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# Sedimentological Study of Bivalve Fossils Site Locality in Hong Hoi Formation, Lampang, Thailand

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***Abstract*—**Hong Hoi Formation is a Middle Triassic deep marine succession presented in outcrops throughout the Lampang Basin of northern Thailand. The primary goal of this research is to diagnose the paleoenvironment, petrographic compositions, and sedimentary sources of the Hong Hoi Formation in Ban Huat, Ngao District. The Triassic Hong Hoi Formation is chosen because the outcrops are continuous and fossils are greatly exposed and abundant. Depositional environment is reconstructed through sedimentological studies along with facies analysis. The Hong Hoi Formation is petrographically divided into two major facies, they are: sandstones with mudstone interbeds, and mudstones or shale with sandstone interbeds. Sandstone beds are lithic arenite and lithic greywacke, volcanic lithic fragments are dominated. Sedimentary structures, paleocurrent data and lithofacies arrangement indicate that the formation deposited in a part of deep marine abyssal plain environment. The sedimentological and petrographic features suggest that during the deposition the Hong Hoi Formation received sediment supply from nearby volcanic arc. This suggested that the intensive volcanic activity within the Sukhothai Arc during the Middle Triassic is the main sediment source.

***Keywords*—**Sukhothai Zone, petrography, Hong Hoi Formation, Lampang, Triassic.

## I. Introduction

THE northern Thailand represents the dramatic geo-tectonic events for a long time and contains widely distributed non-marine, marine clastics and volcaniclastics rocks. In recent studies, northern Thailand is generally subdivided into four major geotectonic domains [1]-[3]. They are, from east to west, the Indochina Block, Sukhothai Zone, Inthanon Zone and Sibumasu (or Shan-Thai) Block. The Sukhothai Zone is considered to be Permo-Triassic Island Arc system (Fig. 1). Hong Hoi Formation is a part of the Lampang Group, which has often been regarded as either a forearc basin sediment of the Sukhothai Zone [4], [5] or intra-arc facies [6]. However, detailed sedimentary facies and actual environment have not been clarified.

There are two highly contrasted interpretations about paleoenvironment of deposition and paleontologic characteristics of the Hong Hoi Fm. The formation deposited from the Middle Triassic to early Late Triassic and is regarded as representing a pelagic deep-marine deposition of the Lampang Group [4], [7]-[8].

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In Ban Huat area of Ngao District, Triassic strata consisting mainly of clastics and limestone are widely distributed (Fig. 2). A few reports on the sedimentary facies of the Hong Hoi Formation are published. Geological study of the sedimentary sequences in this area is important for determining the geological development of Sukhothai Arc System that is related to the subduction process of Paleo-tethys and the Indochina Block [5]. The Middle Triassic bivalves have been recently discovered in the interbedded mudstone and sandstone exposed in the southwestern part of Ngao District. This fossil evidence could lead to the interpretation of paleoenvironment of the mudstone and sandstone units.

This study reports, for the first time, lithofacies, Triassic bivalves fossils, and petrographic analysis of the Hong Hoi Formation from northern Lampang (Ngao District) in order to understand the depositional environments of the formation. The results of this study could, also, explain geodynamic and geotectonic changes of the other parts of the mainland Southeast Asia that were deposited during the same geological periods.

## II. Geological Setting

The Ban Huat area is located in the northeastern part of northern Lampang. The area belongs to the Indochina Block, which constitutes the northern part of Thailand in the mainland Southeast Asia (Fig. 1). The geology of the Triassic Hong Hoi Formation of Ngao area was mainly studied by [4], [9]. Basement rocks in northern Lampang Province consist of low-grade Paleozoic metamorphic rocks, Permian sedimentary rocks of Ngao Group, Permo-Triassic volcanic rocks, and Triassic sedimentary rocks of the Lampang Group with the younger units of Triassic granitoids [10] (Fig. 2). Of these units, the Hong Hoi Formation of Lampang Group is 650-1,000 m thick and composed of clastic rocks and limestone.

## III. Method

Facies analysis is based on field observations and laboratory studies. The use of lithofacies analysis in this study follows the definitive scheme of Bouma [11], Walker [12], and Lowe [13]. Each sample is analyzed under petrographic microscope in order to identify minerals and sedimentary textures.

Fossils of marine bivalves are found in the mudstones. The fossils are used as paleoecology indicators.

## IV. Results

### A. Facies and Interpretation

Facies A consists of very fine-grained, thin-bedded

sandstone. The sandstone contains ripped-up mud clasts (0.2-0.5 mm in diameter) (Fig. 3). They are mainly presented in the bottom part of stratigraphic section (Fig. 2). These sandstone beds are normal grading and have well-defined, flat bases.

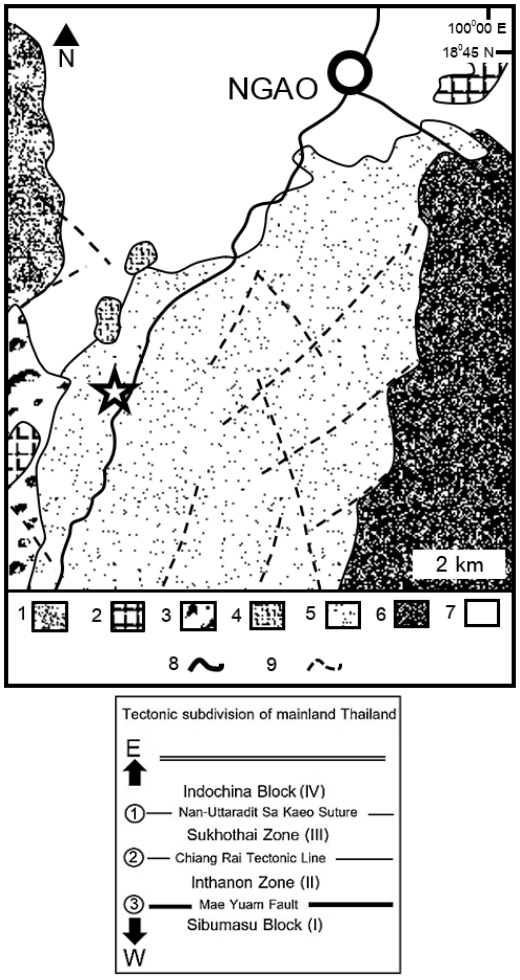


Fig. 1 Geotectonic subdivisions of Thailand indicate the main sutures in Thailand [1], [2]

Thinner beds (5-10 cm thick) commonly have a sheet-like geometry. The top parts rarely exhibit parallel lamination and cross-stratification suggesting southeast-directed paleocurrents (Fig. 3 (a)). Facies A is commonly capped by thin, parallel-laminated mudstone of facies B (Fig. 3 (c)).

Facies B is characterized by massive and laminated mudstone and shale that rarely exhibits weak bioturbation and that yields the bivalve taxa, such as *Daonella* and *Halobia* (Fig. 3 (d)). *Daonella* is frequently preserved as articulated valves. Occasionally, parallel laminations are intercalated with abundant small paper shelled bivalves *Daonella* and *Halobia* (Figs. 3 (e), (f)). Thin mudstone beds, 3-10 cm thick, commonly cover on beds of facies A (Fig. 3 (a)).

Facies A is graded beds, containing medium clasts that are a characteristic product of turbidity currents [11]-[13] and are similar to the $T_b$ division of Bouma's sequence. Overlying parallel-laminated beds correspond to Bouma's sequence $T_{c-d}$ division formed under the bed load. Cross-stratified beds reflect deposition by traction currents (Fig. 3 (b)).

Facies B was probably formed during the latest stage of turbidity currents and partly during the calm conditions after the passage of the turbidity currents [12]. The parallel-laminated shale and mudstones are probably comparable to the Td-e interval of Bouma's turbidite sequence (Fig. 3 (c)).

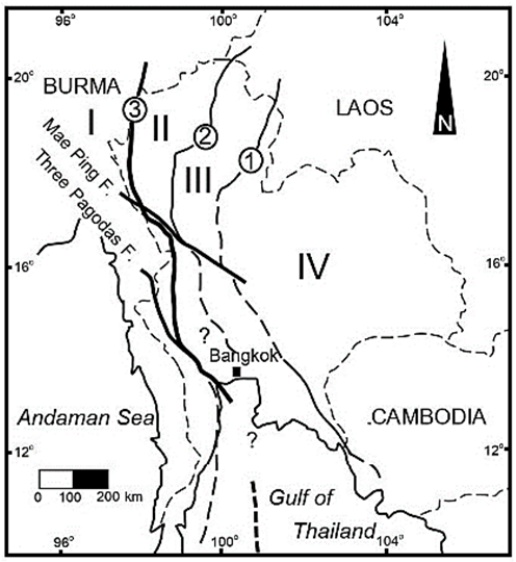


Fig. 2 Geological map of the Ngao area in northern Lampang, with sample localities studied in this work (star symbol) (geological map modified from [10]

1: Permian sedimentary rocks; 2: Permo-Triassic volcanic rocks; 3–6: Triassic Lampang Group (3, Phra That Formation; 4, Pha Kan Formation; 5, Hong Hoi Formation; 6, Pha Deang Formation); 7: Cenozoic; 8: road; 9: fault

### *B. Petrographic Compositional Framework*

The study area is dominated by shale and mudstone with minor amount of sandstone. Coarse-grained units are composed of sandstones, which are generally moderately to poorly sorted and compositionally sub-mature. Petrographic results are plotted in QFL diagrams using the scheme of Pettijohn [14] which show that the sandstones are predominantly (lithic-quartzose) lithic arenites. The overall average composition is Q35%, F22%, L43%. Lithic fragments form between mostly medium- or coarse-grained, sub-angular to sub-rounded. Igneous, metamorphic and sedimentary lithic fragments are all identified. Igneous clasts constitute 16-20% of total rock volume and are mainly fragments of volcanic rocks, pyroclastic and, more rarely, plutonic rock. These clasts include rhyolite and silicified tuff rock types with sub-angular grain shapes. This result suggests that sediment of the Hong Hoi Formation was deposited near the volcanic source area.

The sedimentary rock fragments of sandstone, siltstone, shale, limestone, dolomite and chert constitute 7–10% of the total rock volume, are fine-to medium-grained and sub-rounded shape Quartz clasts, and are the most abundant constituent, comprising 35-65% of the framework. Predominant monocrystalline quartz grains comprise 90% of the total quartz content. Polycrystalline quartz grains are less

abundant, comprising 10% of the total quartz content. Feldspar clasts are mainly plagioclase feldspar, comprising 85% of the total feldspar content.

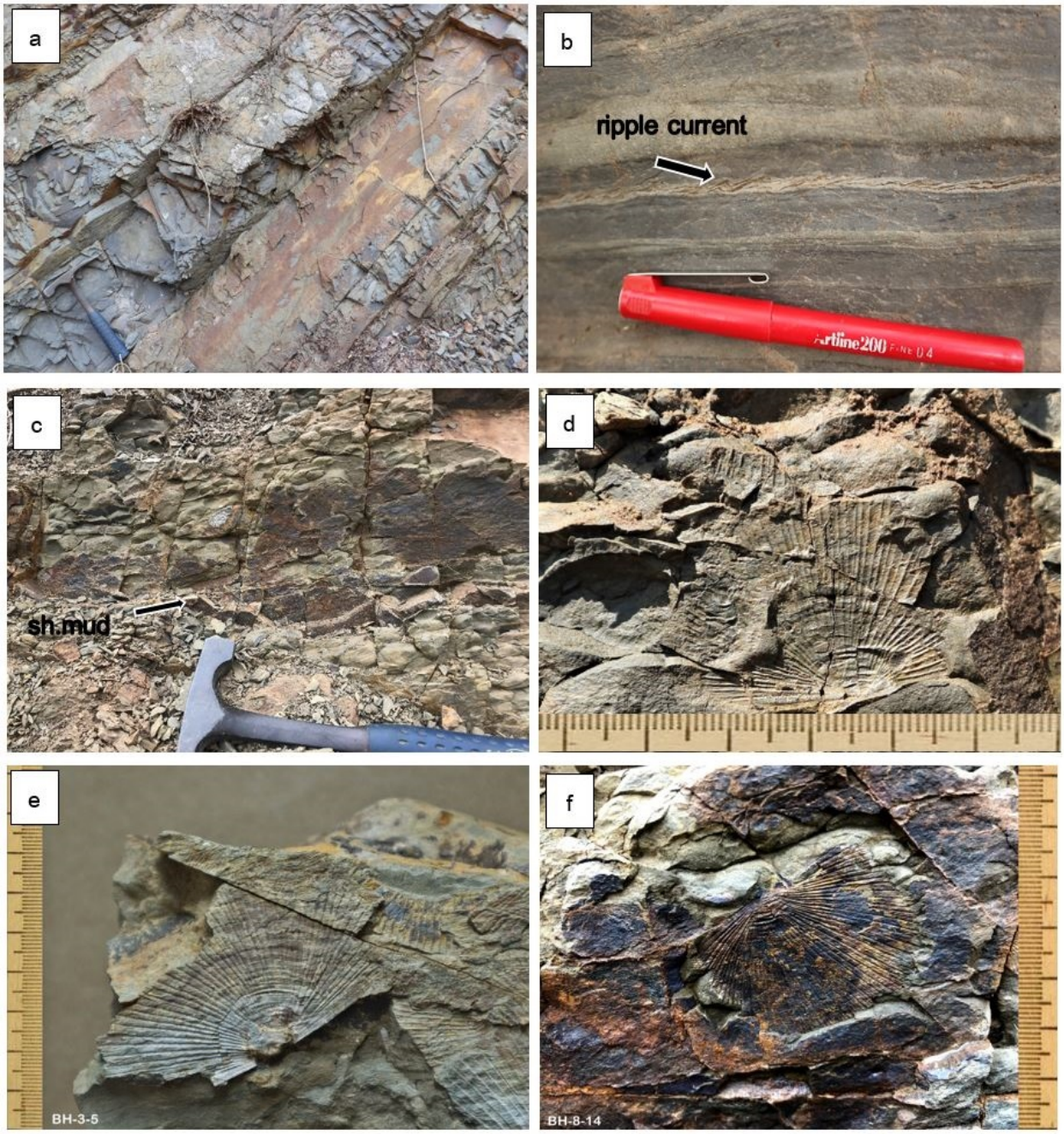


Fig. 3 Lithofacies from the Hong Hoi Formation (a) Facies A. medium- to fine-grained, thin-bedded sandstone (b) Facies A. thinly laminated, fine- to very fine-grained sandstone with ripple current (c) Facies B, some of thin, siliceous beds (sh. mud with arrow) are intercalated within shale-rich alternations (d) Facies B. thin-shelled bivalve of the study section. Scale in centimeter

Shell fragments constituent 5–10% of the total rock components and is dominantly composed of recrystallized calcite which floated in clay-matrixed argillaceous materials. Matrix constitutes 10-25% of the total rock components and dominantly composed of quartz, feldspar, clay minerals and other argillaceous materials. Argillaceous, and calcareous (calcite) cements are abundant, each constituting 12-20% of the total rock volume.

Sandstone samples are classified as lithic arenite and lithic graywacke because the major component is mainly lithic fragment grains [14] (Fig. 4 (a)). Major detrital framework components of the mudstone in this study are contained rich in shell fragment, fine-grained micas and may have some discrete rock fragments and quartz silt (Fig. 4 (b)). In thin-

section, shelly fragments (100-600 microns) were the floated grains in petite matrix from all sampled sedimentary beds, with minor to moderate contribution from rounded to elongated grains, which showed agreement with macrofossil components (Figs. 4 (c), (d)).

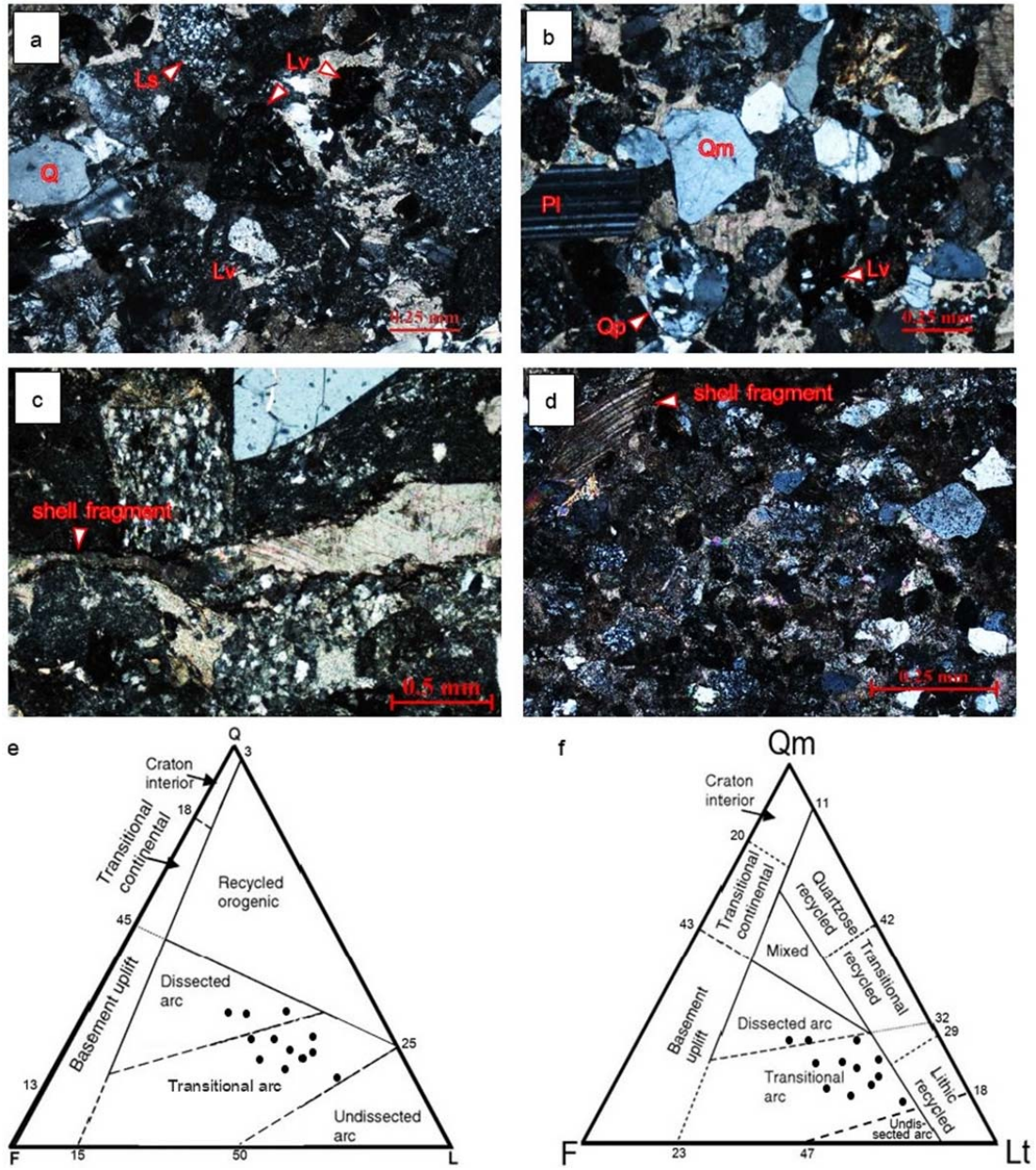


Fig. 4 Photomicrographs of clastic rocks of the Hong Hoi Formation (a) Lithic arenite dominated by volcanic fragments (b) Sandstone dominated by quartz and volcanic fragments (c)-(d) Lithic sandstone with shell fragments; All photomicrographs were taken under crossed polarized light, excepting Fig. 4 (c). (e)- (f) Q–F–L and Qm–F–Lt ternary diagrams with the tectonic fields of [15]. Q= total quartz (mono- and polycrystalline grains), Qm = monocrystalline quartz, F = feldspar (plagioclase and K-feldspar), L= lithic fragments, Lt =lithic fragments and polycrystalline quartz, Qp=polycrystalline quartz, Pl=plagioclase, Lv =volcanic lithic fragment, Ls = sediment lithic fragment

### *C. Provenance*

Provenance interpretations are based on the schemes of Dickinson [15]. The framework constituents of the Hong Hoi Sandstones are indicative of a sediment source derived from suggest transitional and dissected arc provenance field sources because of the lack of plutonic detritus (granite) in the sand population [15], [16] (Fig. 4 (e)). The Qm-F-Lt plot (Fig. 4(f)) shows that the majority of the samples fall in the lithic-recycled orogenic and transitional arc provenances field, while a few samples plot in the fields of dissected arc terrains. The compositional framework of the Hong Hoi Sandstone has a close relationship with the composition of the source rock [5]. During the Middle Triassic times, detritus in the Lampang region was influenced from volcanic activity of island arc.

*D. Bivalve Fossil*

In the Hong Hoi Formation, there are a few types of bivalve fossil that observed by previously researches [7], [17]. This study found three genera of bivalves: *Halobia*, *Daonella* and *Posidonia* (Figs. 3(e), (f)). *Daonella* and *Halobia* are dominant. *Daonella* and *Halobia* consist of three species: *Halobia (Halobia) talauana* Wanner, *Halobia (Halobia) styriaca Mojsisovics*, and *Halobia (Zittelihalobia)* sp.

## V. Discussion

The Hong Hoi Formation records evidences that indicate a depositional environment of basin floor to slope. Thin-bedded mudstones with sandstone suggest a marginal basin-floor in the shelf environment (facies A and B). They consist of sandstone interbedded with mudstone (facies A) with current structure such as cross-lamination and current ripple. This facies is generally overlain by thin-bedded mudstone deposited under calm conditions of facies B. Fine-grained units of facies B are indicative of suspension elements that accumulated in the late stage of gravity flow on basin-floor settings. Bivalve fossils suggest that facies B deposited at the foot of a marginal basin or a deep marine abyssal plain [11]-[13], [18] (Fig. 5).

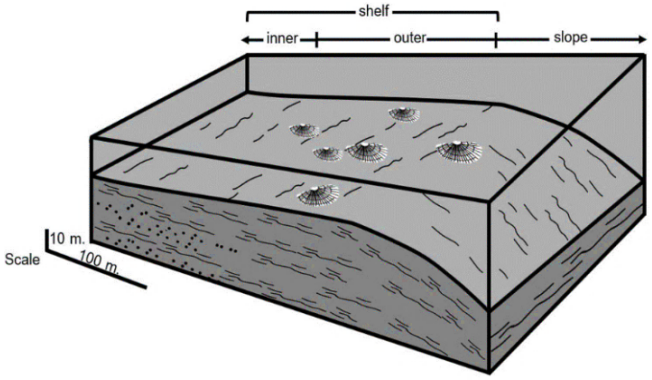


Fig. 5 Depositional models of the Hong Hoi Formation indicates the shelf environment with bivalve fossils deposition


Fig. 6 Photographs of bivalve fossils from the study section (see Fig. 2 for sample localities)

The petrographic and provenance characteristics of sandstone samples indicate that they are lithic sandstones, mainly volcanic lithic fragments. This suggests that volcanic source rocks of the Hong Hoi Formation are derived from the Sukhothai Arc. This interpretation is corresponding with the result of Hara et al. [5]. Thus, the sediment supply of the Hong Hoi Formation is the Sukhothai Arc.

The bivalve fauna from the study are *Halobia*, *Daonella* and *Posidonia* (Fig. 6). *Daonella* and *Halobia* are important elements to support the abyssal plain environment [19]-[21].

## VI. Conclusion

Two lithofacies types are recognized in the marine Triassic clastic strata of the Hong Hoi Formation of the Lampang Group. The succession comprises the interbedded shale, mudstone, and sandstone. Facies A is thin-bedded sandstone with mudstone which are overlain by mudstone of facies B. From facies analysis, the Hong Hoi Formation is interpreted to deposit on marginal basin-floor in shelf environment based on lithofacies, lateral and vertical distribution, sedimentary structures, and paleontological evidences.

The Hong Hoi sandstones are immature lithic arenite and lithic greywacke feldspathic arenite, and the sediment source is from transitional arc and dissected arc of dominantly volcanic to pyroclastic provenance. Based on petrographic studies given above, the Hong Hoi Formation was deposited in the western part area near the Sukhothai Arc.

Abundant bivalves are mainly found in mudstone and shale. They are divided into three assemblages including *Halobia*, *Daonella* and *Posidonia*. The fauna fossils indicated oxygen deficiency, dysoxic milieus, and soupy sediments adaptation.

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