



CHAPTER III

LITHOSTRATIGRAPHY OF THE BIVALVE FOSSIL LOCALITIES

3.1 Lithostratigraphy of the bivalve fossil localities

According to the previous researches on palaeontology, many vertebrate fossils were found and reported from eight localities of the inner mountain range and one locality of outer mountain range (Figure 3.1). The lithology of these localities except the later was recognized as the Sao Khua Formation (Chonglakmani *et al.*, 1985; Wongprayoon and Meesook, 2001). Jearanaiwong (2000) reported 2 localities of bivalves from Phu Pratu Tee Ma and Sam Bak Lo in the west of the Phu Wiang area. Both localities also belong to the Sao Khua Formation.

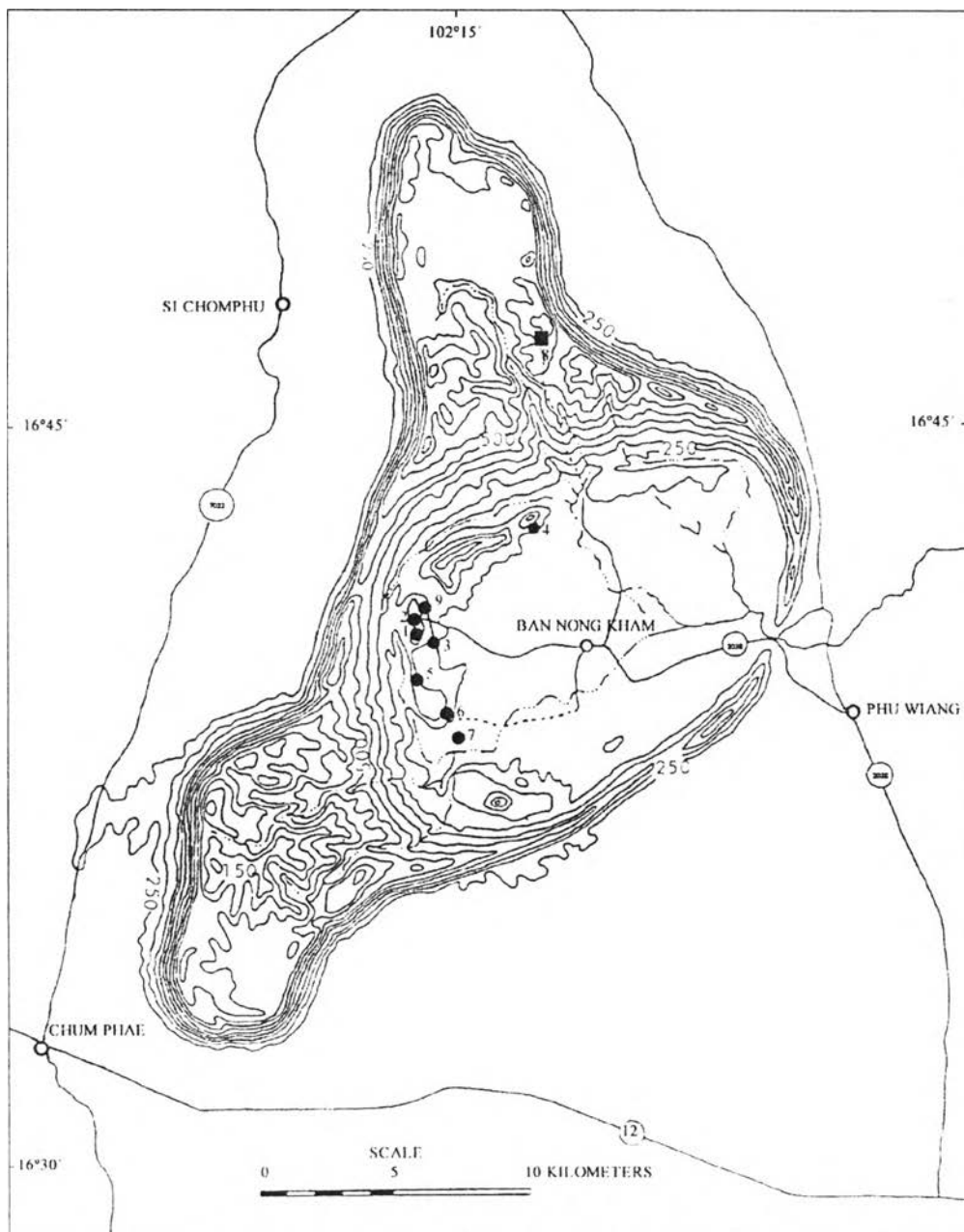


Figure 3.1 Map of dinosaur localities (modified after Suteethorn, 2002)

● Dinosaur fossil locality ■ Dinosaur footprint locality

Based on the reasons mentioned above, the outcrops of the inner mountain range were focused to search for new localities of bivalves.

Five fossil localities were found in the present study (Figure 3.2), and five columnar sections were made to define the characteristics of sedimentary rocks in each bed of bivalve localities. All of the sections are started at the bivalve localities. Each columnar section and outcrop is shown in Figures 3.3 to 3.22. The type section of the Sao Khua Formation and its correlations to other section are shown in Figure 3.23 and 3.24.

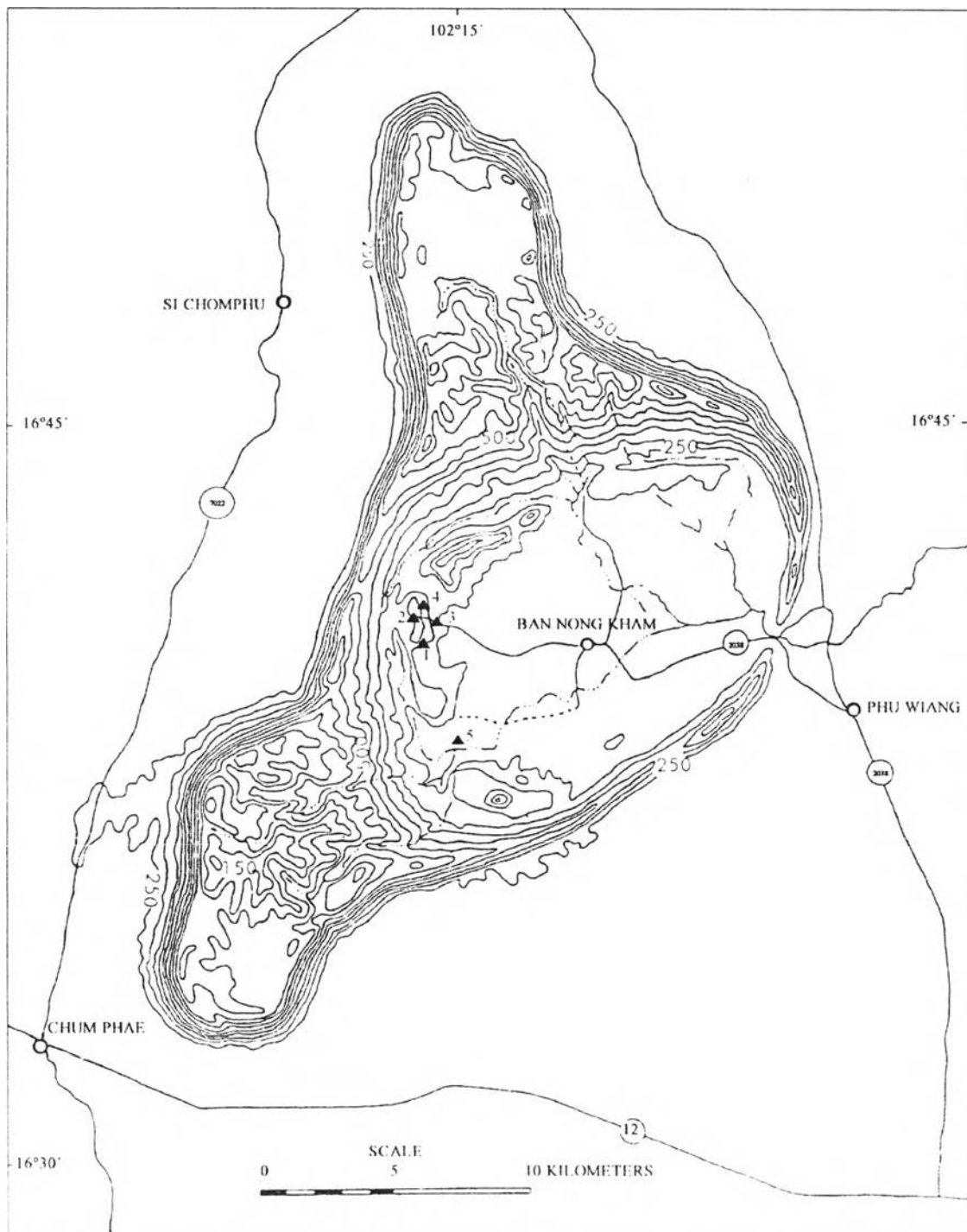


Figure 3.2 Map of bivalve localities.

▲ 1 = PW-M-1

▲ 2 = PW-M-2

▲ 3 = PW-M-3

▲ 4 = PW-M-4

▲ 5 = PW-M-5

3.1.1 Phu Wiang molluscan locality 1 (PW-M-1)

Map sheet: 5442 III AMPHOE CHUM PHAE

UTM grid reference: 053458

Location: Phu Pratu Tee Ma

Accessibility: The tourist trail from Phu Wiang National Park Headquarters to Dinosaur site 3, and to view point.

This section was made at the outcrop near the trail from Dinosaur Site 3 to view point at Phu Pratu Tee Ma, the thickness of this section is about 26.8 m. (Figure 3.3)

Lithology and sedimentary structure: Description is shown in ascending order, the section show 12 m thick of 4 sets of cross-bedding, which each set is interrupted by thin layer of shell fragment (PW-M-1/1) in sandstone bed and lime-nodule conglomerate bed, respectively. These cross-bedding sets are overlain by cross-lamination and laminated fine-grained sandstone beds. They are later overlain by the alternation of mudstone, very fine-grained sandstone, and caliche. In the middle of this set, shell bed (PW-M-1/2) was overlain on lime-nodule conglomerate. The uppermost set starting with shell fossils in mud-nodule conglomerate bed (PW-M-1/3) was overlain by laminated muddy fine-grained sandstone bed with bioturbation, the uppermost bed is laminated fine-grained sandstone.

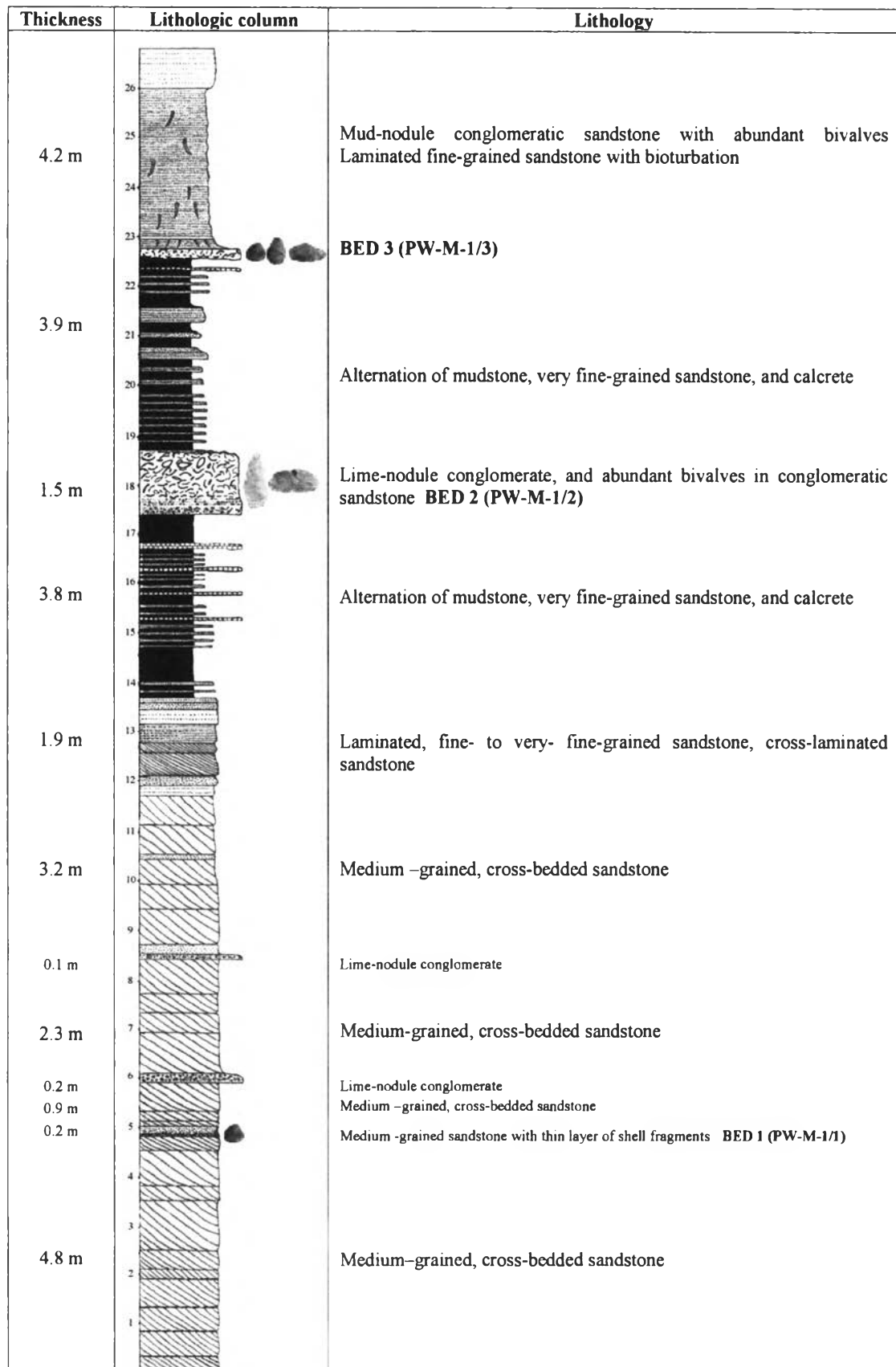


Figure 3.3 Lithostratigraphical columnar section of the Sao Khua Formation at Phu Wiang molluscan locality 1 (PW-M-1) Grid reference 053458



Figure 3.4 Cross-bedded sandstone. Grid reference 053458



Figure 3.5 Phu Wiang molluscan locality 1 Bed 1 (PW-M-1/1), thin layer of shell fragments in sandstone bed overlie on cross-bedded sandstone Grid reference 052458



Figure 3.6 Phu Wiang molluscan locality 1 Bed 2 (PW-M-1/2). Grid reference 050459



Figure 3.7 Calcrete layer (behind the camera cover) forming in the alternation of mudstone and very fine-grained sandstone; the top is resistant beds of mud-nodule conglomerate bed (Phu Wiang molluscan locality 1 Bed 3: PW-M-1/3) and laminated muddy fine-grained sandstone bed in the uppermost. Grid reference 050459



Figure 3.8 Mud-nodule conglomerate bed (Phu Wiang molluscan locality 1 Bed 3: PW-M-1/3) with abundant bivalves; and overlying laminated muddy fine-grained sandstone bed. Grid reference 050459



Figure 3.9 Laminated muddy fine-grained sandstone with incline burrow at the center of picture. Grid reference 050459

3.1.2 Phu Wiang molluscan locality 2 (PW-M-2)

Map sheet: 5442 III AMPHOE CHUM PHAE

UTM grid reference: 050465

Location: Phu Pratu Tee Ma

Accessibility: The road from Phu Wiang National Park's tourist center to Dinosaur site 2.

This section was made at the outcrop near the top of Phu Pratu Tee Ma, the thickness is about 22 m, and this section contains the Dinosaurs Site 2 and shell bed (PW-M-2) (Figure 3.10).

Lithology and sedimentary structure: the description is shown from the bottom to the top; the lower set is about 5.5 m thick of the alternation of very fine-grained sandstone bed with bioturbation, laminated muddy fine-grained sandstone bed with ripple mark on bedding surface, and mudstone. The overlying set is alternation of calcrete, fine- to medium-grained sandstone, and mudstone, and the 12 m thick of alternation of laminated muddy fine-grained sandstone and fine-grained sandstone which contain the Dinosaur Site 2 bed near the uppermost part; the uppermost set is lime-nodule conglomerate bed and thick shell bed in conglomeratic sandstone.

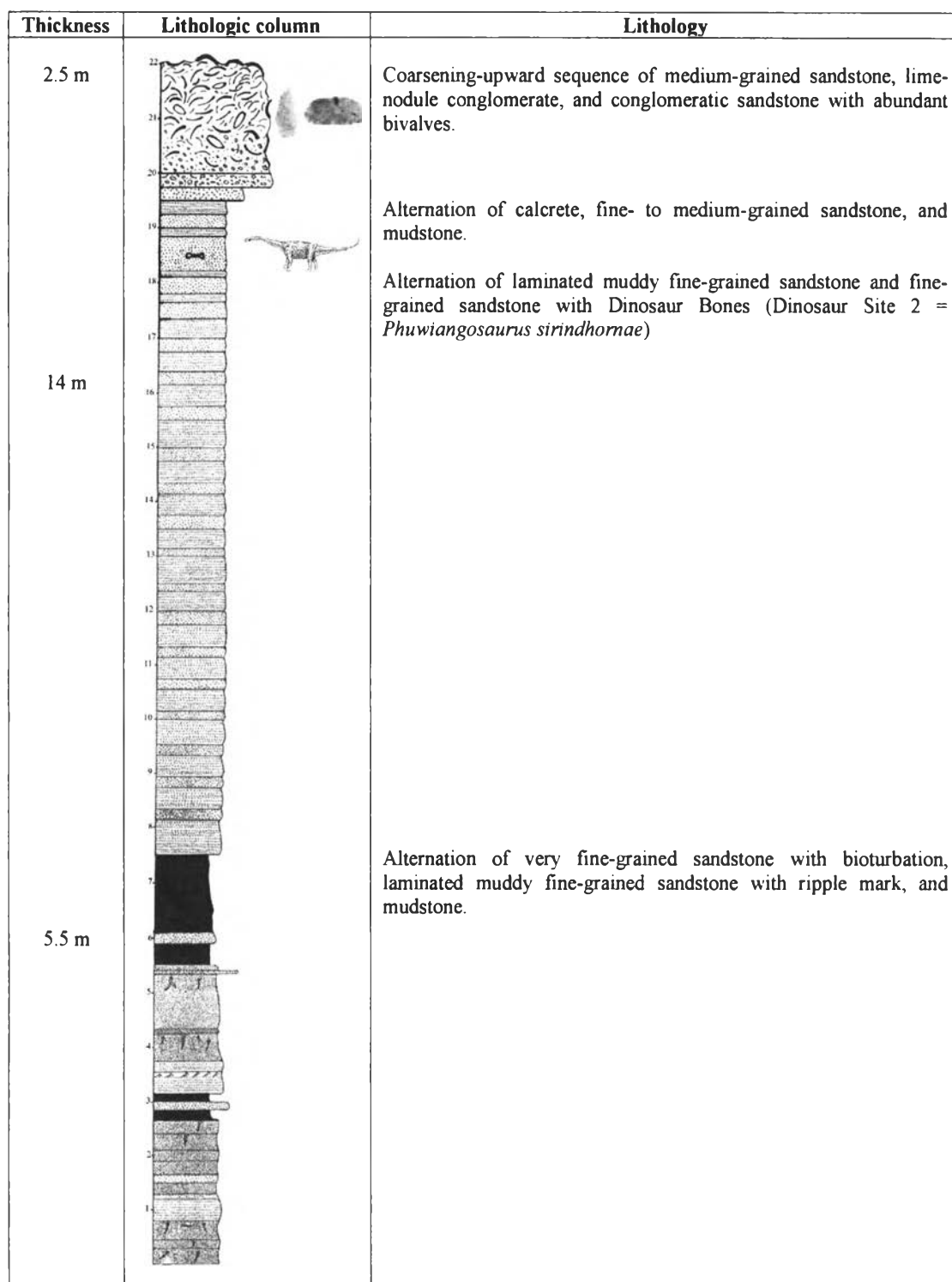


Figure 3.10 Lithostratigraphical columnar section of the Sao Khua Formation at Phu Wiang molluscan locality 2 (PW-M-2). Grid reference 050465

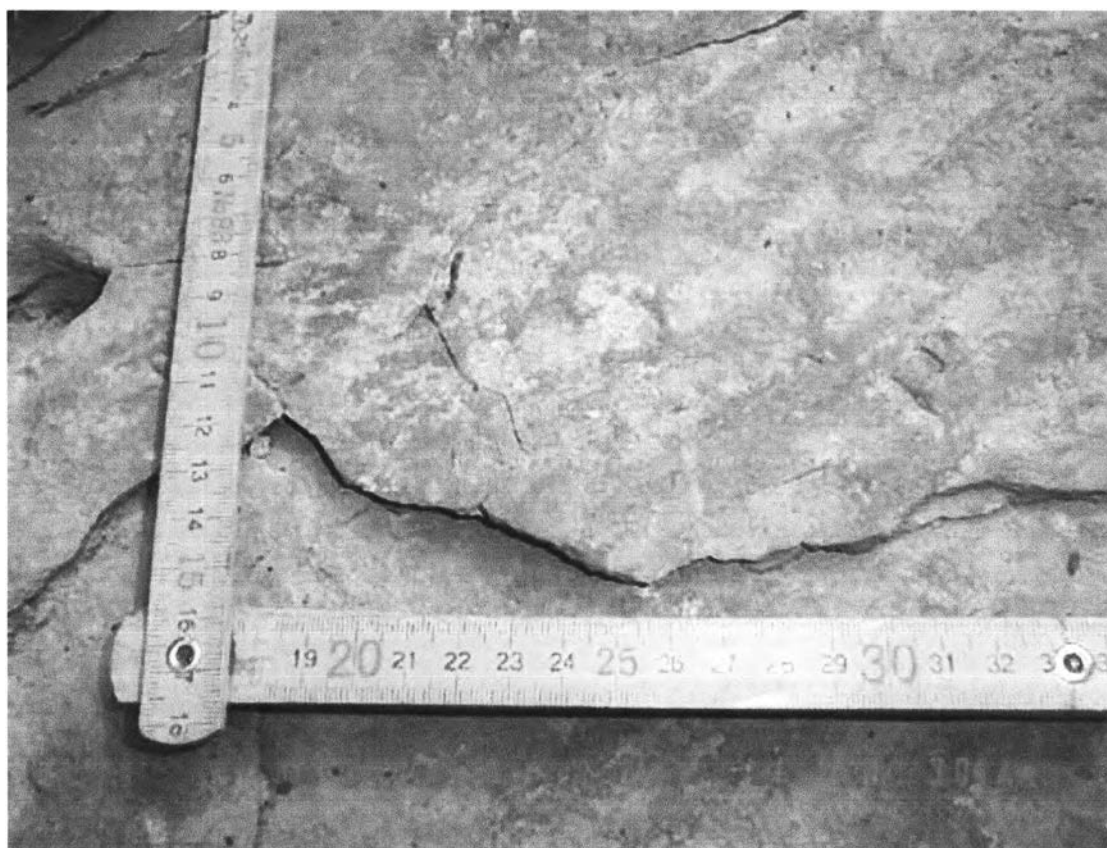


Figure 3.11 Ripple mark on bedding surface of laminated fine-grained sandstone. Grid reference 051466



Figure 3.12 Phu Wiang molluscan locality 2 (PW-M-2). Grid reference 050465

3.1.3 Phu Wiang molluscan locality 3 (PW-M-3)

Map sheet: 5442 III AMPHOE CHUM PHAE

UTM grid reference: 056460

Location: Phu Pratu Tee Ma

Accessibility: The road from Phu Wiang National Park's tourist center to Dinosaur site 2.

This section was made at the outcrop exposed at the foot of Phu Pratu Tee Ma, near the left side of the road cut to Dinosaur Site 2. The thickness is about 7 m (Figure 3.13).

Lithology and sedimentary structure: Description is shown in ascending order; the first 3.2 m is the fining-upward sequence of medium, fine and very fine-grained sandstone bed overlain by the 2.8 m thick of the alternation of mudstone bed and very fine-grained sandstone bed, the uppermost is about 1 m thick of laminated fine-grained sandstone bed overlain by shell bed in lime-nodule conglomeratic sandstone.



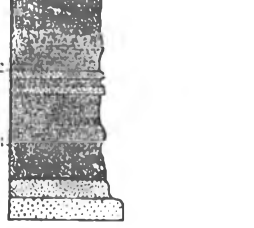
Thickness	Lithologic column	Lithology
1 m		Laminated fine-grained sandstone, conglomeratic sandstone with abundant bivalves.
2.8 m		Alternation of mudstone and very fine-grained sandstone
3.2 m		Fining-upward sequence of medium, fine, and very fine-grained sandstone

Figure 3.13 Lithostratigraphical columnar section of the Sao Khau Formation at Phu Wiang molluscan locality 3 (PW-M-3). Grid reference 056460



Figure 3.14 The outcrop of lower part of the section of Phu Wiang molluscan locality 3 (PW-M-3); the rolling stones in the trough broke from shell bed above. Grid reference 056460



Figure 3.15 Phu Wiang molluscan locality 3 (PW-M-3). Grid reference 056460

3.1.4 Phu Wiang molluscan locality 4 (PW-M-4)

Map sheet: 5442 III AMPHOE CHUM PHAE

UTM grid reference: 052470

Location: Phu Pratu Tee Ma

Accessibility: The road from Phu Wiang National Park's tourist center to parking area, and take the tourist's trail to Dinosaur Site 9.

This section was made at the outcrop of shell bed overlying the red sandstone of Dinosaur Site 9 bed; the thickness of the section is about 14.5 m. (Figure 3.16)

Lithology and sedimentary structure: The description is shown in ascending order; the lowermost set is about 0.9 m thick of convolute or wavy laminated fine-grained sandstone bed with ripple mark, overlain by 0.7 m thick of cross-bedding sandstone bed and laminated fine-grained sandstone bed; the following set is about 2.4 m thick of several cross-laminated fine-grained sandstone beds with bioturbation and ripple mark; after, is about 4.5 m thick of set of several fine-grained sandstone beds with bioturbation and contain dinosaur fossil in the upper most bed of this set; then about 5.5 m thick of mudstone bed and some intercalation of thin bed of fine-grained sandstone, the internal mould of articulated shells were found in mudstone bed in lower part of this set; the top cover with about 0.5 m of medium and laminated medium-grained sandstone beds.

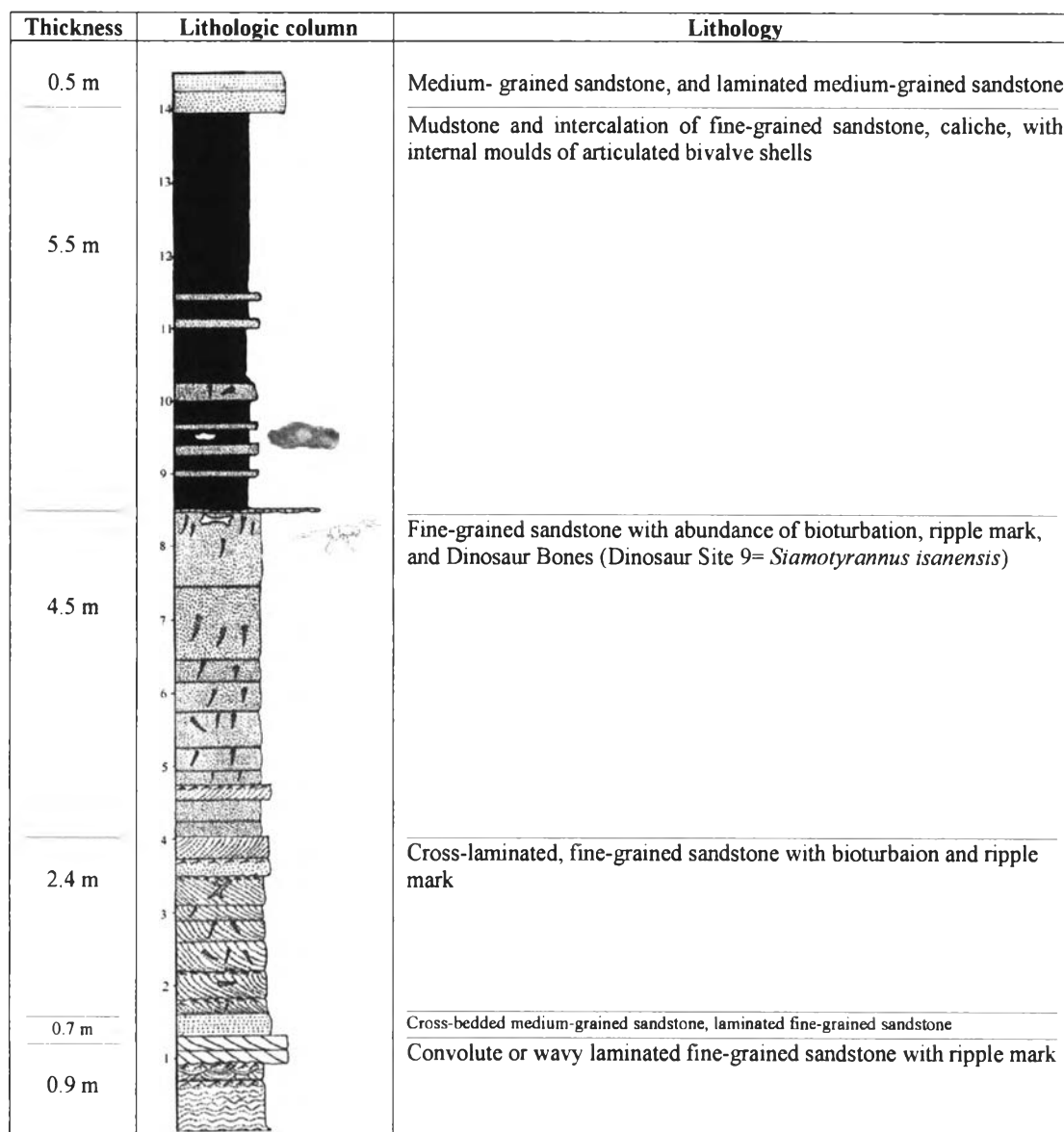


Figure 3.16 Lithostratigraphical columnar section of the Sao Khua Formation at Phu Wiang molluscan locality 4 (PW-M-4). Grid reference 052470



Figure 3.17 Vertical and horizontal carbonate rootlet on the bedding surface of red brown siltstone bed of Dinosaur Site 9, underlying Phu Wiang molluscan locality 4 (PW-M-4). Grid reference 052470



Figure 3.18 Phu Wiang molluscan locality 4 (PW-M-4); the internal moulds of articulated valves were found on the surface of weathering out mudstone at the center of the figure. Grid reference 052471

3.1.5 Phu Wiang molluscan locality 5 (PW-M-5)

Map sheet: 5442 II AMPHOE PHU WIANG

UTM grid reference: 067419

Location: Phu Noi

Accessibility: At Ban Muang Kao, take the road to Huai Bong Weir, and walk across Huai Bong to the locality.

This section was made at the outcrop exposed at the southern foot of Phu Noi hillcock near Dinosaur Site 7; the thickness of the section is about 10 m. (Figure 3.19)

Lithology and sedimentary structure: The description is shown in ascending order; the lower set is the alternation of about 2 m thick of fine-grained sandstone, very fine-grained sandstone, and medium-grained sandstone; the overlying beds are shell bed in mud-nodule conglomeratic sandstone; the following is about 5.8 m thick of laminated fine-grained sandstone beds which the lower bed contain bioturbation; then overlain by the mud-nodule conglomeratic sandstone and thick bed of very fine-grained sandstone; and this cycle repeat again about 0.5 m thick.







Thickness	Lithologic column	Lithology
0.5 m		Mud-nodule conglomeratic sandstone, very fine-grained sandstone
1.3 m		Very fine-grained sandstone
0.1 m		Mud-nodule conglomerate sandstone
5.8 m		Laminated fine-grained sandstone with rare bioturbation
0.1 m		Mud-nodule conglomeratic sandstone with abundant of bivalves
2.2 m		Alternation of fine, very fine, and medium-grained sandstone

Figure 3.19 Lithostratigraphical columnar section of the Sao Khau Formation at Phu Wiang molluscan locality 5 (PW-M-5). Grid reference 067419



Figure 3.20 Phu Wiang molluscan locality 5 (PW-M-5); the weathering out of mud-nodule conglomeratic sandstone bed (red brown color). Grid reference 067419



Figure 3.21 The weathering out of mud-nodule conglomeratic sandstone bed contains abundant of bivalves. Grid reference 067419



Figure 3.22 The trigonal shape bivalve in the host rock mud-nodule conglomerate. Grid reference 067419

3.2 Type section of the Sao Khua Formation

The Sao Khua Formation was proposed by Ward and Bunnag (1964) for the section of thick siltstone and widely separated sandstones that underlies strike valleys between the Phra Wihan and Phu Phan Formations in drainage area of the Huai Sao Khua, an intermittent stream that flows westward parallel to and north of highway between Udon Thani and Nong Bua Lamphu. The formation there is 512 m thick.

A few fossils were found in a thick calcareous, conglomeratic sandstone, and in an overlying conglomerate in the upper part of the type section. They include shell, a tooth, and silified bone fragments. The shells have been identified as naticoid gastropods and two species of bivalves, *Cardinioides magnus* and *Mytilus rectangularis* (Kobayashi *et al.*, 1963)

3.2.1 Details of the fossil horizons

These fossil horizons describe in ascending order below

Unit 21: Thickness is 10.5 m of sandstone underlying unit 22; pale red to light brownish gray, well cemented calcareous, thick-bedded; conglomeratic in zones with fragments of grayish red siltstone up to 1 cm in diameter. Scattered fossils include shell of naticoid gastropod and thick-shelled bivalves of which *Cardinioides magnus* has been identified from a single specimen; a single cone-shaped, striated tooth has been identified as that of an ichthyosaur.

Unit 22: Thickness is 2.1 m of conglomerate, pale red, well cemented; contain nodular pebbles of grayish red calcareous caliche up to 2 cm. in diameter in fine- to medium-grained, calcareous, sandy matrix. Scattered fossils include shell of naticoid

naticoid gastropod and bivalves of which *Mytilus rectangularis* has been identified from a single left valve.

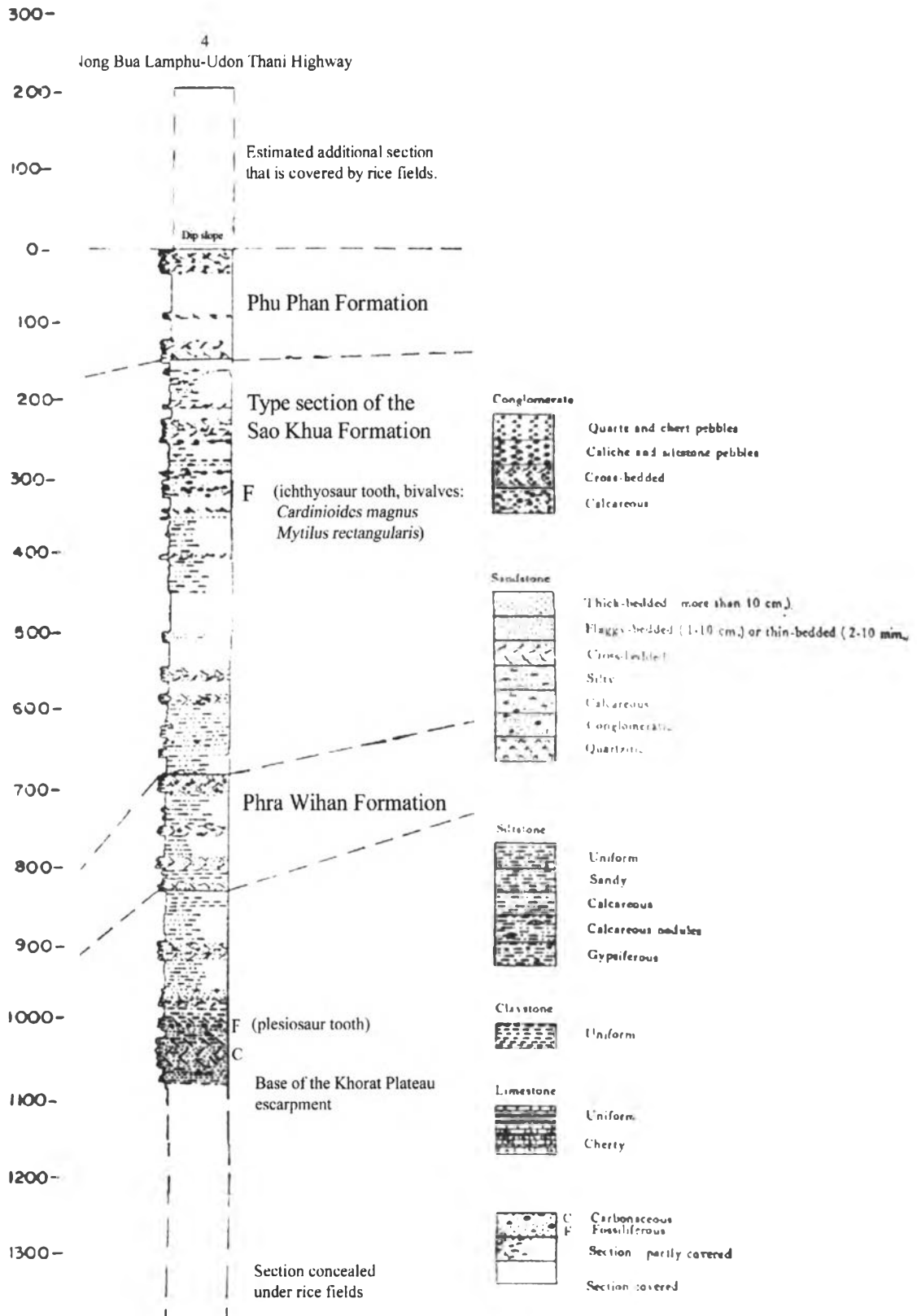


Figure 3.23 The type section of the Sao Khua Formation (modified after Ward and Bunnag, 1964)

3.3 The correlation of columnar sections of Phu Wiang molluscan localities and the type section of the Sao Khua Formation.

Based on the details of measured type section of the Sao Khua Formation by Ward and Bunnag (1964), the fossil horizons can be used to correlate with the section in this study by their similarity of fossils and lithology. (Figure 3.24)

The Unit 21 of the type section is 10.5 m. thick of sandstone with conglomeratic zones with fragments of grayish-red siltstone. The bivalve fossil was identified as *Cardinioides magnus*. The mud-nodule conglomeratic sandstone beds (PW-M-1/3, PW-M-5) can be correlated with unit 21 by their similarity of lithology and trigonal-shape bivalve.

The Unit 22 of the type section is 2.1 m thick of conglomerate containing nodular pebbles of grayish red, calcareous caliche in fine- to medium-grained, calcareous, sandy matrix. The bivalve was identified as *Mytilus rectangularis*. The thick bed of abundant shells in conglomeratic sandstone beds (PW-M-1/2, PW-M-2, PW-M-3) can be correlated with unit 22 by their similarity of lithology and mytiliform-shape bivalve.

Five columnar sections of Phu Wiang molluscan localities can be correlated with the type section of the Sao Khua Formation shown in Figure 3.24

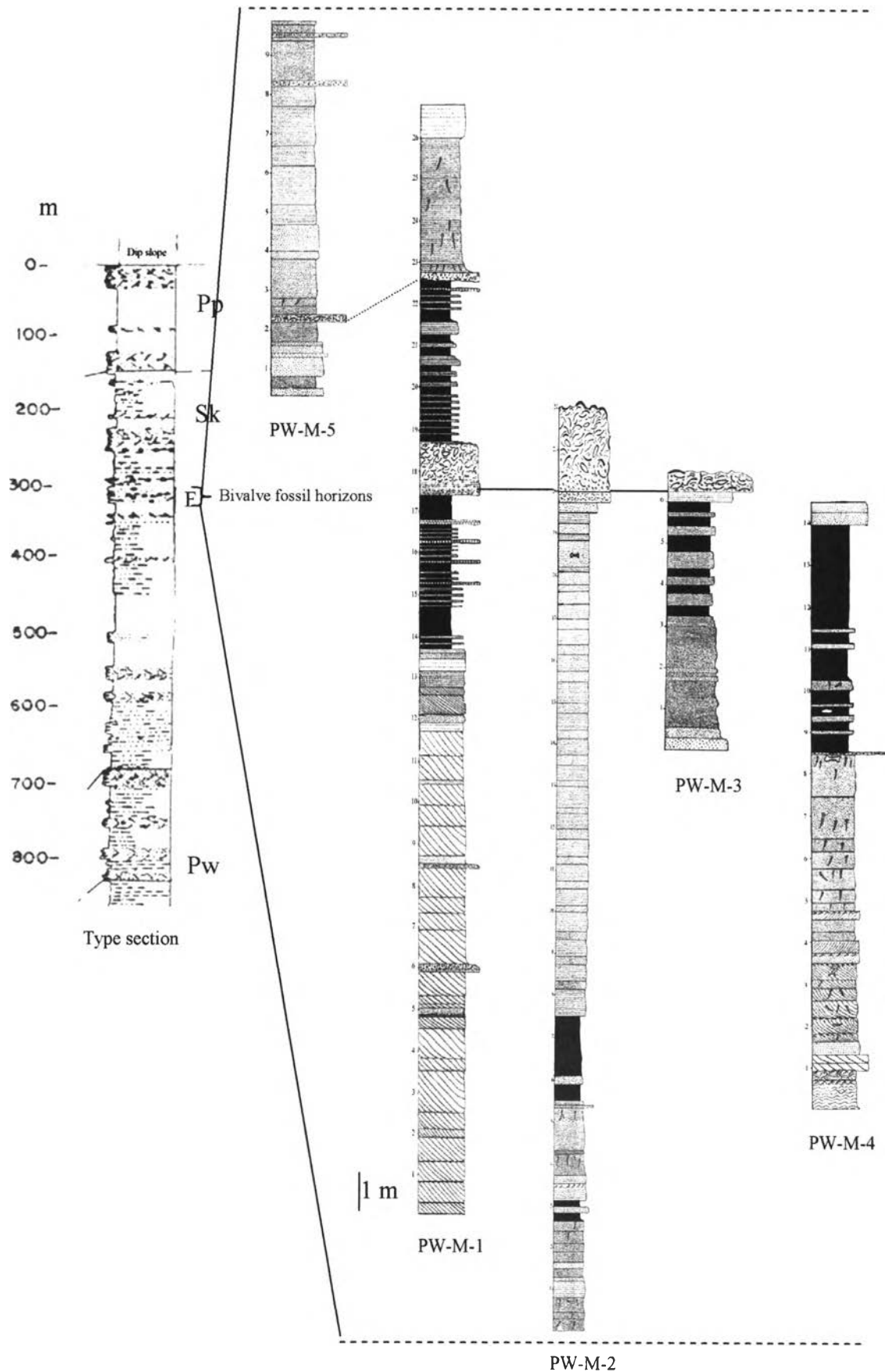


Figure 3.24 Correlation of type section of the Sao Khua Formation (modified after Ward and Bunnag, 1964) with the sections of Phu Wiang molluscan localities (scale in m) (Pp=Phu Phan Formation; Sk=Sao Khua Formation; Pw=Phra Wihan Formation)