CHAPTER IV

TAXONOMY OF BIVALVE FOSSILS

4.1. General features of Bivalvia

4.1.1. Main characters of Bivalvia

The Bivalvia are aquatic mollusks which fundamentally are bilaterally symmetrical and laterally compressed. They invariably are provided with a shell consisting of two wholly or partly calcified valves lying on left and right sides of the body. Typically, the two valves are of equal convexity; but in some forms bilateral symmetry has been lost, usually as the result of cementation of one valve to the substrate, and the valves differ in size to a varying extent.

The valves are connected dorsally by an only partially calcified, elastic structure **(ligament)** and open and close by hinging along an axis which passes through or close to this (Figure 4.1). Typically, the hinge axis has an approximately anteroposterior direction. The two valves thus open along their anterior, posterior, and ventral margins.

The valves are closed by the action of muscle **(adductor muscle)**, two or one in number, attached to the inner face of each valve.

The animal lacks a head, radula, and jaws. Cephalic sensory organs found in other mollusks are thus absent.

The **month** and **anus** are usually at opposite ends of the body (Figure 4.2). The month lies between two pairs of ciliated, flap-like structures known as **labial palps**, which consist in conducting food to it (Figure 4.3).

A **foot** present in most Bivalvia is an extensile structure which most commonly serves mainly for burrowing.

Most forms have a pair of **gills** or ctenidia which are suspended within the mantle cavity from the body and are arranged symmetrically with regard to the median plane of the mollusk.

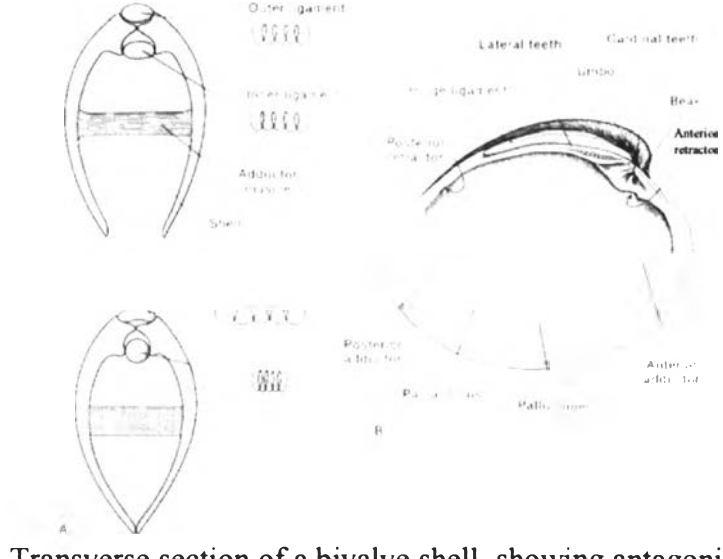

Figure 4.1 A. Transverse section of a bivalve shell, showing antagonistic functions of hinge ligaments and adductor muscles. When the valves are closed by the adductor muscles; the outer hinge ligament is stretched and the inner ligament is compressed. B. Inner surface of the left valve of the marine calm *Mercenaria.* (After Ruppert and Barnes, 1994).

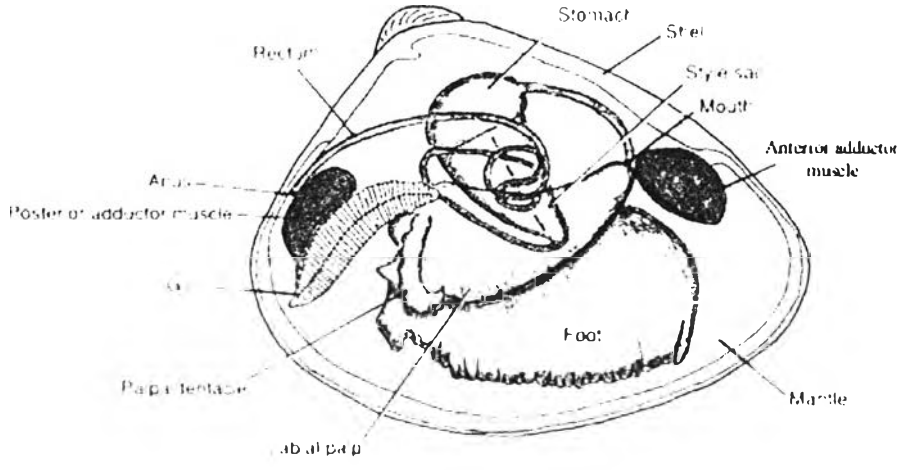

Figure 4.2. Body of *Nucula* with right valve and mantle removed, shows in lateral view (After Ruppert and Barnes, 1994).

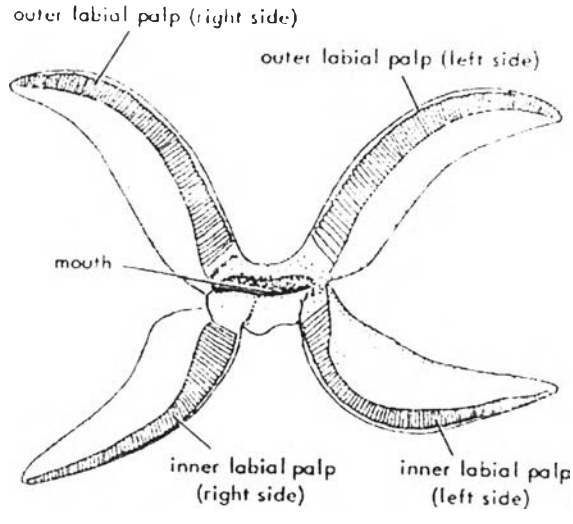

Figure 4.3. Labial palps of *Mytilus edulis*, anterior view of month and lips showing their relation to palps. (After Cox *et al.*, 1969)

4.1.2. Morphology of Bivalve shell

4.1.2.1. Shape

When describing the outline of bivalve as seen in lateral view, recourse is usually made to such terms as suboval, subtrigonal, *etc.* (Figure 4.4). It is preferable wherever possible, however to use terms such as mytiliform, pectiniform, which evoke the shape of well-known genera.

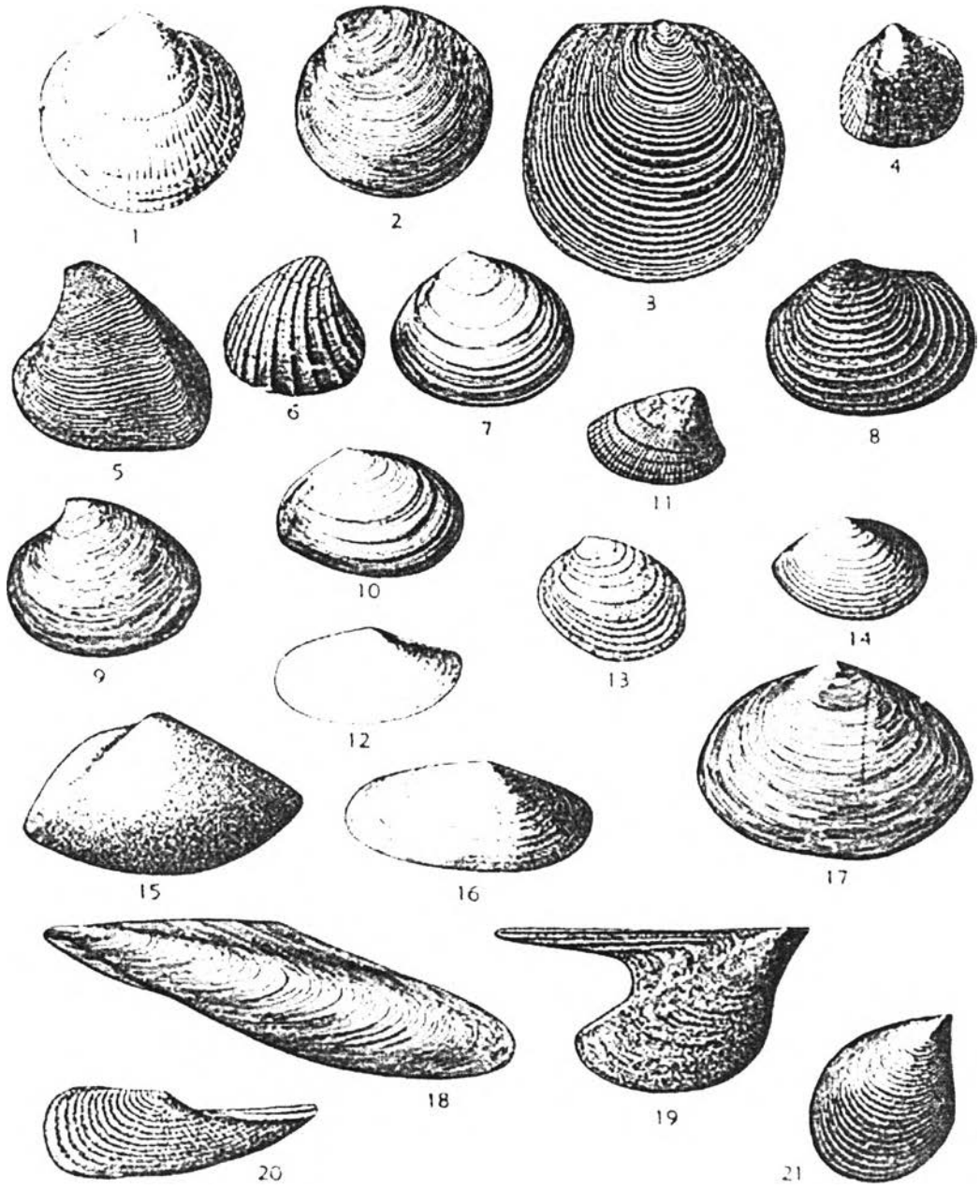

Figure 4.4. Shapes of bivalve shells, illustrating terms commonly used to describe them; 1,2. Circular or orbicular.; 3,7. Subcircular or suborbicular.; 4,8. Subquadrate.; 5,6. Trigonal.; 9. Trigonally suboval.; 10. Suboval.; 11. Subtrigonal.; 12. Subelliptical.; 13,14. Oval.; 15. Donaciform or rhomboidal.; 16. Elongate elliptical.; 17. Elliptical.; 18. Lanceolate or modioliform.; 19. Alate (bialate) or pteriiform.; 20. Rostrate or nuculaniform.; 21.Mytiliform. (After Cox *et al.*, 1969)

4.1.2.2. The measurement of shell

The length as the distance between two planes perpendicular to the cardinal and hinge axes, and just touching both the anterior and posterior extremities of shell. The height is measured perpendicular to the length. (Figure 4.5)

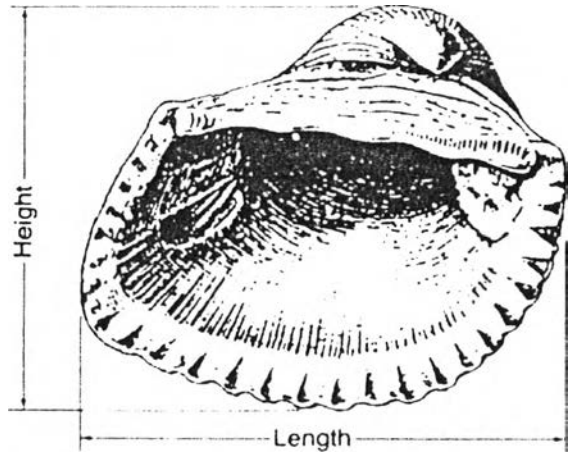

Figure 4.5. Measurement of bivalve shell. (After Raup and Stanley., 1971)

4.1.2.3. General external features of shell

A typical bivalve shell consists of two similar, more or less oval, usually convex valves, which are attached and articulate dorsally with each other. Each valve starting with the larval shell, growth of bivalve shell proceeds by successive increments along the margins of the two valves. This is commonly preserved on each valve of the adult shell, forming a small, nose-like angle termed the beak.

In adult shell, the beak occupies a position close to the middle of the length, the shell is described as equilateral (Figure 4.6 A), but if the beak lies closer to one end or the other the shell is described as inequilateral. (Figure 4.6 B)

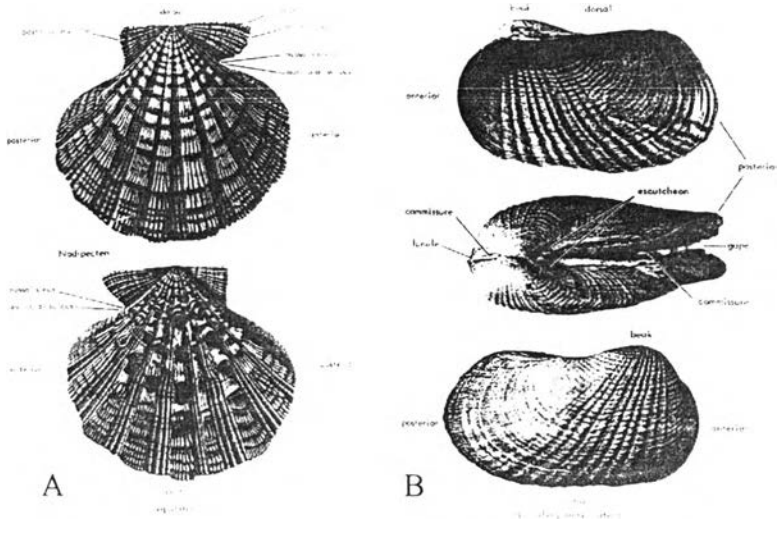

Figure 4.6. Position of beak. A. Equilateral.; B. Inequilateral. (After Cox *et al.*, 1969)

The umbo (plural is umbones) is the point of maximum curvature, a rather indefinite sense to denote the general region of the valve which surrounds this point and extends to the beak The umbonal cavity is the part of the interior of the valve that lies within the umbo.

The umbones are described as prosogyrate if they curve in such a manner that the beaks point in an anterior direction, as opisthogyrate if they point in posterior position, and as orthogyrate if each beak points directly toward the other valve.

In many shells, one or more ridges or carinae originate at the beak. Most commonly such a ridge passes over the umbo on the posterior side of the umbonal pole and runs diagonally across the surface of the valve toward an angle which may be considered to separate the ventral from posterior margin. This ridge is usually termed the posterior ridge or diagonal ridge.

4.1.2.4. Internal calcareous structures of hinge

The function of the hinge teeth, which lie below the actual axis about which the two valve hinge, is to guide them into the exact position in which they will fit tightly together when they are closed by the adductor muscles, and to interlock so that any rotational or shearing movement of the valves are prevented.

In many groups of the Bivalvia, it is usual to refer to two categories of teeth, cardinal teeth lying just below the beaks, and lateral teeth situated close to the dorsal margins at some distance from the beaks. Lateral teeth are described as anterior laterals or posterior laterals according to the end of the shell to which they are the more closely situated.

The term pseudolateral teeth have been applied to elongate longitudinal teeth which their proximal end is close to the beak (found, for example, in many Unionidae). Many authorities on the Unionidae apply the term pseudocardinal to teeth agreeing with the above definition of cardinals but differing from the cardinal teeth of other groups in their very irregular form.

Several terms including the letter "-odont" have been introduced in connection with hinge dentition, and it is important to distinguish their use as descriptive adjectives from those for names of taxonomic categories, in some cases with definitions extended beyond their literal meaning. The type of dentition, described as follows

4.1.2.4.1. Taxodont (Greek = a single rank or line) consists of a series of short, straight or chevron-shaped teeth occupying the entire length of the dorsal margin. (Figure 4.7) The taxodont type of hinge is met with very early in the geological history of Bivalvia in representatives of the Superfamily Nuculacea, but it has also arisen as a secondary development in the Arcacea.

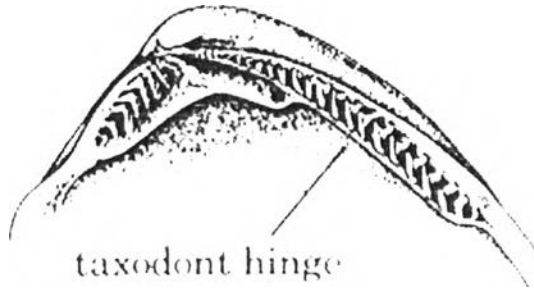

Figure 4.7. Taxodont hinge (After Hylleberg, 2000)

4.1.2.4.2. Actinodont (Greek = ray) dentition is another that appeared very early in the history of Bivalvia. The teeth radiate from the beak and the outer ones are more or less elongate, usually diverging only slightly from the dorsal margin to which they are adjacent.(Figure 4.8)

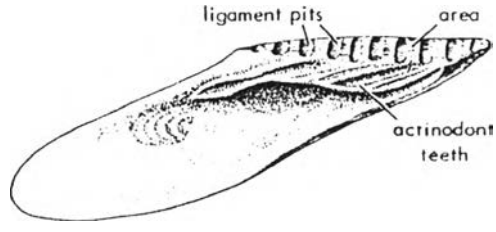

Figure 4.8. Actinodont hinge. (After Cox *et al.*, 1969)

4.1.2.4.3. Schizodont (Greek = to split) it was originally applied primarily to the type of dentition found in the Family Trigoniidae, in which the median tooth of the left valve, one of a small number radiating from the beaks, is broad and bifid. (Figure 4.9) Forms belonging to the freshwater Superfamily Unionacea have been described as schizodont, as their dentition shows some similarity to that of the Trigoniacea. The types of hinge found in these two Superfamilies probably arose independently from the actinodont type. There is no clear differentiation of the teeth into cardinals and laterals.

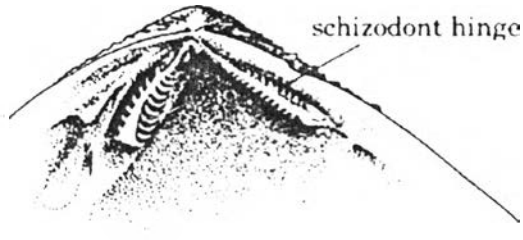

Figure 4.9. Schizodont hinge. (After Hylleberg, 2000)

4.1.2.4.4. Heterodont (Greek = to different) type of dentition was so termed because of the presence of distinctly differentiated cardinal and lateral teeth.(Figure 4.10) The lateral teeth are obscure in many representative of some heterodont familier. When laterals are present, they may belong to both anterior and posterior categories or only to one.

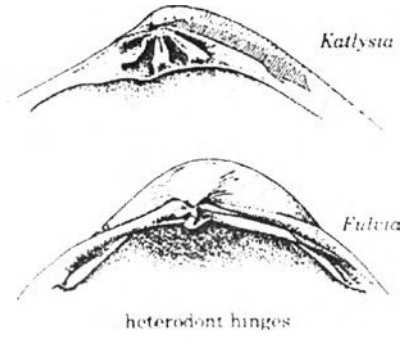

Figure 4.10. Heterodont hinge. (After Hylleberg, 2000)

4.1.2.4.5. Pachyodont (Greek = thick, stout) consists of heavy, blunt, amorphous teeth. (Figure 4.11) These mostly correspond to the dentition of cardinals, but certain lamellar teeth present.

Figure 4.11. Pachyodont hinge. (After Cox *et al.*, 1969)

4.1.2.4.6. Isodont (Greek = equal) there are two equal teeth in each valve, placed symmetrically on either side of a triangular or rounded resilium pit and received in corresponding sockets in the other valve. (Figure 4.12)

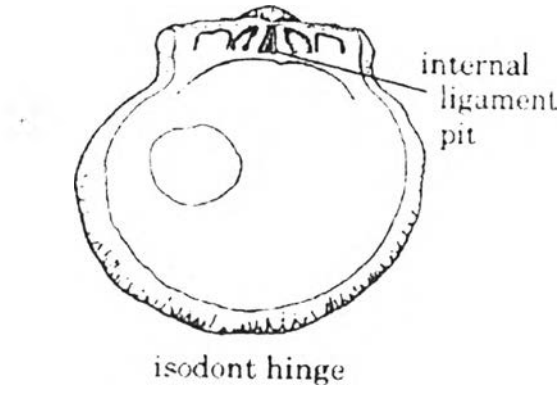

Figure 4.12. Isodont hinge. (After Hylleberg, 2000)

4.1.2.4.7. Dysodont (Greek prefix = badly, ineffectively) the apparently feeble and relatively in effective dentition found in some mytiliform shells, and consisting of small denticles situated close to the beak. (Figure 4.13)

Figure 4.13. Dysodont hinge. (After Hylleberg, 2000)

4.2. Classification of Bivalvia

Many authors established classification of Bivalvia such as Dall (1913), Thiele (1935), Franc (1960), Cox (1960), and Newell (1965). The comparison of classifications is shown in Table 4.1. This study follows Newell's classification.

Table 4.1 Comparative classifications of Class Bivalvia (After Cox *et al.*, 1969)

DALL, 1913	THIELE, 1934-35		FRANC, 1960		COX, 1960		NEWELL, 1965	
PRIONODESMACEA	TAXODONTA		PROTOBRANCHIA	NUCULIDAE NUCULANIDAE MALLETIIDAE	PROTOBRANCHIA	PALAEOTAXODONTIDA	PALAEO-TAXODONTA	NUCULOIDA
				SOLEMYIDAE		LIPODONTIDA	CRYPTO-DONTA	SOLEMYOIDA
						CRYPTODONTIDA		PRAECARDIOIDA
			FILIBRANCHIA	TAXODONTA	PTERIOMORPHIA	EUTAXODONTA	PTERIOMORPHIA	ARCOIDA
	ANISOMYRIA			ANYSOMYRIA		ISOFILIBRANCHIDA		MYTILOIDA
						PTEROCONCHIDA		PTERIOIDA
						COLLOCONCHIDA		
	EULAMELLIBRANCHIA	SCHIZODONTA	EULAMELLIBRANCHIA	SCHIZODONTA	HETEROCONCHIA	SCHIZODONTIDA	PALAEO-HETERODONTA	TRIGONIOIDA
						NAIADIDA		UNIONOIDA
TELEODESMACEA		EXTINCT		EXTINCT		PANTODONTIDA		MODIOMORPHOIDA
		EXTINCT		RUDISTES		PACHYODONTIDA	HETERODONTA	HIPPURITOIDA
		HETERODONTA		HETERODONTA		HETERODONTIDA		VENEROIDA
		ADAPEDONTA		ADAPEDONTA		ASTHENODONTIDA		MYOIDA
ANOMALODESMACEA		ANOMALODESMATA		ANOMALODESMATA		EUDESMODONTIDA	ANOMALO-DESMATA	PHOLADOMYOIDA
			SEPTIBRANCHIA			SEPTIBRANCHIDA		

4.3. Systematic description

Freshwater bivalve fossils had been reported from the Sao Khua Formation of the Phu Wiang area by Meesook and Wongprayoon (1999), Jearanaiwong (2000), Wongprayoon and Meesook (2002). Five species were reported as *Trigonioides* sp., *Plicatounio* sp., *Unio* sp., *Nippononaia* sp. and *Exogyra* sp.

In this study, 15 different morphology of shells and internal moulds are classified and identified to 2 orders, 2 families; the 2 identified taxa including 2 genera, 2 species; the 13 unidentified taxa including 6 indeterminate genera and species, and 7 uncertain affinity.

The systematic classification and morphological terms used in this study are those of Cox *et al.* (1969). All linear measurements of specimens are in millimeters (mm). The description of bivalve fossils in this study are shown below

Phulum Mollusca CUVIER, 1975
Class Bivalvia LINNAEUS, 1758
Subclass Pteriomorphia BEURLEN, 1944
Order Mytiloida FERUSSAC, 1822
Superfamily Mytilacea RAFINESQUE, 1815
Family Mytilidae RAFINESQUE, 1815
Subfamily Mytilinae RAFINESQUE, 1815

Mytilinae *gen. et sp. indet.*

2000 *Exogyra* sp.; Jearanaiwong, p.77-78, pl.3.
2002 *Exogyra* sp.; Wongprayoon and Meesook, p.29-30, fig.18.

Material: Fourteen shells: PW-M-1/3.1-14; and seven incomplete internal moulds: PW-M-1/2.1-5; PW-M-2.1; PW-M-3.1 from four shell beds.

Occurrence: Fourteen recrystalized shells were derived from block sample of mud-nodule conglomerate bed (PW-M-1/3). Five internal moulds were found from conglomeratic sandstone (PW-M-1/2). One internal moulds with some remains of recrystalized shell were found from conglomeratic sandstone (PW-M-2). One internal mould was found from conglomeratic sandstone (PW-M-3).

Description: Wedge-shaped, large shell elongate but small shell spatulate beak terminal, blunt carina which runs from beak to ventral margin, dysodont teeth on anterior margin, growth line present on ventral part.

Discussion: This species was firstly reported as *Exogyra* sp. from the Sao Khua Formation in the Phu Wiang area (Jearanaiwong, 2000), but to judge from the photographs in his report, those specimens could well belong to Subfamily Mytilinae in Family Mytilidae by their similarity of shell shape. In this study, the total number of this species is small and moderately poor preservation, only these incomplete shells and incomplete internal moulds, it is difficult to recognize these materials to previously know genera.

Furthermore, *Mytilus (Pachymytilus) rectangularis* Kobayashi and Hayami, 1963 was described from the specimen found in calcareous conglomerate of the Sao Khua Formation at Km 39.04 on Highway from Udon Thani to Nong Bua Lamphu. This taxon can be compared to the present materials, but less contrast of the published photographs. Details of shell can not be examined in this study and need to examine the type specimen in the future.

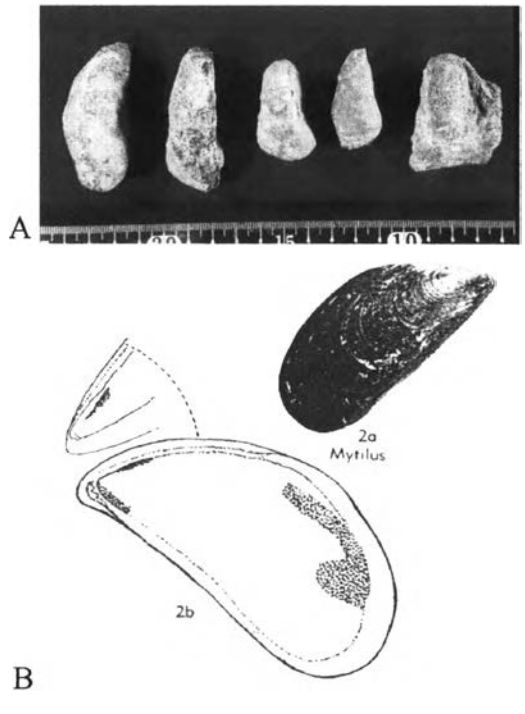

Figure 4.14 A. Mytilinae *gen. et sp. indet.*: PW-M-1/2.1-5 from the present study; B. Typical *Mytilus* sp. in Cox *et al.* (1969).

Subclass Palaeoheterodonta Newell, 1965
Order Unionoida Stoliczka, 1871
Superfamily Unionacea Fleming, 1828
Family Unionidae Fleming, 1828
Subfamily Unioninae Fleming, 1828
Genus *Unio* Philipsson, 1788

Diagnosis: Posterior slope generally distinct, coarse ridges on umbo looped or broken, remainder of shell smooth, periostracum with or without rays. (Cox *et al.*, 1969)

Life span of taxon: Triassic to Recent. (Cox *et al.*, 1969)

Distribution: Europe, Asia, Africa, and Russia. (Cox *et al.*, 1969)

Unio sp. cf. *U. samplanoides* Kobayashi, 1968

2000 *Unio* sp.; Jearanaiwong, p.69-71, pl.1

Materials: Two internal moulds of articulated valves: PW-M-4.1-2

Occurrence: These specimens were found as the weathering debris of red mudstone of Phu Wiang molluscan locality 4 (PW-M-4) near to Dinosaur Site 9.

Description: Shell elongate, gently convex, thin, length less than three times of height; dorsal margin nearly parallel to ventral; umbo located at about one-fourth the length; ventral margin slightly sinuate in the middle part; anterior margin tapering, anterior end blunt at about mid-height; posterior margin rounded; one lateral tooth in left valve, lamelliform, very long; Pseudocardinal tooth, anterior and posterior adductor muscle scar, pallial line, and all characters of internal right valves are not preserved on the mould.

Discussion: The present materials are closely related to *Unio samplanoides* Kobayashi, 1968, from the Khok Kruat Formation of Nam Phung Dam site, Amphoe Phu Phan, Changwat Sakon Nakhon. These materials are slightly different from *U. samplanoides* in shell length, which the length of *U. samplanoides* more than three times the height. According to the less number of internal mould, which some characters disappear. *Unio* sp. cf. *U. samplanoides* was used for the Phu Wiang specimens for the time being.

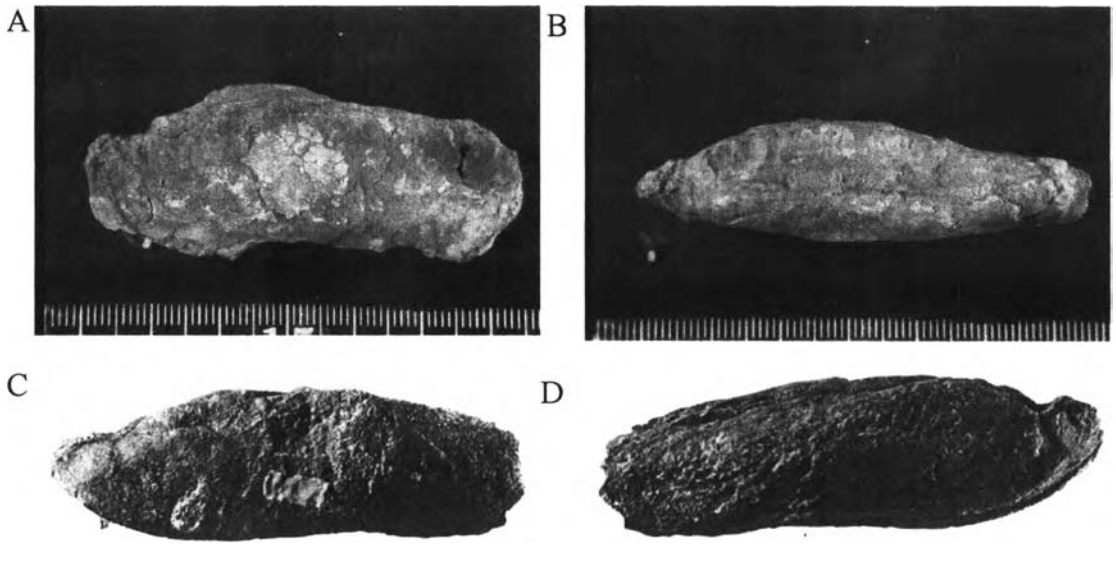

Figure 4.15 internal mould of *Unio* sp. cf. *U. samplanoides*: PW-M-4.1 from this study: A. left side, B. dorsal view; Holotype of *Unio samplanoides* Kobayashi, 1968, internal mould, C. left side D. right side.

Genus *Nippononaia* Suzuki, 1941

Diagnosis: Subelliptical, medium sized, with many acute V-shaped ridge centering on line from beak to middle of ventral margin which in finely crenulated (Cox *et al.*, 1969)

Life span of taxon: Late Cretaceous (Cox *et al.*, 1969)

Distribution: Japan, North America, Thailand (Kobayashi, 1963)

Nippononaia mekongensis Kobayashi, 1963

Material: One articulated shell: PW-M-5.1; and thirteen disarticulated valves: PW-M-1/3.15-27.

Occurences: One articulated shell was collected from weathering of mud-nodule conglomeratic sandstone bed (PW-M-5). Thirteen recrystalized disarticulated valves were derived from block sample of mud-nodule conglomerate bed (PW-M-1/3). These specimens comprise nine left valves and four right valves.

Description: Shell subelliptical, nearly twice as long as high, strongly convex and quite equilateral; maximum length and thickness lying respectively a little below and above the mid-height; umbo small or medium in size, orthogyle and located at a distance 2/5 to 3/8 the length of the shell; preumbonal outline rounded more strongly on the ventral than the other side; post-umbonal outline subtriangular, produced posteriorly or posteroventrally and subtruncated diagonally or subvertically in posterior, posterior rostration developed through growth.

Test thick; the tendency for small shells that the umbo is shifted more interiorly in the grown stage (Figure 5.4), the post-umbonal outline looks slender in the young shell, but later the rostration greatly develops.

Surface ornamented by numerous fine subvertical ribs in the middle and anterior parts, and few stout ribs in posterior alternating with equally strong groove, both series of ribs join together, they form acute v-shaped ridges below umbo pointed ventrally; umbonal carination increase; pre and post-umbonal cardinal area depressed; shallow sinuation occurs on anterior ventral margin and deep sinuation occur on posterior ventral margin. (Adapted after Kobayashi, 1963)

Discussion: *Nippononaia mekongensis* Kobayashi, 1963 differs from other known *Nippononaia* species by very suddenly change of ribs from numerous fine ribs in anterior part to few strong stout ribs in posterior part behind the umbo. The presence of *N. mekongensis* in the rock of PW-M-5 may extend the age of these rocks up to Aptian-Albian corresponding to the Khok Kruat Formation at Ban Na Yo, Mukdahan. However, the previously mentioned Sao Khua Formation in this location may be change to the Khok Kruat Formation according to the *N. mekongensis*, and detailed study may be need to be done in the future.

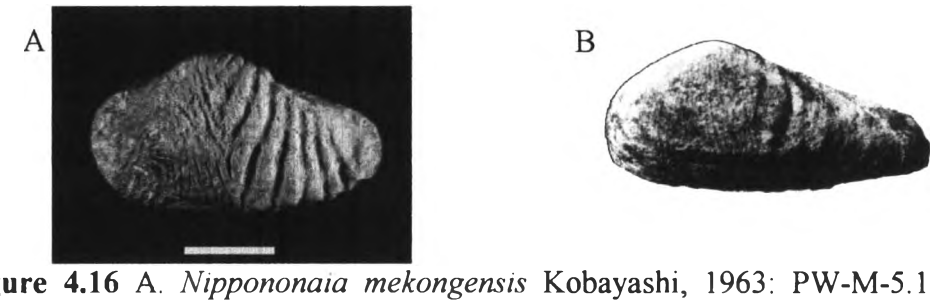

Figure 4.16 A. *Nippononaia mekongensis* Kobayashi, 1963: PW-M-5.1 from the present study; B. Holotype of *Nippononaia mekongensis* Kobayashi, 1963 from the Khok Kruat Formation of Ban Na Yo, Mukdahan.

Table 5.1 Measurement of shell dimentions in *Nippononaia mekongensis* Kobayashi, 1963

specimen		Articulation (ar. or disar)	Length (mm)	Height (mm)	Breadth (mm)	Preumbonal Length (mm)	Preumbonal Length/Length
Kobayashi (1963)	1	ar.	24.25	12.20	9.00	9.60	0.40
	2	ar.	34.30	17.90	15.30	10.30	0.30
	3	ar.	41.50	22.80	19.50	14.80	0.36
This study PW-M-1/3	1	disar.(l)	10.40	7.00	-	4.00	0.38
	2	disar. (l)	16.00	9.20	-	5.70	0.36
	3	disar.(r)	*Ca* 15.20	10.00	-	*Ca* 6.40	0.42
	4	disar.(r)	*Ca* 16.60	11.40	-	*Ca* 5.30	0.32
	5	disar.(l)	*Ca* 16.80	11.60	-	*Ca* 7.20	0.43
	6	disar.(l)	*Ca* 16.50	10.80	-	*Ca* 7.20	0.44
	7	disar.(l)	*Ca* 19.40	*Ca* 13.00	-	*Ca* 6.10	0.31
	8	disar.(r)	*Ca* 22.10	16.00	-	*Ca* 7.60	0.34
	9	disar.(l)	21.50	*Ca* 15.50	-	*Ca* 9.10	0.42
	10	disar.(r)	*Ca* 24.70	16.30	-	*Ca* 9.70	0.39
	11	disar.(l)	25.30	18.40	-	9.30	0.37
	12	disar.(l)	36.30	21.40	-	11.20	0.31
	13	disar.(l)	*Ca* 45.10	*Ca* 26.90	-	10.30	0.23
This study PW-M-5	14	ar.	33.80	19.50	13.60	11.40	0.34

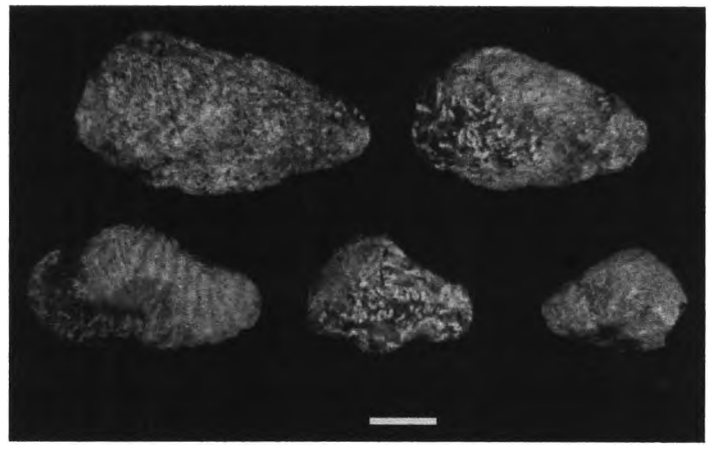

Figure 4.17 ontogenic variations in *Nippononaia mekongensis* Kobayashi, 1963 from PW-M-5 (left below), and PW-M-1/3 of the Phu Wiang area

Unionidae *gen. et sp. indet.* (1)

Materials: One articulated shell, and five disarticulated valves: PW-M-5.2-7.

Occurrence: These materials were found as weathering debris of mud-nodule conglomeratic sandstone bed in the southern part of Phu Noi (PW-M-5).

Description: Shell ear-shaped, moderately thick, moderately convex and quit equilateral; maximum length lying below mid-height. Umbo small located at a distance about 1/5 the length of the shell; pre-umbonal outline rounded with slightly pointed at the anterior end of shell; post-umbonal outline subtriangular with posterior rostration; ventral margin more sinuated at postero-ventral part;

Surface ornamented by numerous incline fine ribs run from pre-umbonal area to centro-ventral area; sharp ridge run from umbo to the posterior end which originated few incline stout ribs from the knob on the ridge run to centro-ventral area; umbonal ridge short; present behind the umbo and run parallel to hinge line, small knob present

Hinge plate narrow with tooth-like pseudocardinal tooth; lateral tooth lamelliform; umbonal cavity shallow.

Comparison and Discussion: This species has hinge characteristics belonging to family Unionidae. Although, the presence of its tooth-like pseudocardinal tooth can be compared with genus *Contradens, Ensidens, Elongaria. Ptychorhynchus,* and *Rectidens*, it shows important differences in its shape, which less elongate, thick and stout, contrary to genera mentioned above. According to the small number of available materials, reference, time limitation and difficulty of fossil preparation, the fine ornamentation and muscle scar can not be assessed. Therefore, these specimens are left in open nomenclature for the time being.

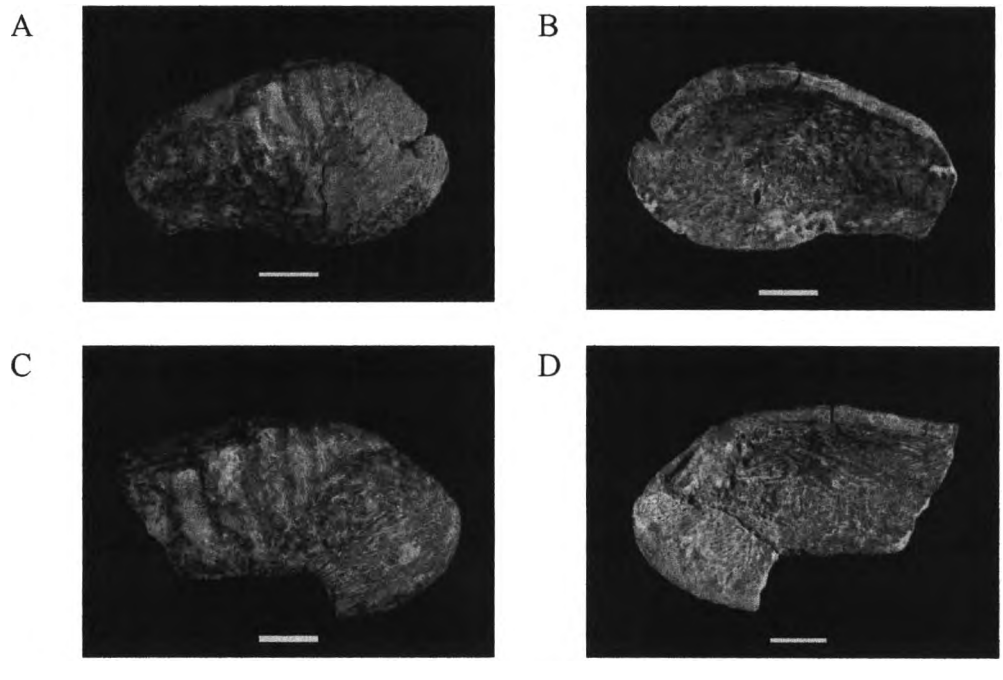

Figure 4.18 Unionidae *gen. et sp. indet.* (1)**;** A-B: PW-M-5.2; A. External view of shell; B. Internal view of shell; C-D: PW-M-5.3; C. External view of broken shell; D. Internal view of broken shell.

Unionidae *gen. et sp. indet.* (2)

Material: One disarticulated left valve: PW-M-5.8

Occurrence: One disarticulated left valve was found as weathering debris on the weathering mud-nodule conglomeratic sandstone bed (PW-M-5)

Description: shell subtrigonal, rather drawn out behind strongly convex, thick; anterior end round, posterior margin perpendicularly truncated, nearly straight; posterior slope crossed by long incline tubercles originating at posterior ridge and run toward posterior margin; pseudocardinal teeth thick and furrowed, consist of anterior set and umbonal set, anterior set with high tooth like teeth outside and compressed auxiliary teeth inside, umbonal set compressed triangular shape with 4 furrows; Two lamelliform lateral teeth, sharp, with deep socket between them; interdental interval short and arcuate; umbonal cavity deep.

Comparison and Discussion: The hinge characteristic is closely related to genus *Psoronaia* in Subfamily Quadrulinae, but it shows big difference in pseudocardinal teeth which can not separate from subset like present material as well as lateral teeth, and interdental interval show contrary to *Psoronaia*. According to small number of available material, this specimen is left in the open nomenclature, and wait for more discoveries of available materials.

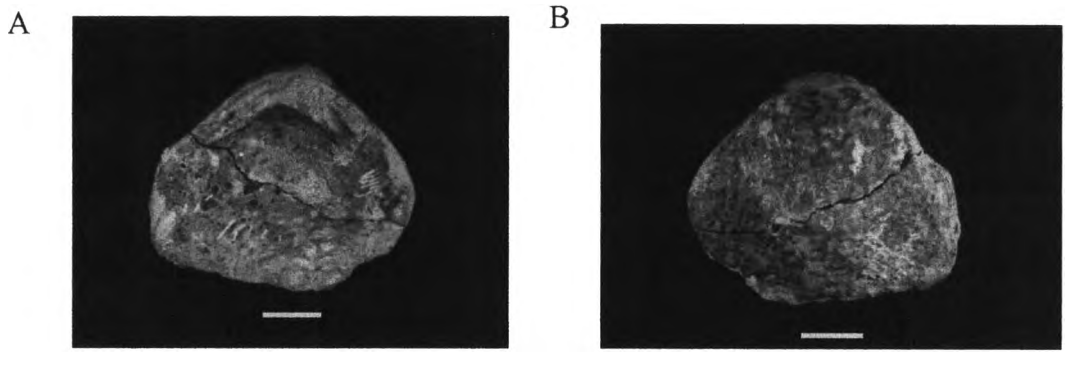

Figure 4.19 Unionidae *gen. et sp. indet.* (2)**:** PW-M-5.8**;** A. Internal view of shell; B. External view.

Unionidae *gen. et sp. indet.* (3)

Material: Two disarticulated left valves: PW-M-5.9-10

Occurrence: Two disarticulated left valves were found as weathering debris on the weathering mud-nodule conglomeratic sandstone bed (PW-M-5)

Description: shell subtrigonal, rather drawn out posterior, strongly convex, thick, anterior end round but posterior end rather pointed; posterior slope crossed by tuburcles originating on blunt posterior ridge; growth line present. One tooth-like pseudocardinal tooth, thick; two lamelliform lateral teeth, slightly sharp with deep socket between them; interdental interval short and arcuates; umbonal cavity deep.

Comparison and Discussion: According to hinge characteristics, these materials belong to Family Unionidae and are closely related to Subfamily Quadrulinae. However, the generic level can not recognize their affinity with the known genera. Accordingly, these specimens are left in open nomenclature, and wait for the discovery of more well preserved fossils, especially the right valves.

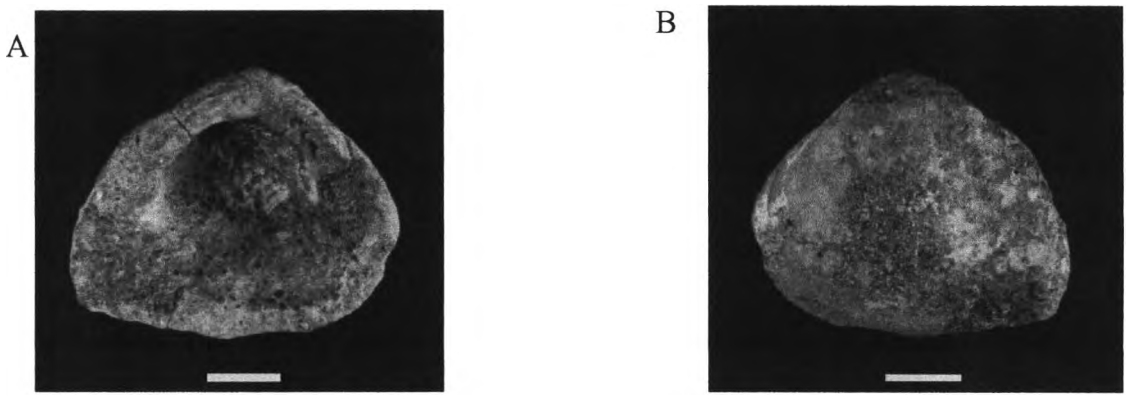

Figure 4.20 Unionidae *gen. et sp. indet.* (3)**:** PW-M-5.9-10; A. Internal view of shell; B. External view of shell.

Unionidae *gen. et sp. indet.* (4)

2000 *Trigonioides* sp.; Jearanaiwong, p.72-76, pl.2.

Material: Fourteen disarticulated right valves and four disarticulated left valves: PW-M-5.11-28

Occurrence: These shells were found as weathering debris on the weathering mud-nodule conglomeratic sandstone bed (PW-M-5)

Description: shell triangular, strongly convex, thick, anterior end slightly round posterior end slightly pointed; posterior slope crossed by incline plicate morphology which consists of four blunt ridge and their intervals; growth line present. Right valve with one large tooth-like pseudocardinal tooth, one sharp lamelliform lateral tooth, interdental interval slightly short and arcuates; left valve with large and deep socket of psudocardinal and one broad and deep socket of lateral teeth; umbonal cavity deep.

Comparison and Discussion: These trigonal shells were previously reported as *Trigonioides* sp. (Jearanaiwong, 2000). After redescribing the specimens in Phu Kum Khao Dinosaur Museum and photographs of Jearanaiwong's report, the specimens show the hinge teeth with no crenulation which is different from family Trigonioididae. However, the hinge characteristics of this species can be recognized as belonging to family Unionidae which can be related to subfamily Quadrulinae by their short and heavy pseudocardinal tooth, one short lemelliform lateral tooth, and wide smooth or the same position with teeth in the opposite valves. According to present materials, these specimens are leaf in open nomenclature, and wait for the discovery of more well preservation of shells and spend more time to carefully clean specimens to find out fine sculptures for description and nomination in the next publication.

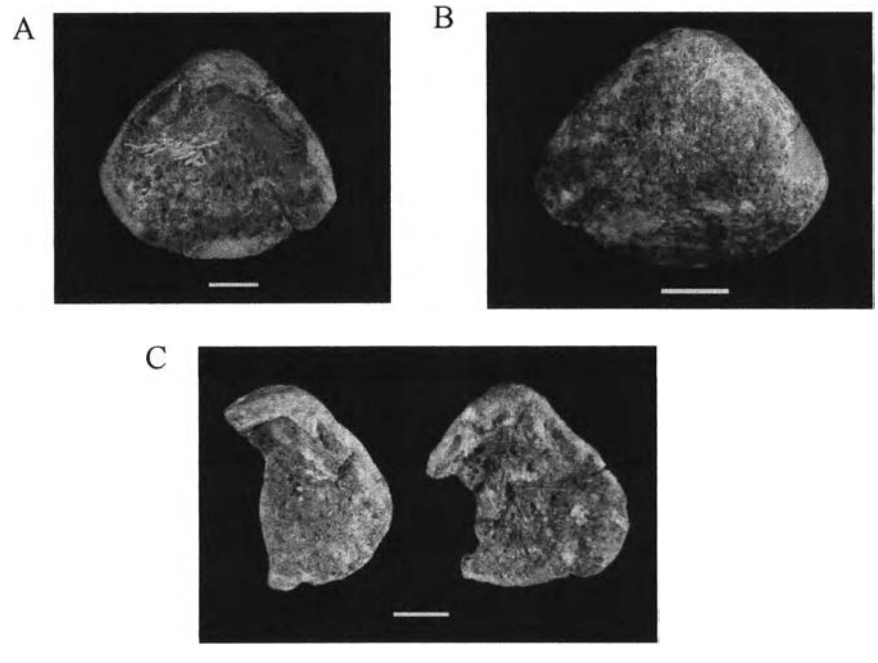

Figure 4.21 Unionidae *gen. et sp. indet.* (4); A-B: PW-M-5.11; A. Internal view of right valve; B. External view of right valve; C: PW-M-5.12-13; Internal view of left valve.

Unionids *gen. et sp. indet.*

Materials: Sixty-seven disarticulated valves: PW-M-1/3.28-94.

Occurrence: Sixty-seven disarticulated valves were derived from block sample of mud-nodule conglomerate bed (PW-M-1/3).

Description: Shell subtrigonal, strongly convex, hinge teeth were covered by the matrix.

Comparison and Discussion: The outline of these shells similar to Unionidae gen. indet. (2-4) mention before. But hinge teeth were covered by the matrix, that their affinity can not be examined. These fossils are left in unionids group, which may comprise all of 3 taxa of trigonal shape Unionidae *gen. et sp. indet* and wait for examination and discovery of key characters to identify by only outline of shells.

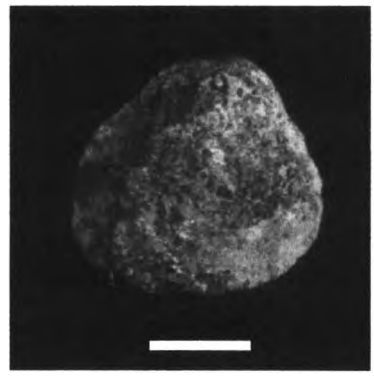

Figure 4.22 Unionids *gen. et sp. indet.*: PW-M-1/3.28; External view of right valve.

Subclass *incertae cedis*
Order *incertae cedis*
Superfamily *incertae cedis*
Family *incertae cedis*
Subfamily *incertae cedis*

***incertae cedis* (1)**

Materials: Eighteen disarticulated valves: PW-M-1/3.95-112.

Occurrence: Eighteen recrystalize disarticulated valves were derived from block sample of mud-nodule conglomerate bed (PW-M-1/3). These specimens comprise nine left valves and nine right valves.

Description: Shell subtrigonal, quite compressed, beak prominent, anterior end truncate, posterior part round, posterior end rather point at postero-ventral area.

Comparison and Discussion: The outline of these shells is similar to *Psoronaias* and *Amblema* (*Psonula*) in subfamily Quadrulinae of family Unionidae. Because of internal shell covered by thick matrix, the details of hinge teeth and muscle scar cannot be examined. Therefore the classification and identification below class Bivalvia is impossible for the time being

Figure 4.23 *incertae cedis* (1)**:** PW-M-1/3.95; External view of right valve.

incertae cedis (2)

Materials: Seven disarticulated incomplete valves: PW-M-1/3.113-119.

Occurrence: Seven recrystalize disarticulated valves were derived from block sample of mud nodule conglomerate bed (PW-M-1/3), these specimens comprise five left valves and two right valves.

Description: Shell trapezoid, quite convex, beak prominent, both anterior end and posterior end truncate, one ridge present from umbo to postero-ventral margin.

Comparison and Discussion: The outline is similar to *Unio (Heterunio)* in Subfamily Unioninae and *Peudodontoides* in Subfamily Anodontinae, both are Family Unionidae. However, the small number of incomplete valves in this study is difficult to ascertain in classification and identification below class level.

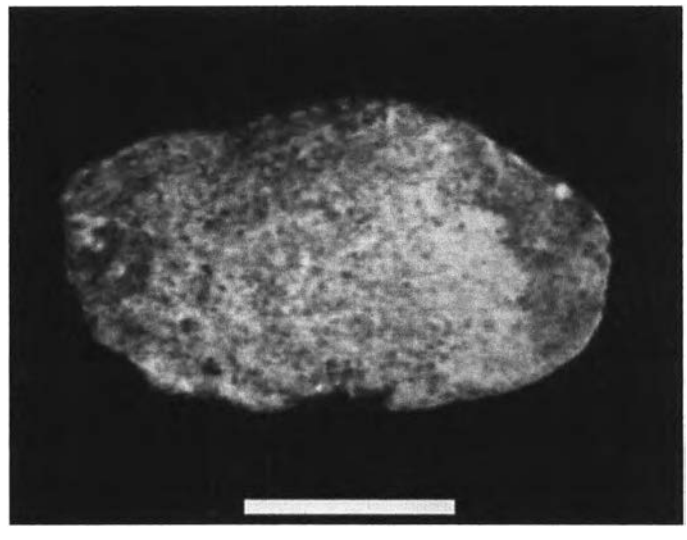

Figure 4.24 *incertae cedis* (2): PW-M-1/3.113; External view of right valve.

incertae cedis (3)

Materials: One fragment of umbo part: PW-M-1/3.120.

Occurrence: One fragment of recrystalization of umbo part was derived from block sample of mud -nodule conglomerate bed (PW-M-1/3)

Description: Umbo thick, wide angle; the estimation of shell is subelliptical shape; hinge teeth is unclear.

Comparison and Discussion: Because of only one strange poor preservation of umbo at hand, the classification and identification is therefore impossible and wait for the discovery of more materials. This specimen is left in open nomenclature.

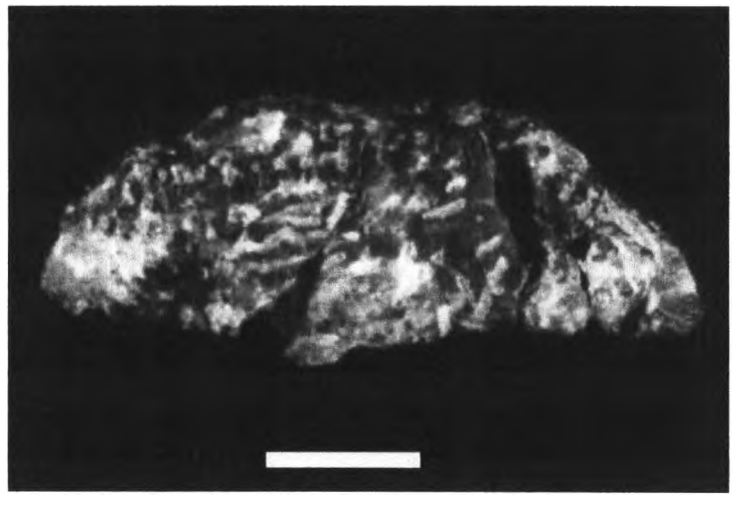

Figure 4.25 *incertae cedis* (3)**:** PW-M-1/3.120; External view.

incertae cedis (4)

Materials: Six incomplete disarticulated valves: PW-M-1/3.121-126.

Occurrence: Six incomplete disarticulated valves were derived from block sample of mud nodule conglomerate bed (PW-M-1/3). All shells are right valves

Description: Shell trigonally ovate, quit convex, beak prominent, anterior slightly concave, posterior convex.

Comparison and Discussion: With only six incomplete shells at hand, the outline of these materials is similar to *Seaphotrigonia* and *Vaugonia (Orthotrigonia)* of Family Trigoniidae. However, hinge teeth cannot be examined, classification and identification is therefore impossible, these specimens are left in open nomenclature for the time being.

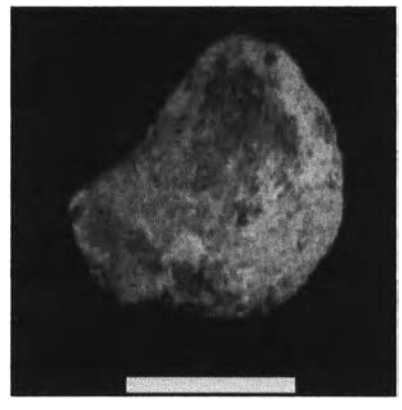

Figure 4.26 *incertae cedis* (4): PW-M-1/3.121; External view.

incertae cedis (5)

Materials: Eight disarticulated incomplete valves: PW-M-1/3.127-134.

Occurrence: Eight recrystalize disrticulated valves were derived from block sample of mud nodule conglomerate bed (PW-M-1/3). These specimens comprise two moderate left valves and six small unidentified valves.

Description: Shell oblong, convex, beak prominent, anterior margin rather round with blunt point at the anterior end; ventral margin concave, posterior margin narrow, rather round, and point to postero-ventral direction; winged dorsally from umbo to posterior margin.

Comparison and Discussion: The strange morphology of these shells cannot compare to former known bivalves. With the specimens at hand, only two moderate size were recognized and six young shells were recognized as same species by oblong and convex shell shapes. However, the small number and poor preservation of these materials cannot classify and identify. Therefore, these specimens are left in open nomenclature, and wait for the discovery of more and complete shells.

Figure 4.27 *incertae cedis* (5)**:** PW-M-1/3.127; External view left valve.

incertae cedis (6)

Materials: Eleven disarticulated incomplete valves: PW-M-1/3.135-145.

Occurrence: Eleven recrystalize disrticulated valves were derived from block sample of mud nodule conglomerate bed (PW-M-1/3).

Description: Shell elliplic, quite compressed; beak small, orthogyle and located about middle of the length of the shells, anterior, posterior, and ventral margin round and slightly round.

Comparison and Discussion: The outline of these shells is similar to genus *Tutuella* in Family Pseudocardiniidae, Subclass Palaeoheterodonta, and Genus *Heterodon* in Family Tellinidae, Subclass Heterodonta. However, the details of hinge teeth and other fine sculptures cannot examine for the time being, because of the thick matrix cover. Therefore, these specimens are left in open nomenclature, and wait for the discovery of more shells.

Figure 4.28 *incertae cedis* (6)**:** PW-M-1/3.135; External view.

incertae cedis (7)

Materials: Seven articulated internal moulds. : PW-M-1/2.6-9, PW-M-2.2-3. PW-M-3.2.

Occurrence: Four specimens from PW-M-1/2; two specimens from PW-M-2, and one specimen from PW-M-3.

Description: Shell elliplic, quite compressed; beak small, orthogyle and located near anterior end, many small ribs run from umbo to ventral margin.

Discussion: The detail of hinge teeth cannot be examined for the time being. Therefore, these specimens are left in open nomenclature.

Figure 4.29 *incertae cedis* (7)**:** PW-M-1/2.6; External view.