microscopically, the eminent microfacies are the microfacies I, V, VI and the microfacies II is rare.

The distinctive characteristic of this member is the obvious appearance of massive rugose corals in the biostrome.

The lower boundary of this member is uncertain due to its unexposed lowest part in the measured section D , where the upper limit is marked by the last appearance of the massive coral biostrome which is clearly located in the horizon A24, B38 and C21, but in the measured section D the last appearance of biostrome appears to be covered by topsoil probably between the horizon D17 and D18.

Accordingly, the probable type section of this member is composed of the lower part of the measured section D, from horizon D45 to D18 located at Wat Khao Lamphean, and the lower part of the measured section B from horizon B45 to B38. The type section of the Wat Khao Lam Phean Member is about 90-meters thick and, texturally can be can be divided into 4 distinct parts as shown in Figure 4.3.

The lower part of the number appears to begin at the continuation of horizon D45 to D34 characterized by the grain-supported biomicrite facies succession. The dominant microfacies are the microfacies I (algal and mixture of skeletal fragments packed biomicrite) and microfacies V (foraminifer biomicrudite).

The lower middle part extents from horizon D33 to D26 and are characterized by the pelletal facies succession. It consist predominantly microfacies IX (biopelmicrite) and subordinate microfacies I (algal and mixture of skeletal fragments packed biomicrite).

The upper middle part ranges from horizon D25 to B42 and are characterized by the mud-supported facies succession. The microfacies VI (sparse biomicrite and fossiliferous micrite) are dominate.

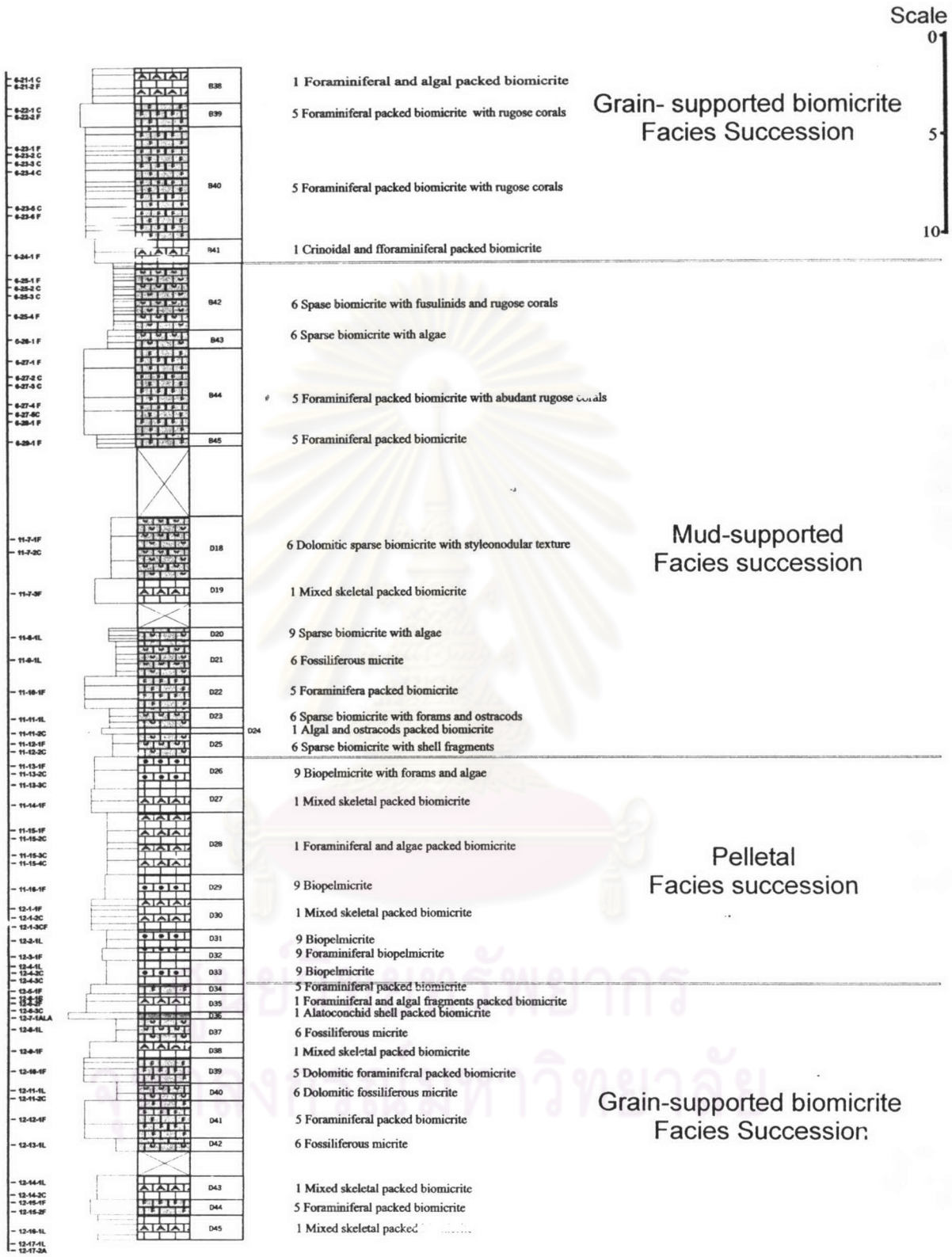

Figure 4.3 Vertical composite lithostratigraphic sequence of Wat Khao Lamphean Member (WKL).

The fossils are very abundant consisting of colonial rugose coral, fusulinids and algal fragments. Microscopically, the eminent microfacies are the microfacies I, V, VI and the microfacies II is rare.

The distinctive characteristic of this member is the obvious appearance of massive rugose corals in the biostrome.

The lower boundary of this member is uncertain due to its unexposed lowest part in the measured section D , where the upper limit is marked by the last appearance of the massive coral biostrome which is clearly located in the horizon A24, B38 and C21, but in the measured section D the last appearance of biostrome appears to be covered by topsoil probably between the horizon D17 and D18.

Accordingly, the probable type section of this member is composed of the lower part of the measured section D, from horizon D45 to D18 located at Wat Khao Lamphean, and the lower part of the measured section B from horizon B45 to B38. The type section of the Wat Khao Lam Phean Member is about 90-meters thick and, texturally can be can be divided into 4 distinct parts as shown in Figure 4.3.

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The upper middle part ranges from horizon D25 to B42 and are characterized by the mud-supported facies succession. The microfacies VI (sparse biomicrite and fossiliferous micrite) are dominate.

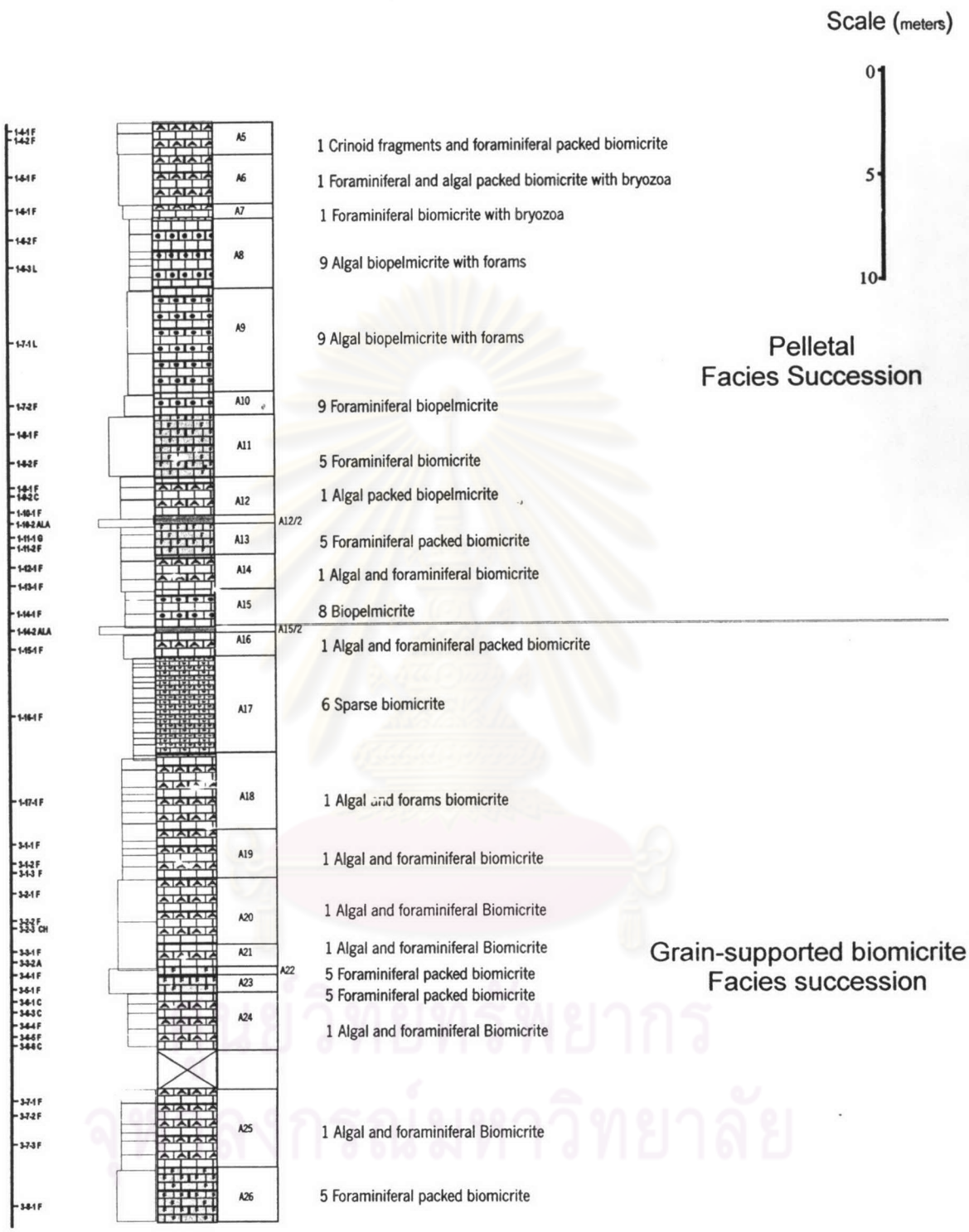

Figure 4.4 Vertical composite lithostratigraphic sequence of Ban Chon Muang I Member (BCM1).

4.2.3 Ban Chon Muang II Member (BCM2)

Like the fore-going member, the name of this member is derived from Ban Chon Muang located in the southern part of study area. The member is characterized by thickly to very thickly bedded bioclastic and peloidal limestone with sparry calcite cement at the upper sequence which is the distinctive character of the member. The algal fragments are extraordinarily abundant. Microscopically, the eminent microfacies are composed mainly of the microfacies VII (biosparite) and VIII (biopelsparite) and particularly microfacies III (encrenite) which is found only in this member.

This member is present in the measured section A, B, C and E. Its lower boundary is placed at the first occurrence of sparry calcite cement in the horizon A4, B17 and C5, whereas its upper boundary is marked by the last appearance of the sparry calcite cement in the horizon B3 and E15.

The complete succession of this member is present only in the measured section B. Accordingly, the section B is regarded to as the type section of the Ban Chon Muang II Member as shown in the Figure 4.5. The member is about 58 meters thick, and can be separated into 2 parts.

Its lower part range from horizon B17 to B8, and is characterized by grain-supported, mixed pellet and bioclastic facies succession consisting of a mixture of various microfacies i.e., the microfacies I, III, V, VI, VII, VIII and IX. Almost all microfacies show grain-supported fabrics of the various grain components.

Its upper part extents from horizon B7 to B3, and is characterized by the grain-supported algal biosparite facies succession consisting of the microfacies VII, biosparite containing that dominant algal fragments, and minor of microfacies I.

4.2.4 Ban Phu Noi Member (BPN)

This member is named in accordance with the name of Ban Phu Noi which is located in the western part of study area. This member is characterized by medium to very

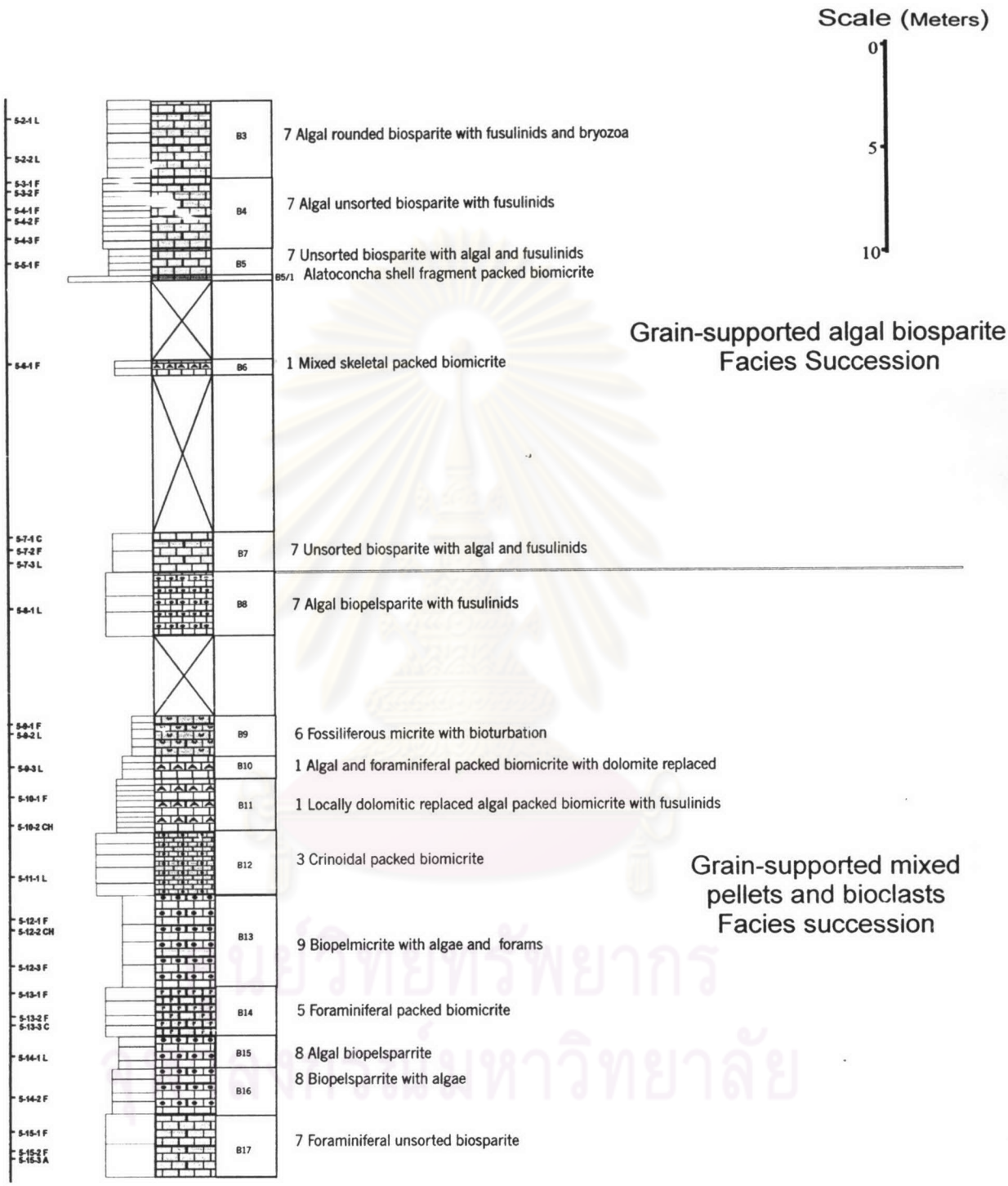

Figure 4.5 Vertical composite lithostratigraphic sequence of Ban Chon Muang II Member (BCM2).

thickly bedded micritic limestone with, locally, nodular and elongated chert. The algae are very abundant whereas the fusulinids and corals are locally found. Microscopically, the most eminent microfacies is the microfacies I and a special microfacies IV (argillaceous sparse biomicrite), is found only in this rock unit.

This member is present only in the section E. Its lower boundary is marked at the last appearance of sparry calcite cement in the horizon E15 and its upper boundary is uncertain due to unexposed upper most succession. Accordingly, the measured section E is referred to as the type section of the Ban Phu Noi Member as shown in the Figure 4.6. The member is about 45 meters thick, and can be separated into 2 parts.

Its lower part starts from horizon E15 to E7, and is characterized by the grain-supported algal biomicrite facies succession. The microfacies I (algal and mixture of skeletal fragments packed biomicrite), is the only obvious microfacies discovered in this part of the member.

Its upper part extends from horizon E6 to E1, and characterized by the dominant mud supported facies succession consisting of a mixture of microfacies II, IV and VI.

4.3 Reconstruction of depositional environments

In general, numerous parameters characterize the depositional environments. The depositional environment reconstruction is based on a knowledge of the modern environmental processes and effects which exhibites their sedimentary characteristics in an attribute of facies.

4.3.1 Shoaling-upward model

James (1984) proposed a typical vertical sequence of shoaling-upward cycle as shown in Figure 4.7 which is the hypothetical carbonate sequence in the shallow shelf sea environments.

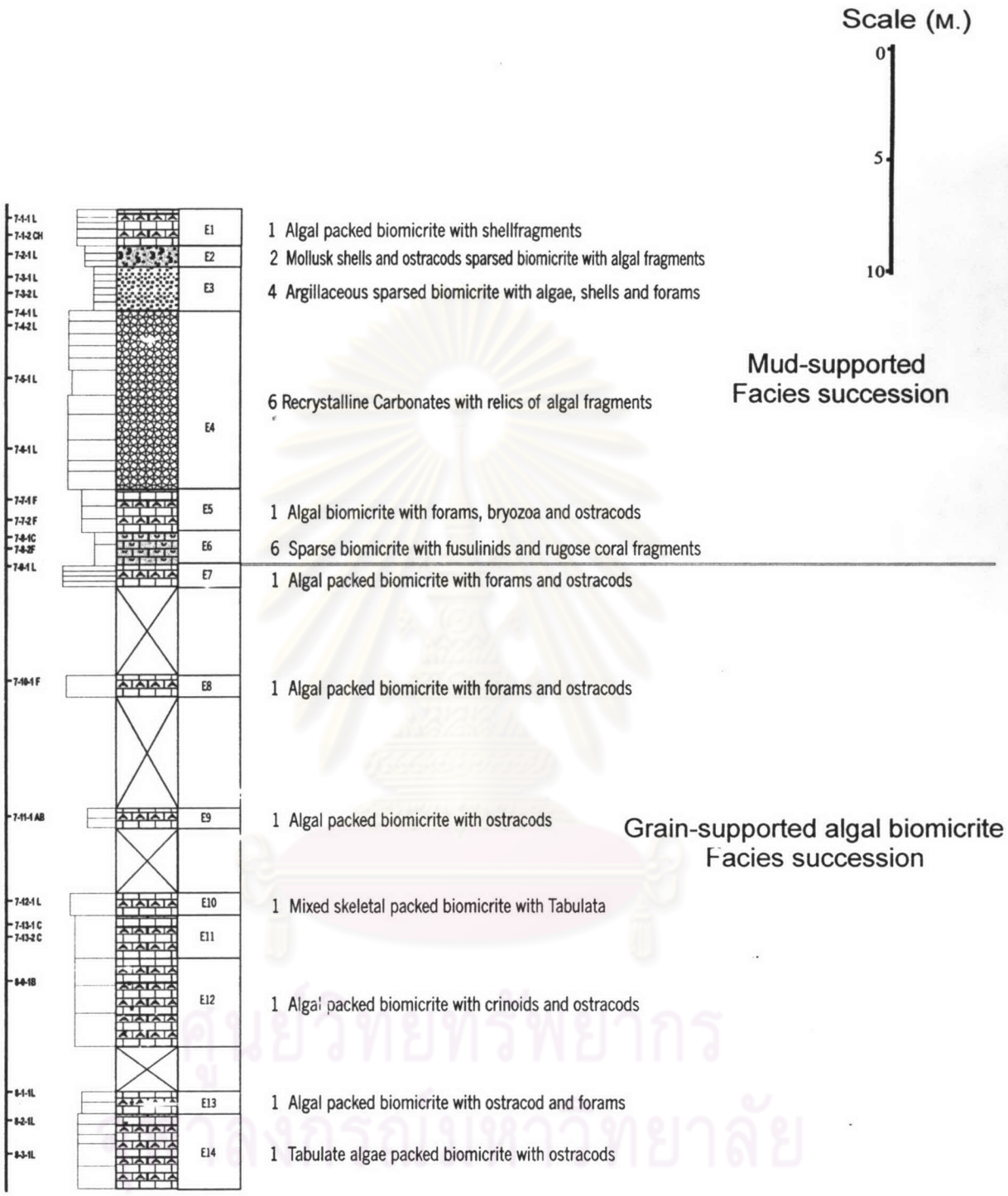

Figure 4.6 Vertical composite lithostratigraphic sequence of Ban Phu Noi Member (BPN).

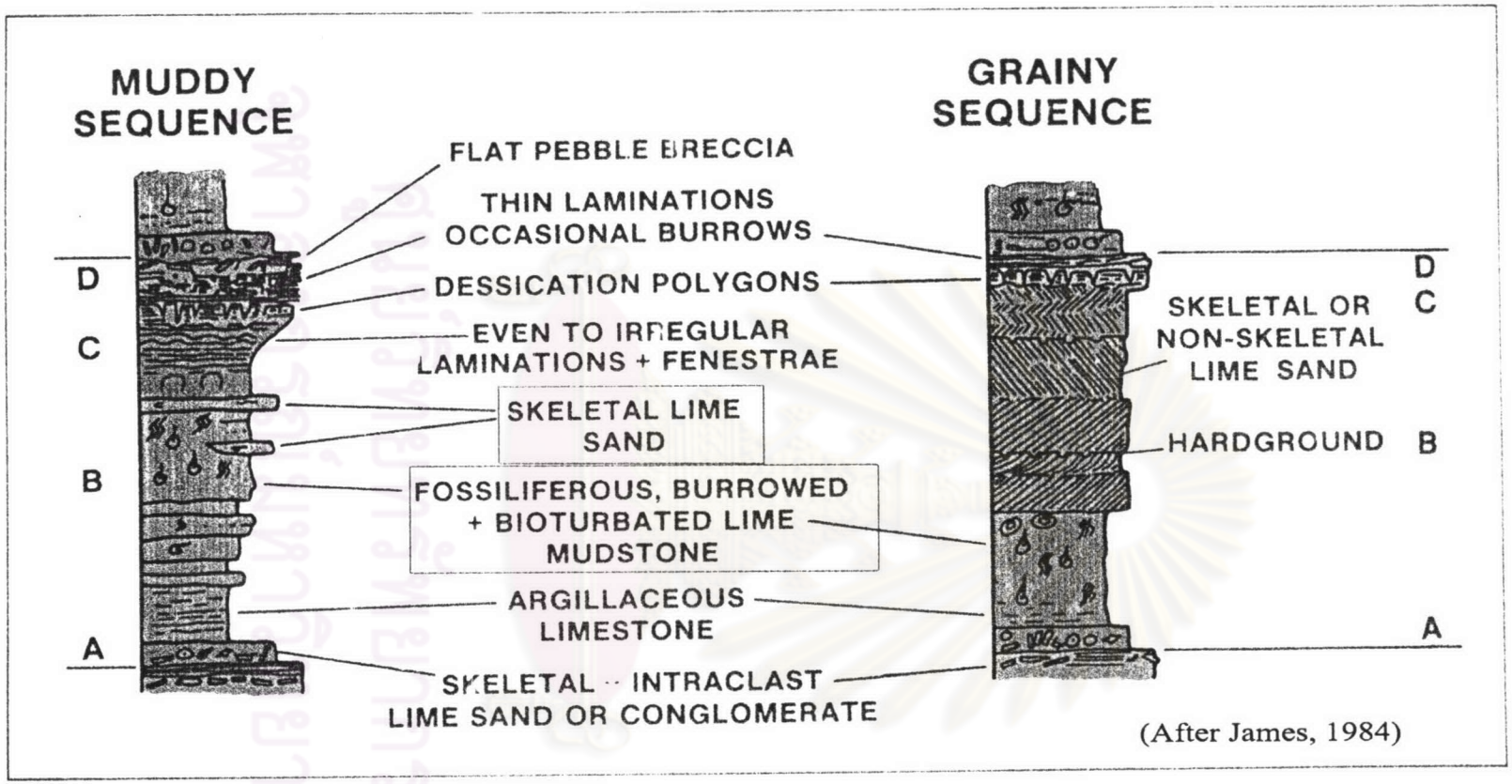

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Figure 4.7 Hypothetical shoaling-upward carbonate sequences (James, 1984). A. Basal trangressive lag; B. Subtidal restriced to open marine; C. intertidal; D. Supratidal. According the comparison, the succesions in the recent stuy area are deposit in the subtidal zone.

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From the analysis of the general lithology, bed characteristics and fossils assemblage of the succession in the study area which is almost comprised of thickly to very thickly-bedded limestone and contains a lot of shallow marine fossils such as the colonial rugose corals, foraminifera and the dasycladacean algals, these characters are exhibit that the depositional environment are shallow marine environments.

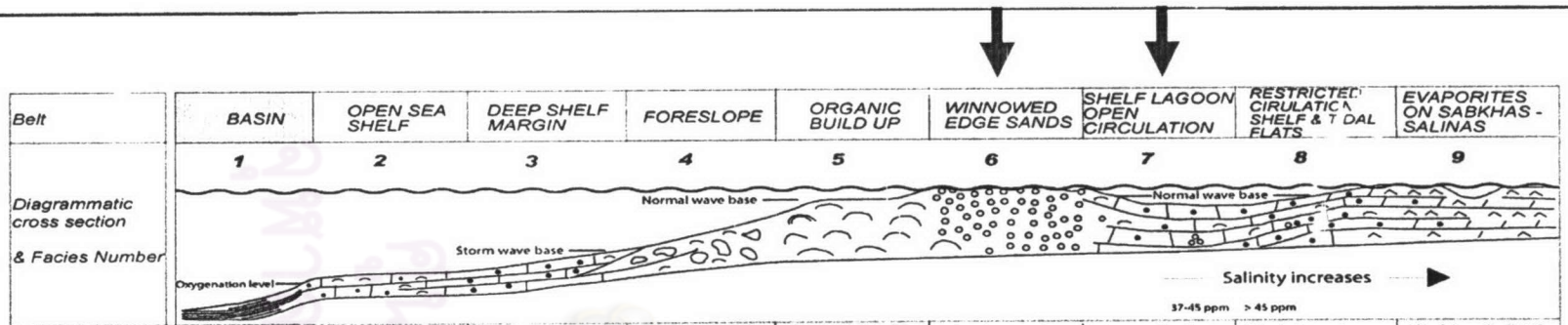
By comparison to nine microlithofacies and their vertical relationships in small scaled, the abundance of micritic mud and various type of bioclasts in sand size indicate that the depositional environments quit not rapidly change and almost in subtidal zone (zone B) throughout the periods of deposition. The sequence which is represented by fossiliferous mudstone (muddy microfacies) and periodically intercalated the skeletal lime sand (grainy microfacies) are well correlated to the muddy sequence model. In the other hand, the sequence which almost contain grainy microfacies and represented by skeletal lime sand or the large size could be compared with the grainy sequence model.

4.3.2 Standard microfacies

Willson (1975) and Flugel (1982) proposed 24 standard microfacies types (SMF) assignable to nine standard facies belts (figure 4.8). This standard is recently convinced by many scientists and may apply to compare and determine the depositional environments.

From come along side, nine microlithofacies established in the study area can be compared to the standard microfacies types (SMF) as summarized in the Table 4.2.

Accordingly above mentioned, the microlithofacies discovered in Khao Lamphean are all located on the middle shelf facies (No. 5 though 7). Almost abundant facies are shoal environments in the belt No. 6 (winnowed edge sand) and No.7 shelf lagoon open circulation in the middle shelf. But some microfacies I are characteristic of baffestone in the biostrome which can probably be interpreted as the autochthonous reef rocks in early stage of patchy reef buildup in the belt No.5. Meanwhile, the microfacies IV which is



Belt	BASIN	OPEN SEA SHELF	DEEP SHELF MARGIN	FORESLOPE	ORGANIC BUILD UP	WINNOWED EDGE SANDS	SHELF LAGOON OPEN CIRCULATION	RESTRICTED CIRULATION SHELF & TIDAL FLATS	EVAPORITES ON SABKHAS - SALINAS
Diagrammatic cross section & Facies Number	1	2	3	4	5	6	7	8	9
Facies	a) Fine Clastics b) Carbonates c) Evaporites	a) Carbonates b) Shale	Toe of Slope carbonates	a) Bedded fine grain & slumps b) Foreset debris & lime sands c) Lime mud mases	a) Boundstone b) Crust on accumulations of debris lime mud; bindstone c) Bafflestone	a) Shoal lime sands b) Islands w. dune sands	a) Lime snad bodies b) Wackestone-mudstone areas, bioherms c) Areas of clastics	a) Bioclastic wackestone, lagoons and bays b) litho-bioclastic sands in tidal channels c) Lime mud-tide flats d) Fine clastic units	a) Nodular anhydirte & dolomite on salt flats. b) Laminated evaporites in ponds
Lithology	Dark shale or silt, thin limestones (starved basin); evaporite fill w. salt	Very fossiliferous limestone interbedded with marls; well segregated beds.	Fine grain limestone; cherty in some cases.	Variable, depending on water energy upslope; sedimentary breccia and lime sands	Massive limestone-dolomite	Calcarenitic-oolite lime sand or dolomite	Variable carbonate and clastics	Generally dolomite and dolomitic limestone	Irregularly laminated dolomite and anhydrite, may grade to red beds
Color	Dark brown, black, red	Gray, green, red, brown	Dark to light	Dark to light	Light	Light	Dark to light	Light	Red, yellow, brown
Grain type and depositoinal texture	Lime mudstone,; fine calcisiltites	Bioclastic and whole fossil wackestone; some calcisiltites	Mostly lime mudstone with some calcisiltites	Lime silt and bioclastic wackestone-packstone; lithoclastics of varying sizes	Boundstones and pockets of grainstone; packstone	Grainstones well sorted; rounded	Great variety of textures; grainstone to mudstone	Clotted, pelleted mudstone & grainstone; laminated mudstone; coarse lithoclastic wackestone in channels	
Bedding and sedimentary structure	Very even mm laminations; rhythmic bedding; ripple cross lamination	Thoroughly burrowed; thin to medium; wavy to nodular beds; bedding surfaces show diastems	Lamination may be minor; often massive beds; lenses of graded sediment; lithoclasts & exotic blocks. Rhythmic beds	Slump in soft sediments; sofeset bedding; slope bioherms; exotic blocks	Massive org. structure or open framework with roofed cavities; Lamination contrary to gravity	Medium to large scale cross bedding; festoons common	Burrowing traces very prominent	Birdseye, stromatolites, mm lamination, graded bedding, dolomite crusts on flats. Cross-bedded sand in channels	Anhydrite after gypsum; nodular, rosettes, chickenwire, and blades; irregular lamination; carbonate caliche
Terrigenous clastics admixed or interbedded	Quartz silt & shale; fine grain siltstone; cherty	Quartz silt, siltstone, & shale; well segregated beds	Some shales, silt, & fine grained siltstone	Some shales, silt, & fine grained siltstone	None	Only some quartz sand admixed	Clastics and carbonates in well segregated beds	Clastics and carbonates in well segregated beds	Windblown, land derived admixtures; clastics may be very important units
Biota	Exclusively nektonic-pelagic fauna preserved in abundance on bedding planes	Very diverse shelly fauna preserving both infauna & epifauna	Bioclastic detritus derived principally from upslope	Colonies of whole fossil organisms & bioclastic debris	Major frame building colonies with ramose forms in pockets; in situ communities dwelling in certain niches	Worn and abraded coquinas of forms living at or on slope; few indigenous organisms	Open marine fauna lacking; mollusca, sponges, forams, algae abundant; patch reefs present	Very limited fauna, mainly gastropod . algae, certain foraminifera & ostracods	Almost no indigenous fauna, except for stromatolitic algae

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Figure 4.8 Idealized sequence of nine standard facies belts (re-drawn after Wilson, 1978).

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Table 4.2 The depositional environments of 9 microfacies in the study area and their comparison with Standard Microfacies type (SMF).

Microlithofacies	Depositional Environments	SMF
I Algal and a mixture of skeletal packed biomicrudite	Algal shoals, subtidal, shallow water with open circulation close to wave base, open marine in the middle shelf .	9+18
II Shell fragments biomicrudite	Lagoonal mudstone, subtidal, shelf lagoonal with circulation; low-energy water below normal wave base, in open marine the middle shelf.	8
III Encrenite	Echinoderm shoals, subtidal, shallow water with open circulation close to wave base, open marine in the middle shelf.	18
IV Argillaceous sparse biomicrite	Lagoonal mudstone with terrigenous sediment supplied, subtidal, shelf lagoonal with circulation; low-energy water below normal wave base, open to restricted marine in the middle shelf to inner shelf.	8+19
V Foraminiferal packed biomicrudite	Foram shoals, subtidal, shallow water with open circulation close to wave base, open marine in the middle shelf.	18
VI Sparse biomicrite and fossiliferous micrite	Lagoonal mudstone, subtidal, shelf lagoonal with circulation; low-energy water below normal wave base, open marine in the middle shelf .	8
VII Biosparite	Winnowed platform, subtidal, areas with constant wave action at/or above wave-base, open marine in the middle shelf .	11
VIII Biopelsparite	Subtidal, shallow water with moderate circulation and constant wave action at/or above wave-base ,open marine in the middle shelf.	11+16
IX Biopelmicrite	Subtidal, shallow water with moderate circulation ,open marine in the middle shelf.	16

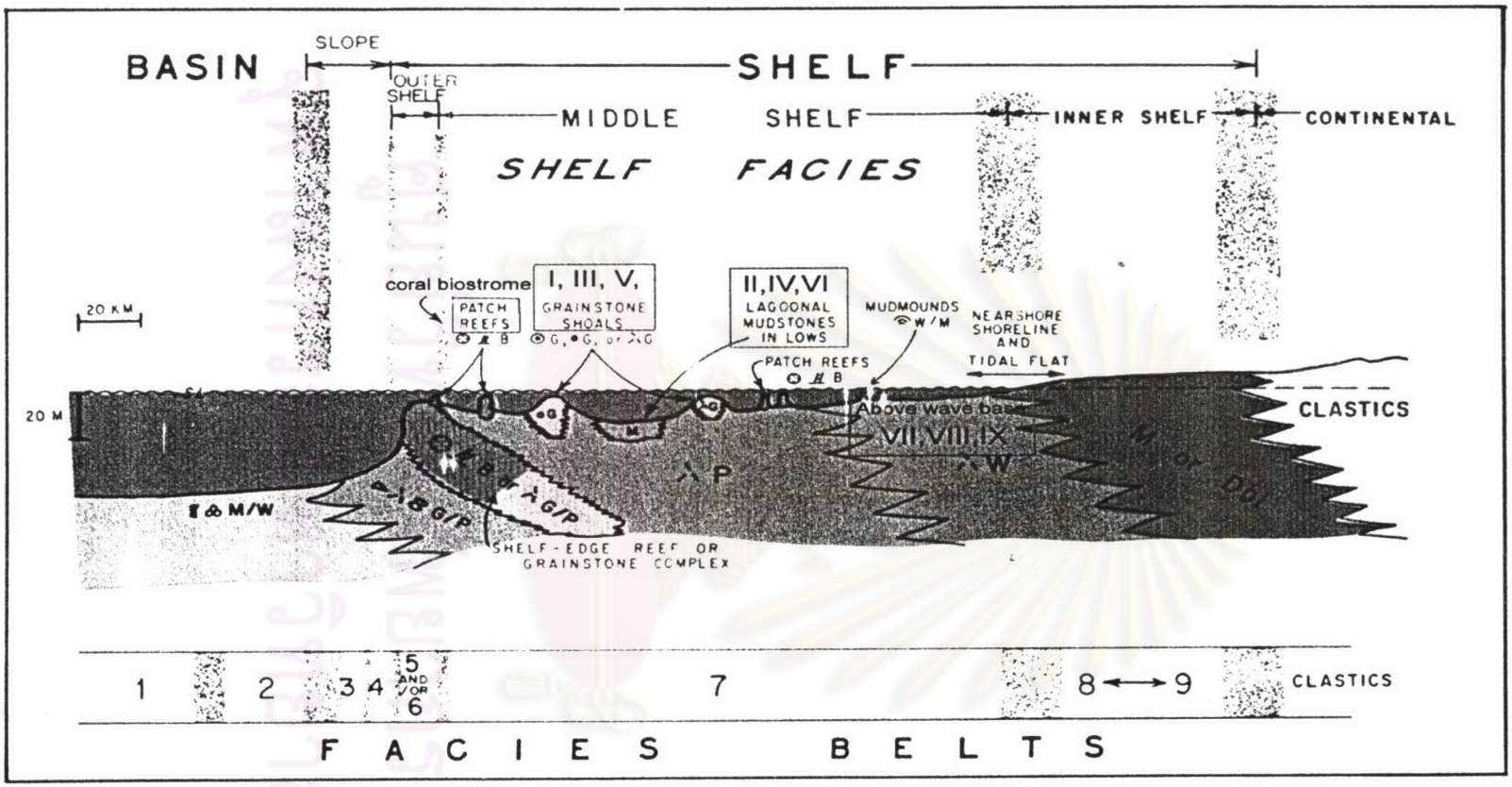

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Figure 4.9 Profile of shelf shows subdivision of the middle shelf facies which can be correlated to the microfacies in the recent study. Patch reefs (=coral and algal biostrome), graistone shoals (=MF I,III, V), grainstone shoals above wave base (=MF VII, VIII), and depression fills with carbonate mud (=MF II, IV, VI) (After Wilson and Jordan, 1983).

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characterized by argillaceous limestone indicate the terrigenous sediment influx in more restricted condition that probably extents to the restricted marine in the inner shelf (belt No. 8).

Wilson and Jordan (1983) adapted the standard microfacies model which is focused on the shelf facies. The microfacies found in the study area could be summarized in accordance with this model as shown in Figure 4.9.

4.3.3 Carbonate platform models and vertical sequences relationship of the microfacies.

The carbonate platform models are important aids for in understanding the evolution and the relation of carbonate facies. But many of the terms that are commonly used to described the different modes have various meanings to geologist. However, there are two comprehensive types of carbonate platforms which are widely accepted in terms of the shelves and ramps that were firstly recognized and distributed by Ahr (1973).

Read (1982) proposed a new concept of classification, characteristics and evolution of carbonate platforms in more details. He divided the platforms into four categories, namely, rimed carbonate shelf, carbonate ramp, isolated platform and drown platform.

From comparison to the description of above mentioned models, the carbonate successions in the present study differ from rimed shelf due to continuous reef barrier seems to be absent, and buildups are typically separated by the patch reefs. Moreover, shallow-water facies are characterized by skeletal-pellet shoal complexes.

Thus, following attempts are conducted on the comparison of a vertical relation of various microfacies in the study area appropriating to depict the carbonate ramp model and adapting to the evolution of their depositional basin.

4.3.3.1 Ramp stage I

This stage is represented by the Khao Lamphean Member (WKL). The water was relatively high. The slope of the ramp is probably steeper the following stage which indicating by relatively abundant of muddy facies.

Almost their related lithofacies may possibly be deposited in mid ramp. The mud-supported facies succession ought to indicate the depressions of the ramp. However, owing to constantly appearance of some skeletal components point to not extreme depths while the depositional environments should not extend to outer ramp.

The grain supported facies succession is representing of various skeletal shoal and patchy reef environments which probably aligned in sub-wave base zone. The coral biostromes actually do not express large buildup by lagging of framestone and blindstone. The bafflestone were observed in fact, as early stage of the patchy reefs or reef meadows which some coral are allochthonous that are characterized by floatstone.

The pelletal facies succession is characterized by pelletal facies and should be deposited in the pellet banks behind the patch reefs and shoals. The calm environments were profit some infaunas to feed and produce some of pellets.

The ramp stage I model is shown in Figure 4.10.

The interpreted depositional environments of the microfacies and their vertical relationship of the Khao Lamphean Member (WKL) are shown in Figure 4.11.

4.3.3.2 Ramp stage II

This stage is represented by the Ban Chon Muang I Member (BMC1). The water may be relatively high. The slop would probably more gently decline which is indicated by relatively lack of the muddy facies.

Overall environments should be resemble to the preceding stage within the mid ramp, but a rare of mud facies succession could indicate few depressions of the seafloor. Coral biostromes are not discovered in this part indicate not well developing or lacking of the patch reefs.

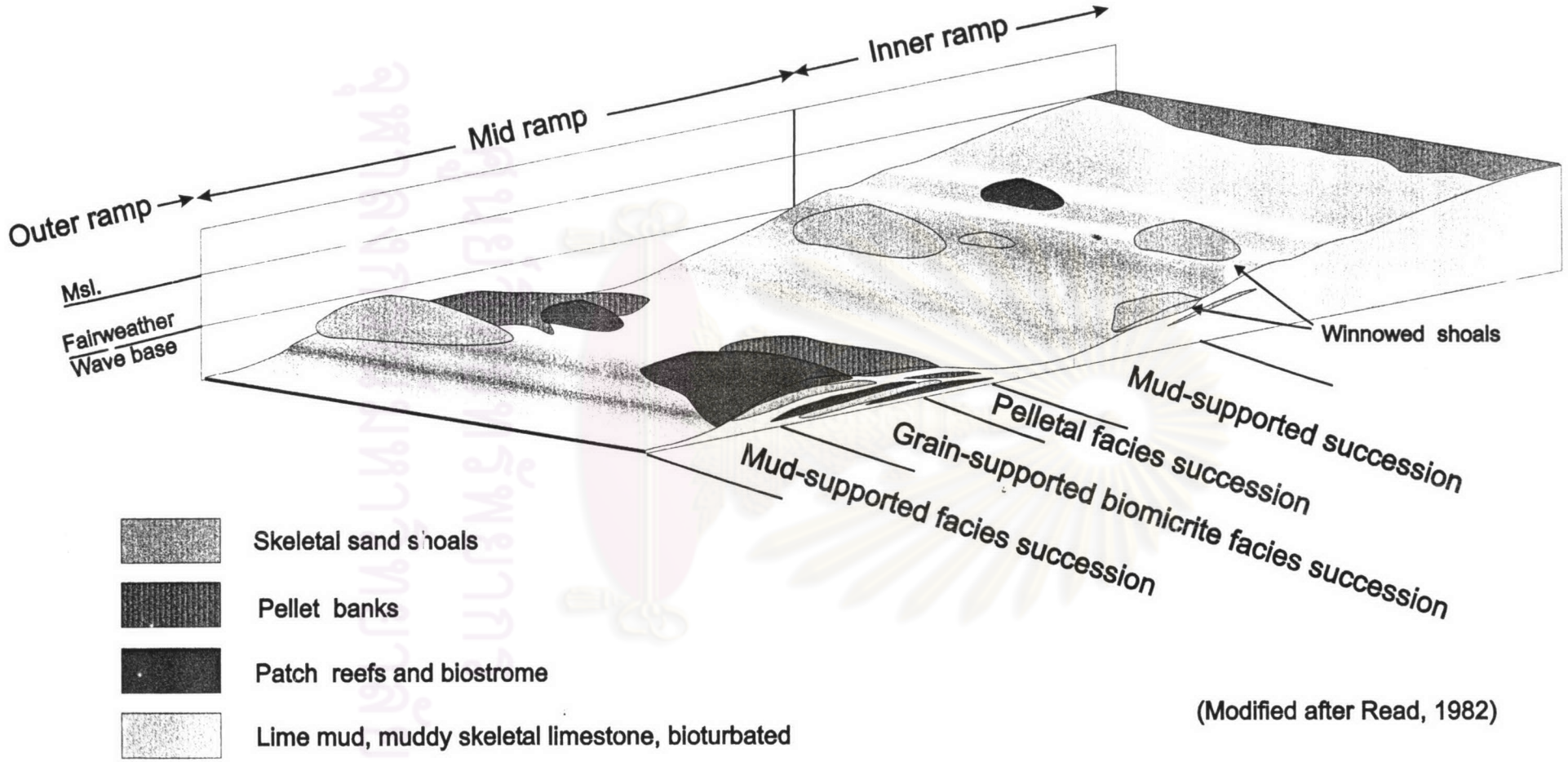

Figure 4.10 The carbonate ramp stage I, representing the Wat Khao Lamphean Member (WKL).

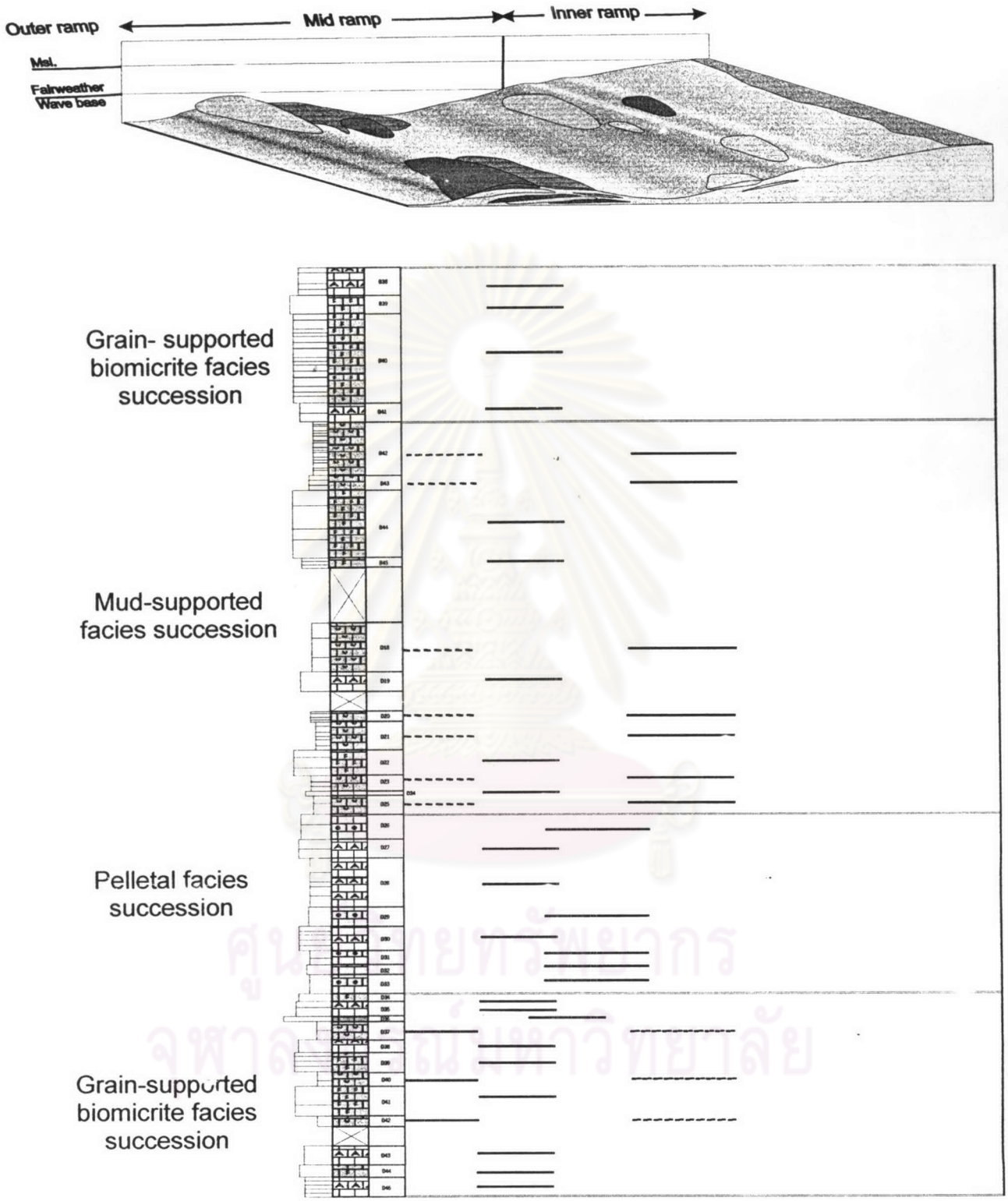

Figure 4.11 **Vertical relationship of the microfacies of the Wat Khao Lamphean Member (WKL) and the interpreted depositional environments.**

The ramp stage II model is shown in Figure 4.12.

The interpreted depositional environments of the microfacies and their vertical relationship of the Ban Chon Muang I Member (BMC1) are shown in Figure 4.13.

4.3.3.3 Ramp stage III

This stage is representing by the Ban Chon Muang Member II (BCM2). The water may be relatively low. The slope could relatively gently incline according to almost representation of the grainy facies and lacking muddy facies.

Almost lithofacies could possibly be deposited in the inner ramp which would be well defined by the sparry calcite cements indicating constantly agitating by wave at/over the wave base resulting to all muddy components were washed out.

The grain - supported mixed pellets and bioclasts facies succession, represent various type of allochems also indicate the shoal, winnowed shoal and shoal protecting environments.

The grain – supported algal biosparite facies succession, could distinctly exhibit the winnowed shoal environments which were constantly wave agitated.

Like the ascending stage, coral patchy reefs are not well defined.

The ramp stage III model is shown in Figure 4.14.

The interpreted depositional environments of the microfacies and their vertical relationship of the Ban Chon Muang Member (BCM2) are shown in Figure 4.15.

4.3.3.4 Ramp stage IV

This stage is represented by the Ban Phu Noi Member (BPN). The water would be relatively moderately deep. The slope seems to be resemble to the ramp stage III which almost facies are the granny microfacies.

In this stage, the reef probably recovered due to representing of the autochthonous reef rocks. Similarly to the ramp stage I, the large buildups seem to be not present because

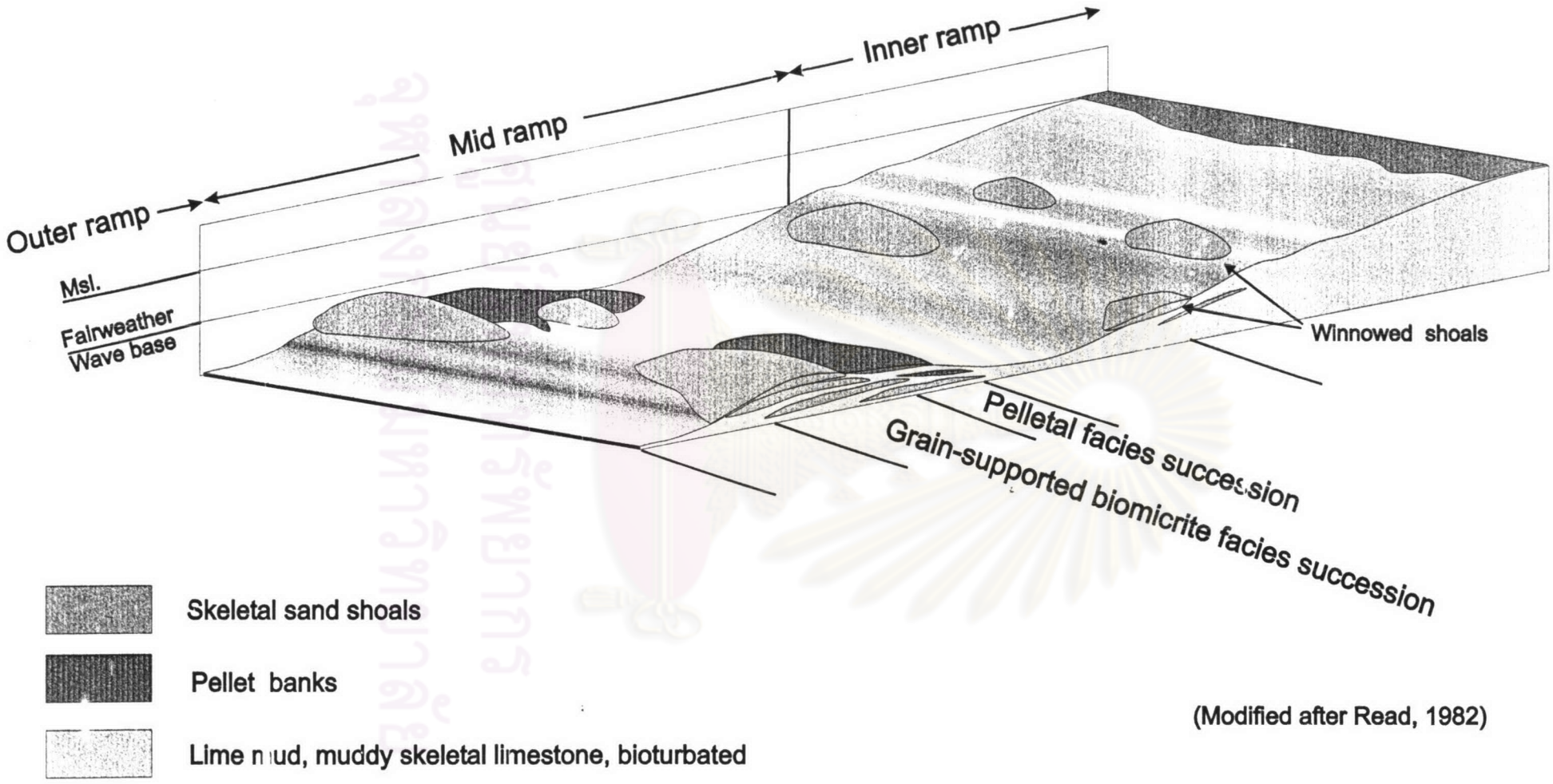

Figure 4.12 The carbonate ramp stage II, representing the Ban Chon Muang I Member (BCM1).

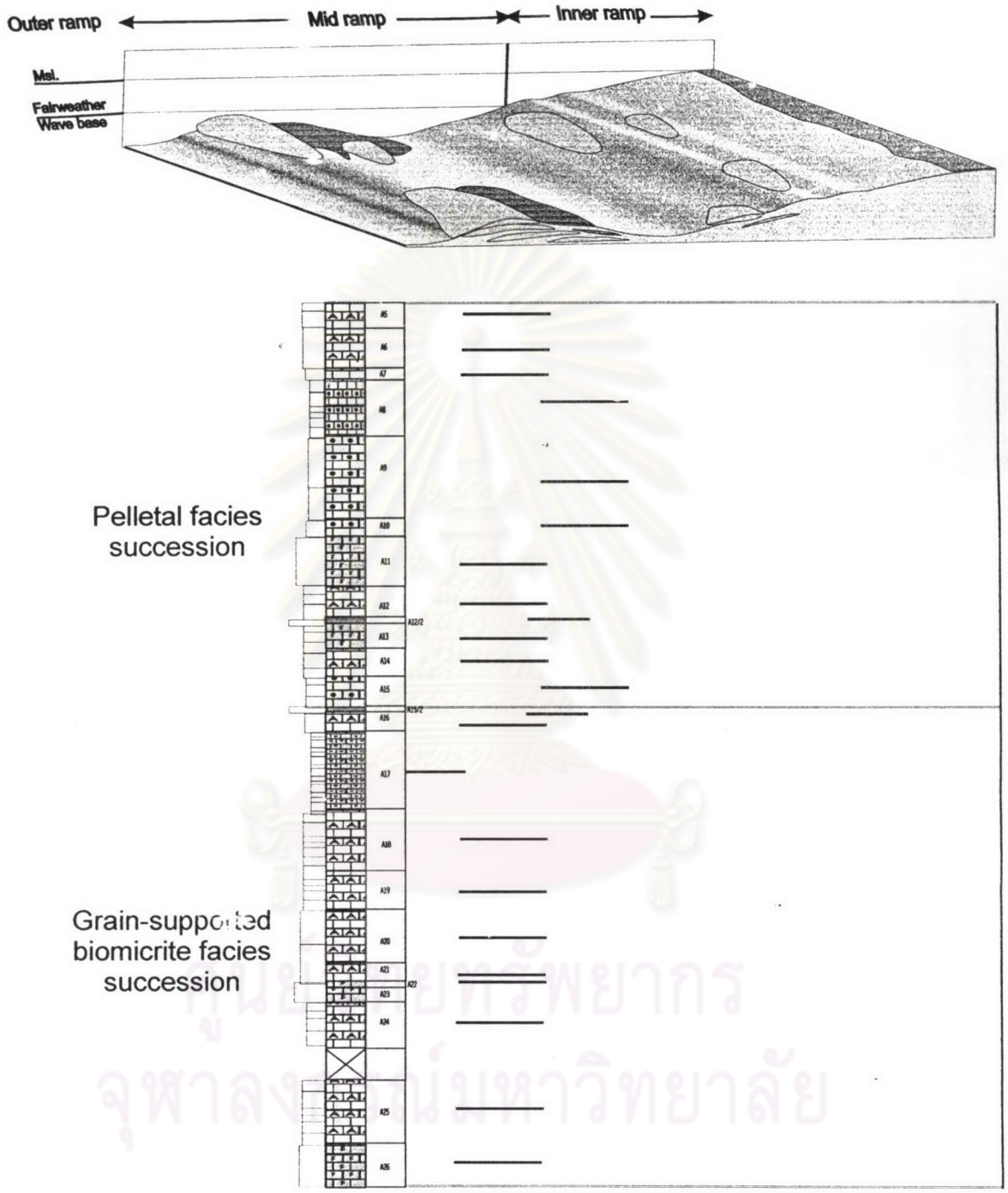

Figure 4.13 Vertical relationship of the microfacies of the Ban Chon Muang I Member (BCM1) and the interpreted depositional environments.

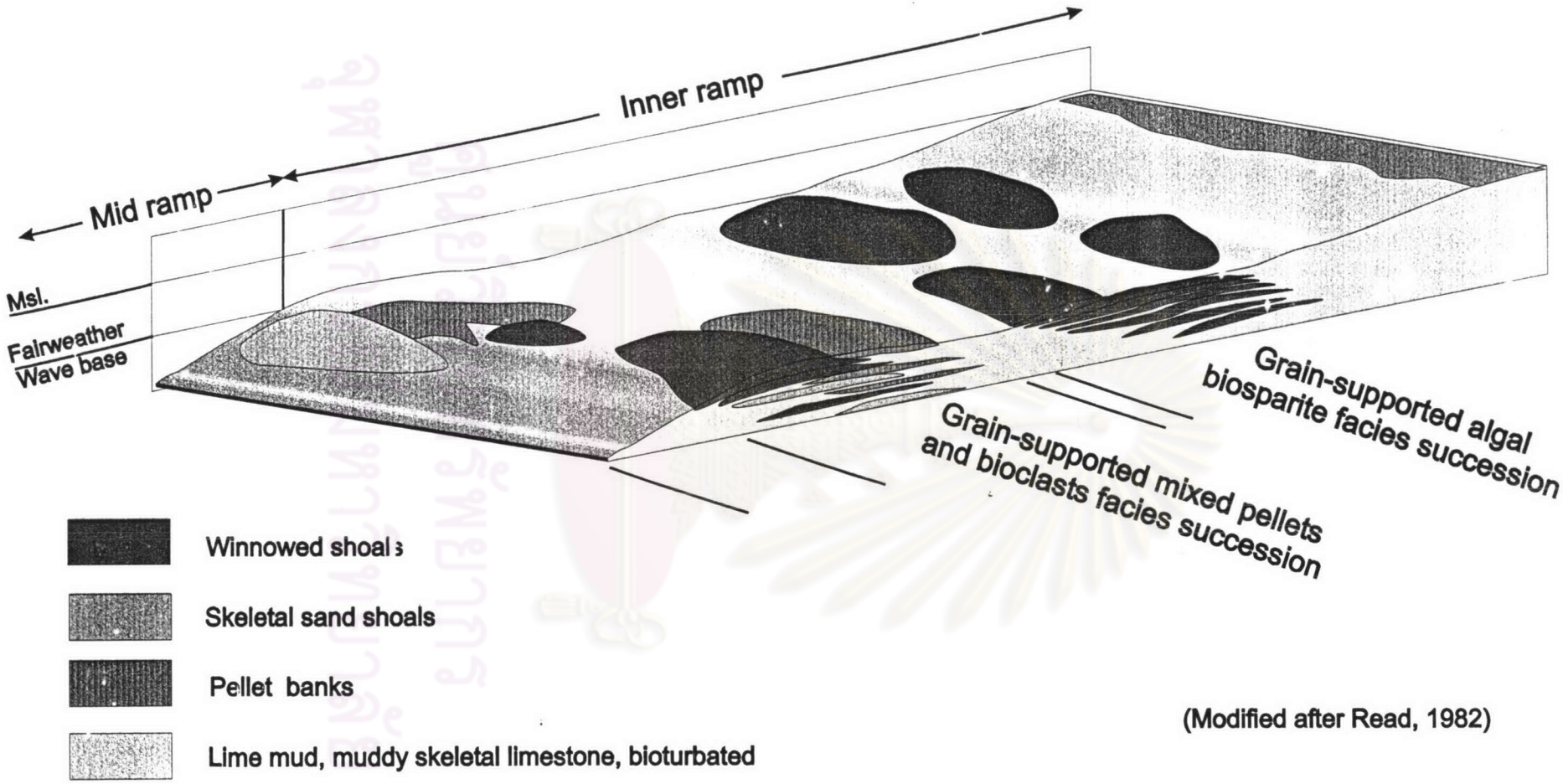

Figure 4.14 The carbonate ramp stage III, representing the Ban Chon Muang II Member (BCM2).

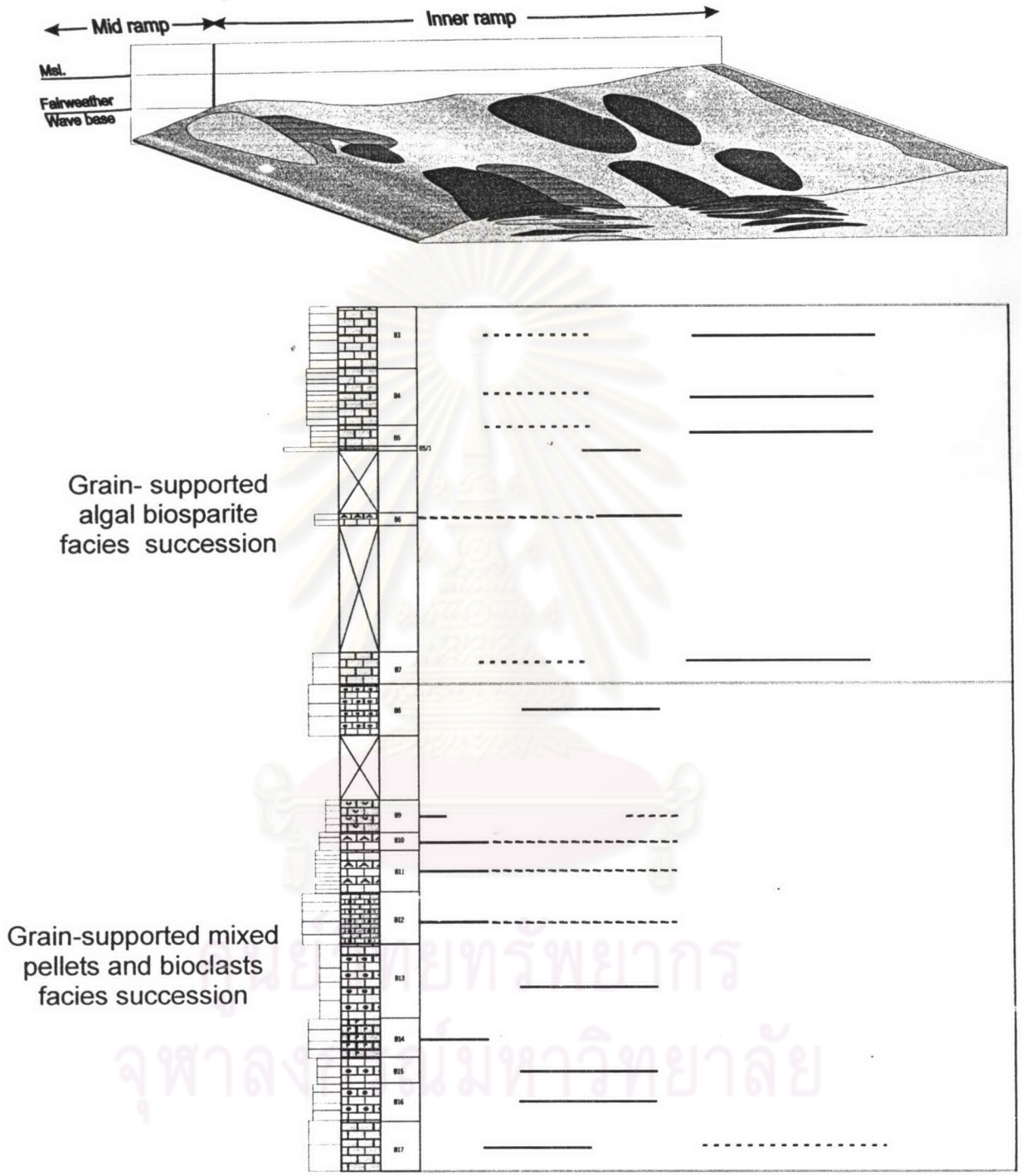

Figure 4.15 Vertical relationship of the microfacies of the Ban Chon Muang II Member (BCM2) and the interpreted depositional environments.

lacking of framestone or blindstone and the reef organisms changed to be branched algae and tabulate (*Sinopora*) corals.

The grain-supported facies succession which the characteristics of the allochthonous and autochthonous algal micritic limestone indicate well protections of the patchy reefs that make few disturbances of wave.

The mud-supported and argillaceous lime facies succession indicate periodically restricted environments which are expressed by the discovery of lamination and argillaceous limestone in the microfacies IV.

The ramp stage IV model is shown in Figure 4.16.

The interpreted depositional environments of the microfacies and their vertical relationship of the Ban Phu Noi Member (BPN) are shown in Figure 4.17.

4.3.3.5 Evolution of depositional basin and relatively sea-level change

The depositional basin of the carbonate succession in the study area express as the characteristics of its evolution from ramp stage, which the water is relatively high with open circulation, to the closely shelf stage, which the water is relatively low with restricted circulation. The initial model of the basin evolution is shown in Figure 4.18.

Focus on the distribution of the depositional environments, the regressive phase of the relative sea-level in the time of deposition is recognized as shown in Figure 4.19.

Following above mentioned, it possibly correlate the relative regression and swallowing ramp to shelf evolution of the carbonate sequence in the study area to be a part of some large scale progressive sequence.

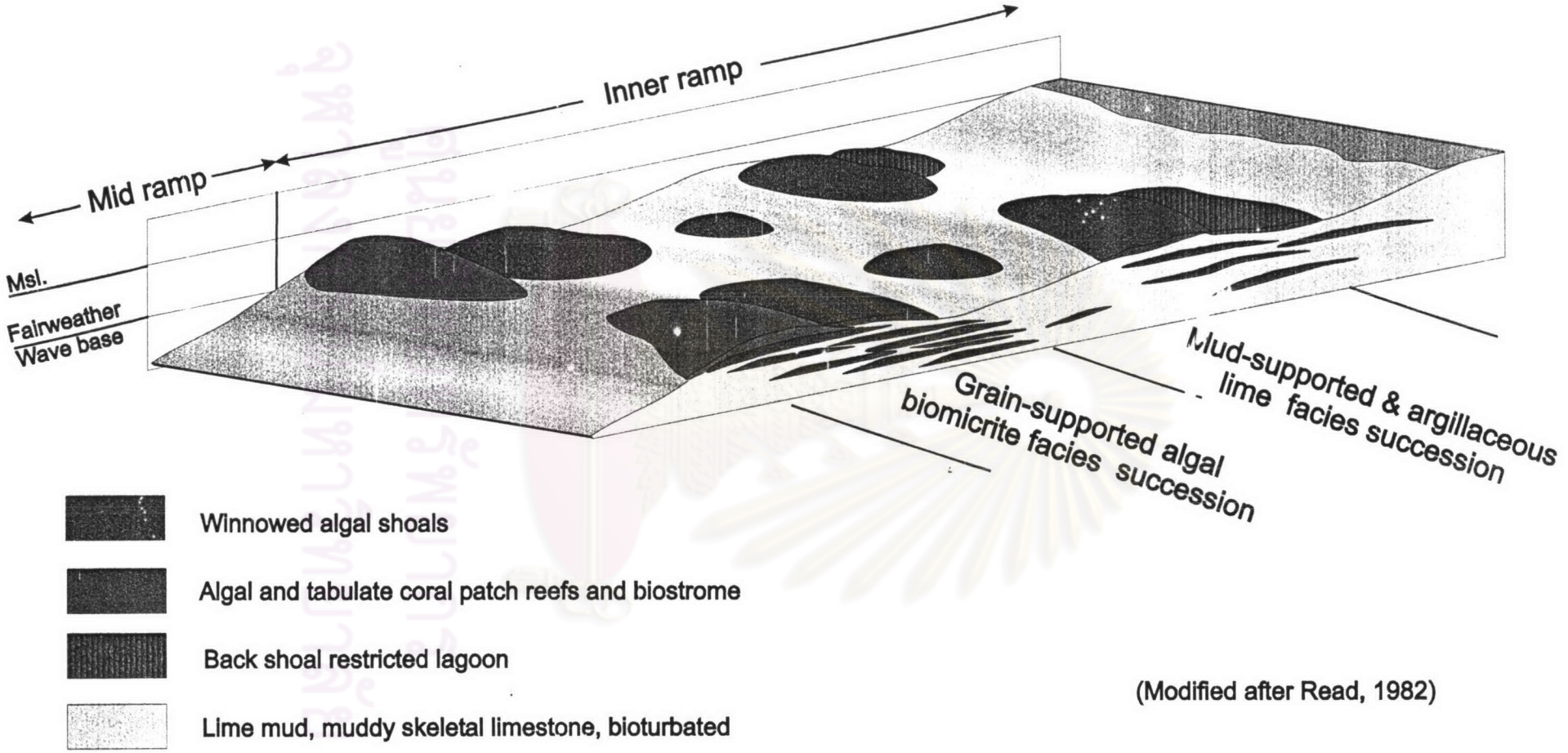

Figure 4.16 The carbonate ramp stage IV, representing the Ban Phu Noi Member (BPN).

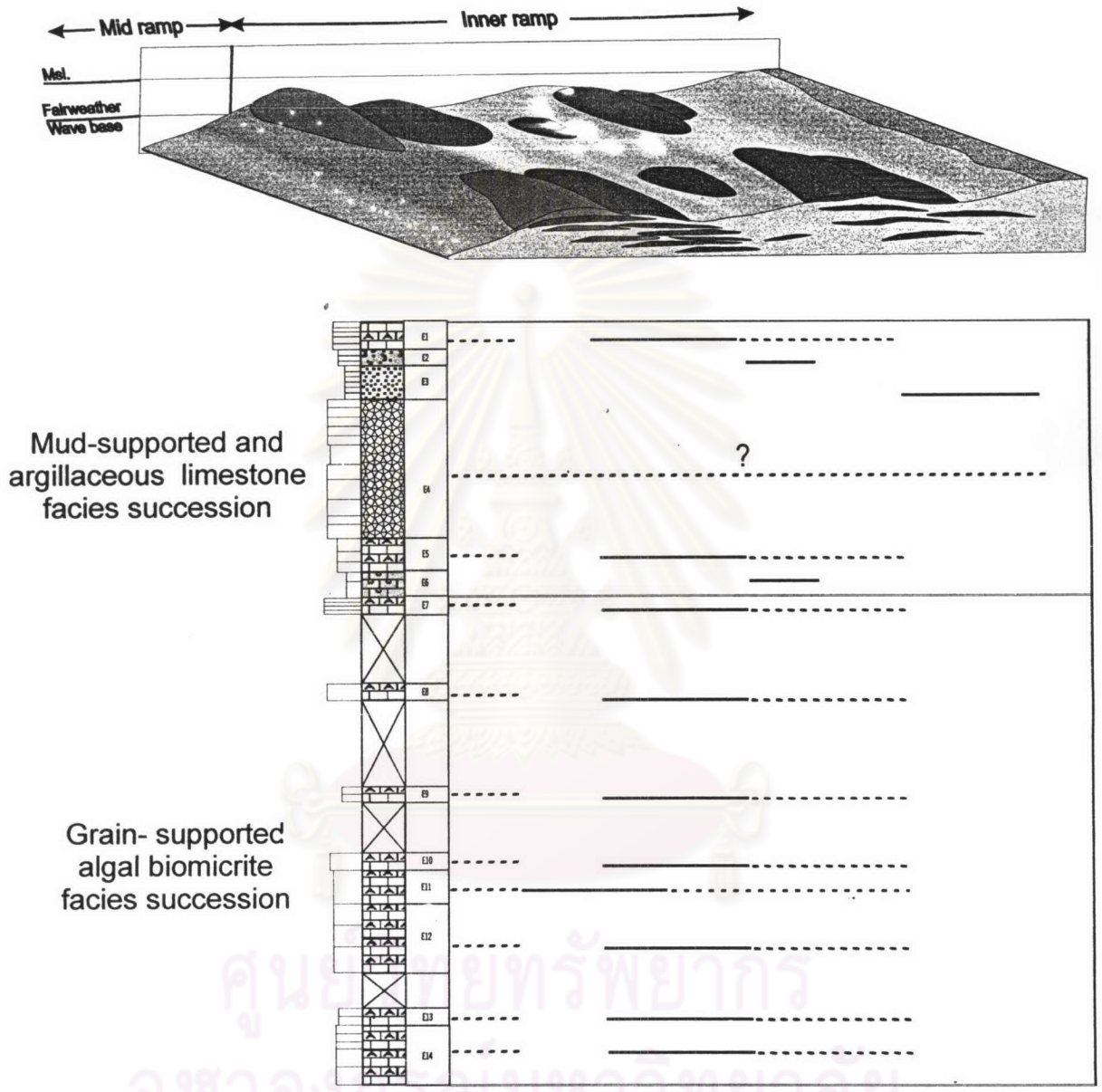

Figure 4.17 **Vertical relationship of the microfacies of the Ban Phu Noi Member (BPN) and the interpreted depositional environments.**

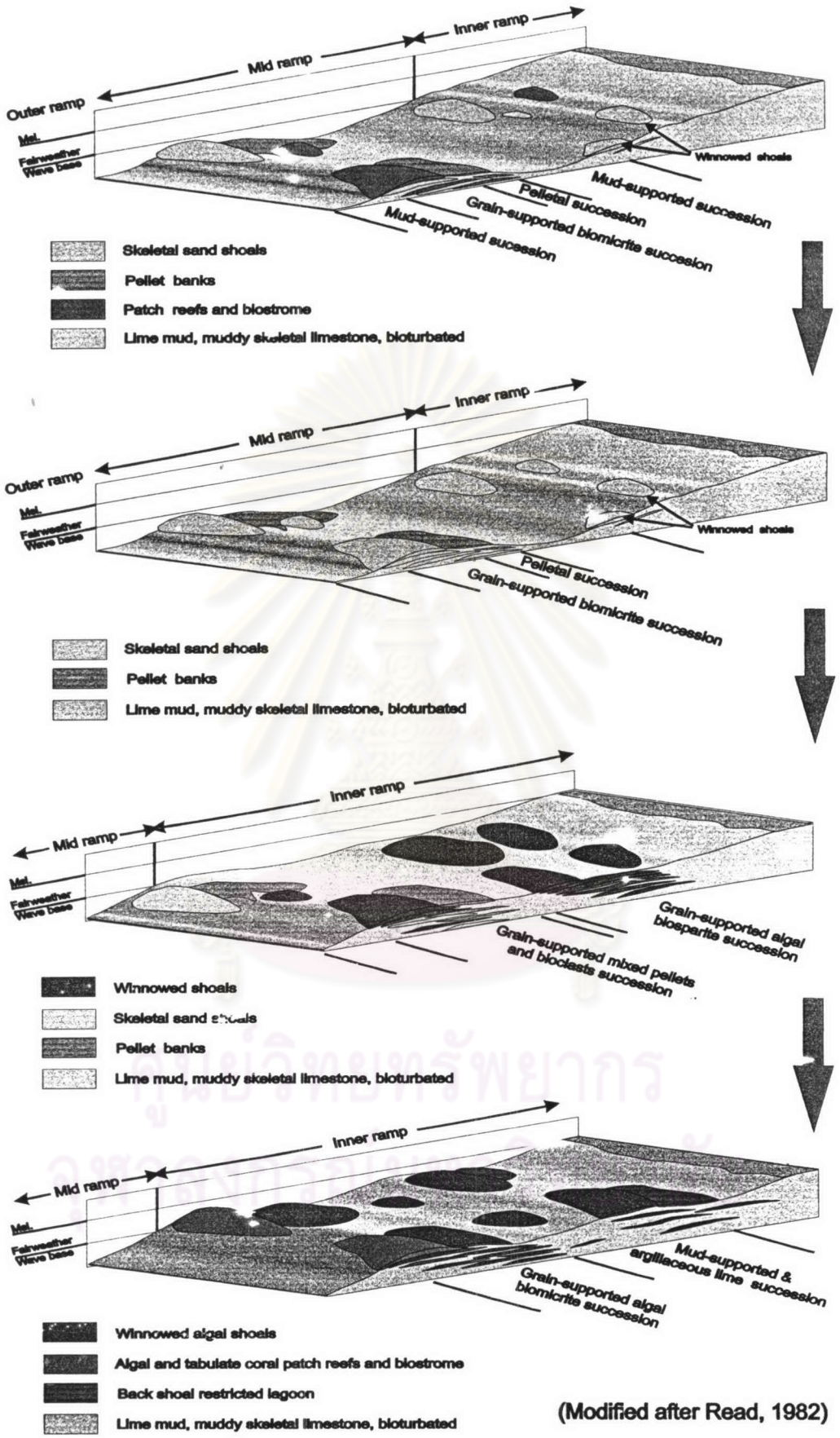

Figure 4.18 Initial model of the evolution of depositional basin of the carbonate succession in Khao Lamphean area.