

CHAPTER V

DISCUSSIONS AND CONCLUSIONS

5.1 DISCUSSIONS

Based on field observations and petrographic investigations, the discussion of this study is the depositional environments and age of marine Triassic rocks in the Mae Sot-Phop Phra area and to discuss the paleogeographic implications of radiolarian faunas.

5.1.1 Depositional environments and age

Well bedded limestone in section MS1 is composed mostly of light gray to dark gray, reddish fine grained limestone and muddy limestones intercalated with thin black calcareous shale. Under microscopic observation, limestone contains abundant radiolarian tests and thin-shell bivalves. Based on the limestone lithology and the occurrence of thin-shell bivalves together with radiolarian tests, it indicates that the rocks were deposited as continental shelf to slope or slightly deep marine environment (Tofke et al., 1993; Selly, 1996; Microberts, 2000). This outcrop is composed of radiolarian fauna containing *Capnuchosphaera* sp. which is the characteristic fauna of Carnian to Norian. Moreover, calcareous shale found in the strata also contains the bivalve *Halobia* sp. which is an index fauna of Upper Triassic. Based on the occurrence of radiolarian fauna and *Halobia* sp., the age of this section is considered as Carnian to Norian (Late Triassic).

Section MS2 is composed of fine- to coarse-grained, thin to thick- bedded gray sandstone and mudstone. Sandstone shows fining upward sequence and lamination. Ripped-up mud clasts are common in the basal beds. The turbidite sequences of sandstone interbedded with mudstones have been observed. The thickness of sandstone beds decrease to the top. The thickness is varied from 10-30 cm to 1 m in the lower part and 5-10 cm in the upper part of the sequence. Mudstone is gray and thin bedded. The ratio of the sandstone to mudstone is 2:1 in the lower part and 1:1 in the upper part of the section. These lithofacies indicate that they were deposited on

continental slope or slightly deep marine environment. Based on the lithostratigraphic correlation, the age of these rocks may be correlated to Anisian to Ladinian.

Chert in Section MGH and Section BKH are mostly composed of 3-10 cm thick, well bedded sequences. Under the microscope, the chert is composed of microcrystalline quartz with clay mineral and abundant radiolarians. Sashida et al. (1998) studied in detail Devonian to Middle Permian radiolarians from the type section of the Fang chert which is well bedded, with beds of several centimeters intercalated with siliceous claystones a few millimeters in thickness. Under microscopic observation, it is composed of abundant radiolarian tests and sponge spicules, with clay minerals and fine-grained quartz. These kinds of chert does not include coarse-grained terrigenous material, therefore, it is thought to be deposited in a pelagic environment far from the continental area (Matsuda and Isozaki, 1991). In contrast, chert of section BKH consists of bivalve fragments and chert of section MGH is dominated by genus *Canoptum* in which the occurrence of the *Canoptum* assemblage could appear only in the sea along the continental margin on which terrigenous clastic could be supplied, and not in the pelagic ocean where chert were deposited. The occurrence of the *Canoptum* assemblage was related to some particular marine conditions characterizing the continental margin (Suzuki, 1993). Therefore, the occurrence of radiolarians from section MGH and section BKH indicates that depositional basins which accumulated on a continental margin rather than in a deep ocean basin. The radiolarians discovered from the 2 sections in the Mae Sot area is very similar to the radiolarian assemblage from Thailand, Japan, Western North America and China (Sashida, 1999; Yao, 1982; Sugiyama, 1997; Blome, 1984; Kozur and Mostler, 1994) which corresponds to the Anisian to Norian (Middle to Upper Triassic). Moreover, the radiolarian assemblage can be related to another area in Thailand as shown in the Figure 5.1.

Section MS3, MS4, PP1 and PP2 are composed of the calcareous shales intercalated with sand lenses containing the thin-shell bivalve *Halobia* sp. and ammonite. These lithofacies indicate that sediments of these sections are deposited as continental

slope or slightly deep marine environment (Sashida et al., 1999; Srinak et al., 2002; Meesook et al., 2005).



Figure 5.1 Schematic diagram showing the distribution of Paleozoic-Mesozoic radiolarian in Thailand (after Kamata, 2006 unpublished data).

Von Braun and Jordan (1976) studied *Halobia* and *Posidonia* bivalves and ammonidia fossils in shale along Kamawkala gorge and the others along Huai Hin Fon stream at the Tak-Mae Sot highway, suggesting the age of Late Triassic. Later Bunopas (1981) provided the stratigraphic data of these areas and studied the bivalve *Daonella sumatrensis* Volz indicative of the middle Carnian age. Recently Meesook et al. (2005) studies turbidite sequences at Ban So O. They consist consist mainly of sandstones and mudstones containing the bivalve *Halobia* sp. and ammonites. Based on these fossils, age determination for the rocks in this area is Upper Triassic. Additionally, this study shows that fossils of *Halobia* sp. and ammonite found in the calcareous shale of section MS3, MS4, PP1 and PP2 indicate the Upper Triassic age.

Tofke et al. (1993) studied detailed Triassic sedimentary rocks in the region of Mae Sariang and reported that the Triassic sedimentary sequences are true ribbon-chert, which contain abundant radiolarian, true pelagic limestones, which contain radiolarian and thin-shell pelagic bivalves, and a thick turbidite sequence of siliciclastics, which contains *Posidonia* and *Halobia* intercalated shales. Chonglakmani (1999) proposed the Triassic sedimentary belt exposed in the Mae Sariang area as the Mae Sariang Group extending southward to Tak, Mae Sot, Kanchanaburi, and to Songkhla in peninsular Thailand, where is known as the Na Thawi Formation. It is considered that this belt facies is deep marine and oceanic facies.

Sashida et al. (1999) summarized the sedimentary facies and fossil occurrence of the Triassic sediments in Thailand and northwestern peninsular Malaysia. They clarified the sub-parallel arrangement of three rock units, from west to east: shallow to slope limestone, clastic, and chert sequences, which extend from the areas of Mae Sariang, Kanchanaburi, southern peninsular Thailand, and northwestern peninsular Malaysia during Middle Triassic time. They suggested that environments of deposition in this area as the shallow to deep marine. Kamata et al. (2002) considered the fossil evidence and the lithological features of the studied section at Mae Sariang which including the chert and red shale associated with calcareous layers of the Mae Sariang Group are thought to be equivalent to the limestone-clastic-chert sequence. They also considered that chert of the Mae Sariang Group have been accumulated on a

continental margin rather than in a deep ocean basin on lithological characters, containing numerous rhombus-shaped dolomite grains in many horizons and the co-occurrence of calcareous shale.

Based upon paleontological points of view, it is considered that the age of rocks in the study areas is mainly Anisian to Norian (Middle to Late Triassic). The Early Triassic radiolarian was not recognized. However, Early Triassic radiolarian is found in chert (Kamata et al., 2002). The studied area can be subdivided lithostratigraphically into 3 facies as pelagic limestone, turbidite sequence, and chert sequences. It is considered that the sedimentary sequences in this study occurred from continental shelf to slope. These rocks show the lateral lithological changes of the shallow to slightly deep marine environments during the same time span (Figure 5.2). The Permian sequence in the Mae Sot-Prop Phra area consists of gray to dark gray sandstone interbedded with mudstone, siltstone and limestone of the Kaeng Krachan Group. This group was distributed in the eastern part of the area. The fossil assemblages are coral, brachiopod, and bryozoa of Lower Permian age. The central part is mainly composed of thick-bedded and massive dolomites and limestones known as the Ratburi Group. This suggests that the Permian sediments were deposited in the shallow environment which not as deep as that of the Triassic period deposited in continental shelf to slope (slightly deep marine environments). In the next period, Jurassic of the Huai Fai Group is well exposed from the Tak-Mae Sot highway, consisting of limestone-marl-mudstone-dominated sequences which have yielded bivalves and ammonites. Based on these fossils, age determination for the rocks in this area is Toarcian to Early Bajocian and the sequences are interpreted to be deposited in the shallow marine environment (Meesook et al., 2005).

The discovery of Anisian to Norian radiolarian fauna in the Mae Sot area will provide new interesting data for radiolarian biostratigraphy in the interval between Middle to Late Triassic. Further more, micropaleontological investigations of western Thailand would be necessary to understand the detailed paleogeography and the tectonic evolution in the Triassic times.

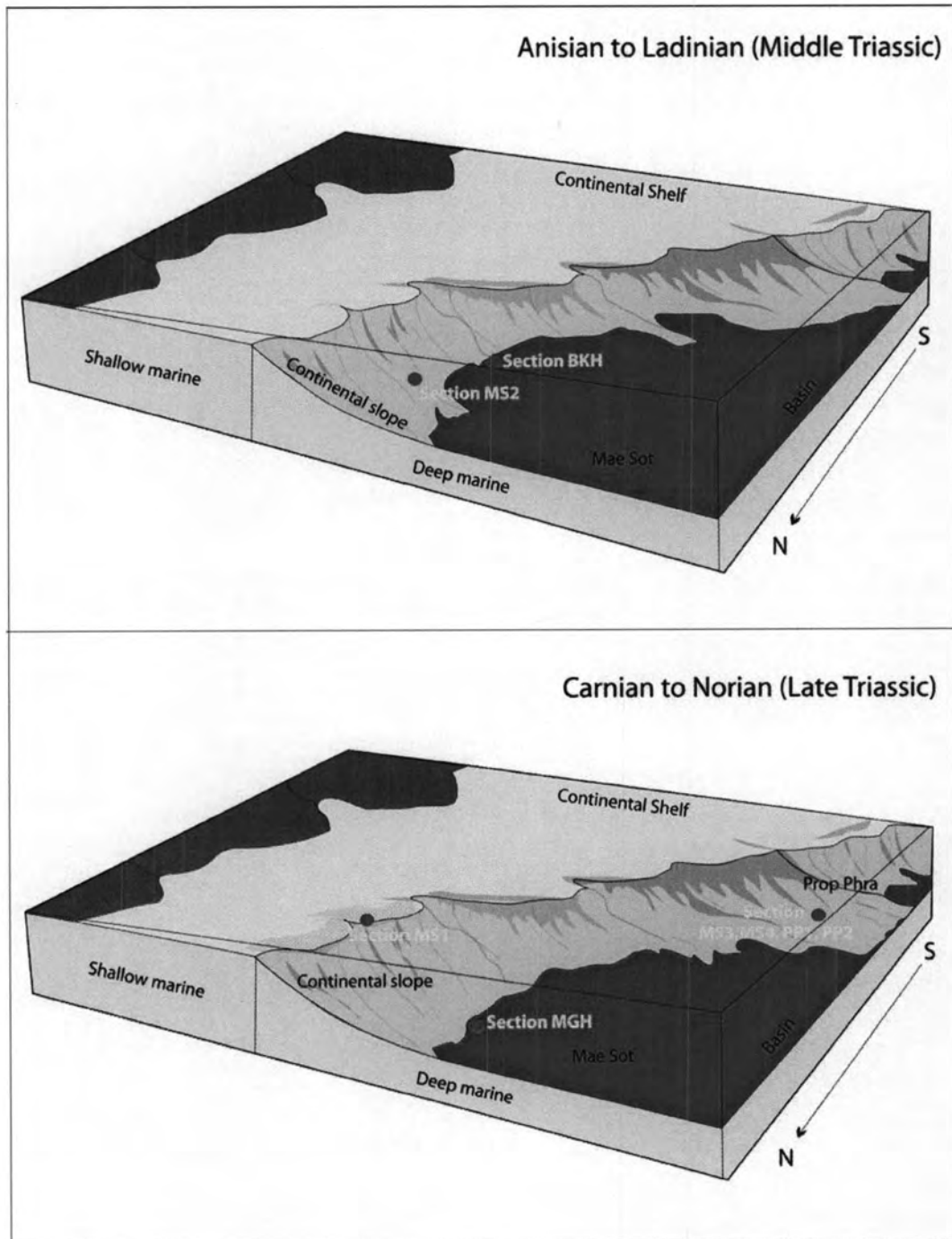


Figure 5.2 Schematic diagrams showing the paleoenvironments in the Mae Sot-Phra area, northwestern Thailand during Anisian to Norian (Middle to Late Triassic).

5.1.2 Paleogeographic implications

Recently, radiolarian biostratigraphical data of pelagic sediments have been used for terrane analysis and to understand the timing of terrane collisions (e.g. Sashida et al., 1993; Sashida and Igo, 1999). The distribution of the pelagic sediments and their geological ages indicates the spatial extent of the Paleotethys Ocean, its processes of development, and its times of opening and/or closing (Kamata et al., 2002). The purpose of this study is to clarify details of the geologic age of these rocks in the area to infer the close timing of Paleotethys Ocean.

Recently, Ueno (1999) proposed new schemes of tectonostratigraphic division in Thailand and subdivided mainland Thailand into four tectonic divisions, from west to east, the Sibimasu Block, the Inthanon Zone, the Sukhothai Zone, and the Indochina Block. The Inthanon Zone is composed of pelagic-oceanic sedimentary rocks representing Paleotethys remnants, and the Sukhothai Zone consists of a volcanic arc sequence, including Paleozoic-Mesozoic sediments. According to these studies, there are several north-south trending tectonostratigraphic units between the Sibumasu and Indochina Blocks.

In the reconstructed paleogeographic map of Middle Triassic, Japan, Russia Far East, and Western North America, which are located at middle to rather high latitude in northern hemisphere at present, their radiolarian faunas are thought to have been deposited at a low latitude in Panthalassa (Isozaki, 1997). Middle Triassic radiolarian-bearing rocks in Northern Thailand were thought to have been deposited at low latitude in Paleotethys Ocean near and connected to the Panthalassa Ocean (Sashida and Igo, 1999). Therefore, Triassic radiolarian fauna from the Mae Sot area in northwestern Thailand are quite similar to those reported from the Japan, Timor Island, Western North America and European Tethys. This suggests that sediments containing Triassic radiolarians distributed in Mae Sot, Mae Sariang (Kamata, 2002; Feng, 2005), Japan (Yao, 1982; Sugiyama, 1997), Timor Island (Sashida, 1999), Western North America (Pessagno et al., 1979; Blome, 1984) and European Tethys (Kozur and Mostler, 1994) were deposited within the same Paleotethys Ocean. As mentioned above, Carnian-Norian (Late Triassic) radiolarians from the Mae Sot area indicates the same

depositional basins. These occurrences imply that the Paleotethys Ocean was existed between the Shan-Thai and Indochina Blocks until the Carnian-Norian time because radiolarian-bearing bedded chert sequences were accumulated. Therefore, the closure of the Paleotethys Ocean between the Shan-Thai and Indochina Blocks in northwestern Thailand probably occurred after the Carnian-Norian (Late Triassic).

5.2 CONCLUSIONS

The Triassic rocks in the Mae Sot-Phop Phra area of northwestern Thailand were defined as a part of the Mae Sariang Group (Bunopas, 1981). The preliminary results from this investigation indicate that:

1. The 8 studied sections: MS1, MS2, BKH, MGH, MS3, MS4, PP1, and PP2 can be lithologically divided into 3 facies. They are composed of pelagic limestone (MS1), turbidite sequence (MS2, MS3, MS4, PP1, and PP2), and chert sequence (BKH, MGH).

Pelagic limestone: well bedded limestone in section MS1 is composed mostly of light gray to dark gray, reddish fine grained limestone and muddy limestones intercalated with thin black calcareous shale. Based on the limestone lithology and the occurrence of thin-shell bivalves together with radiolarian tests, it indicates that the rocks were deposited as continental shelf to slope.

Turbidite sequence: section MS2 is composed of fine- to coarse-grained, thin to thick-bedded gray sandstone and mudstone. Sandstone shows fining upward sequence and lamination. The thickness of sandstone beds decrease to the top. Section MS3, MS4, PP1 and PP2 are composed of the calcareous shales intercalated with sand lenses containing the thin-shell bivalve *Halobia* sp. and ammonite. These lithofacies indicate that they were deposited on continental slope or slightly deep marine environment.

Chert sequence: chert in section MGH and section BKH are mostly composed of 3-10 cm thick, well bedded sequences. It consists of microcrystalline quartz with clay mineral and abundant radiolarians. Chert of section BKH consists of bivalve fragments

and chert of section MGH is dominated by genus *Canoptum*. These lithofacies indicate that they were accumulated on a continental margin rather than in a deep ocean basin.

2. The rocks in the study area are interpreted as having been deposited in continental shelf to slope (slightly deep marine environments).

3. Based on stratigraphical and paleontological lines of evidences, the age of rocks in the study area are assigned as Anisian to Norian (Middle to Upper Triassic).

4. Chert beds have yielded well defined Middle Triassic to Late Triassic radiolarians of 26 genera and 43 species were investigated from 2 sections. The radiolarian assemblages are very similar to these of Thailand, Japan, Western North America and China, corresponding to the Anisian to Norian (Middle to Upper Triassic).

Radiolarian fauna found in section BKH, consists of 9 genera and 19 species. They include *Oertlispongia* sp., *Pseudostylosphaera japonica* (Nakaseko and Nishimura), *Pseudostylosphaera spinulosa* (Nakaseko and Nishimura), *Pseudostylosphaera timorensis* Sashida & Kamata, *Pseudostylosphaera* sp., *Pseudostylosphaera* ? sp., *Triassospongosphaera* sp., *Triassospongosphaera* ? sp., *Eptingium manfridi manfridi* Dumitrica, *Eptingium* cf. *manfridi manfridi* Dumitrica, *Eptingium* ? *manfridi* Dumitrica, *Eptingium* sp., *Eptingium* ? sp., *Pentaspongodicus symmetricus* Dumitrica, Kozur & Mostler, *Muellertortis cochleata cochleata* (Nakaseko and Nishimura), *Triassocampe* cf. *deweveri* (Nakaseko and Nishimura), *Triassocampe* sp., *Spongostephanidium japonicum* (Nakaseko and Nishimura), *Spongostephanidium* sp., *Baumgartneria bifurcata* Dumitrica, *Falcispongia falciformis* Dumitrica, *Falcispongia* sp. and *Staurolonche trispinosa* (Kozur and Mostler).

Radiolarian fauna found in section MGH, consists of 18 genera and 26 species. They are composed of *Canoptum rhaeticum* Kozur & Mostler, *Canoptum laxum* Blome, *Canoptum* cf. *levis* Tekin, *Canoptum* sp., *Canoptum* ? sp., *Triassocampe* sp., *Triassocampe* ? sp., *Vinassaspongia* sp., *Vinassaspongia* ? sp., *Capnuchosphaera triassica* De Wever, *Capnuchosphaera* cf. *triassica* De Wever, *Capnuchosphaera* cf. *deweveri* Kozur & Mostler, *Capnuchosphaera* sp., *Capnuchosphaera* ? sp., *Paronaella* sp., *Paleososaturnalis* sp., *Orbiculiforma* sp., *Hagiastrum augustum* Pessagno,

Staurolonche trispinosa (Kozur and Mostler), *Staurolonche ? trispinosa* (Kozur and Mostler), *Pentaspongodiscus* sp., *Dumitricasphaera* sp., *Poulpus* sp., *Castrum peronatum* Blome, *Castrum ? sp.*, *Xiphotheca longa* Kozur & Mock, *Xiphotheca* sp., *Annulotriassocampe sulovens* (Kozur and Mock), *Zhamojdasphaera latispinosa* Kozur&Mostler, *Kahlerosphaera* sp., *Ferresium* sp., *Ferresium ? sp.* and *Canesium* sp.

5. Paleogeographically, these Triassic strata were formed in the depositional basins in the Paleotethys between the Shan-Thai and Indochina Blocks until the Carnian-Norian time before its closure.