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Discovery of Early-Late Triassic microfaunas from the bedded-chert and 'Jurassic base-conglomerate' at Mae-Sot, NW Thailand: Preliminary report for the Shan-Thai Terrane and end-Triassic orogeny

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Abstract

The Middle and Late Triassic radiolarian faunas were extracted from a vitric tuff rich laminated bedded-chert in the Mae-Sot and Umphang areas of NW Thailand. The radiolarian faunas from the bedded-chert succession are characterized by *Triassocampe postdeweveri* (Early Ladinian), *Pachus multinodosus* (Early Norian), *Sarla natividadensis* (Middle Norian) and *Canoptum rhaeticum* (Norian-Rhaetian), individually. The Triassic chert-sequence is overlain by the 'Jurassic base-conglomerate', an ill-sorted breccia in a reddish-silt matrix. The limestone and chert clasts in the conglomerate yield Early - Late Triassic conodonts and Middle - Late Triassic radiolarians, respectively. Chert clasts in the conglomerate yield among others Norian - Rhaetian radiolarians like *Pachus multinodosus* and *Canoptum rhaeticum*, while Early – Late Triassic conodonts as *Platyvillosus costatus*, *Cratognathodus* cf. *cuspidatus*, *Metapolygnathus polygnathiformis*, *M. carpathicus*, *Ancyrogondolella quadrata* and *A. spatulata* are found in limestone clasts. The silici-pelagic origin of the clasts suggests the presence of an ocean before the end Triassic orogeny along the Mae Sariang Zone that amalgamated the parts of the Shan-Thai block. This first finding of Late Triassic (Norian - Rhaetian) radiolarians from bedded-cherts, next to the Middle Triassic and older radiolarian faunas, adds another element to the reconstruction of the sequence now comprised in the Mae Sariang Zone, W of the Nan-Uttaradit Suture. The occurrence of Triassic limestone, as that of the Chaiburi Formation in the Phatthalung area of the Mae Sariang Zone or the Kodiang Limestone in the 'Western zones', may elucidate the question about the provenance of the Triassic conodont-bearing limestone clasts in the Jurassic base-conglomerate that seals the Mae-Sariang Zone. The newly dated Triassic sequence is further sealed by the continental-shelf deposits of the Toarcian - early Bajocian Hua Fai Group.

***Keywords**: radiolarian chert, conodont limestone, provenance, Jurassic base-conglomerate, NW Thailand, Shan-Thai Terrane, End-Triassic orogeny.*

1. INTRODUCTION

The Mae Sot – Umphang area (NW Thailand) is structurally a part of the Shan-Thai Terrane. For the Triassic developments, the details on the formal nomenclature that has been established in Thailand are derived from Chonglakmani & Grant-Mackie (1993) and Carey et al. (1995), complemented by several authors. Hirsch et al. (2005a,b) compiled the tectonostratigraphic terranes of SE Asia (Fig. 1). After a Late Paleozoic history of detachment from Gondwana, it transited into the lower latitudes of the Sibumasu Province in the Middle Permian and became a part of the low latitude Cathaysian Province during the Late Permian (Shi & Archbold, 1998). The Jurassic so called 'base-conglomerate' is significant for the understanding of the tectonic evolution and of the Shan-Thai Terrane to the Asian Continent (Hada et al., 1999). The section along the Tak - Mae Sot highway, NW Thailand, exposes well this significant Shan-Thai Terrane event. According to Hirsch et al. (2005a,b), the studied section belongs to the Mae Sariang Zone. The Permian – Triassic sequence is topped by the pre-Jurassic TM3 bedded-chert that yields Middle and Late Triassic radiolarians. The 'Jurassic base-conglomerate' TM4 is composed of

varicoloured clasts of limestones and cherts in a reddish-silt matrix. The limestone clasts yield Early – Late Triassic conodonts and the chert clasts contain Middle and Late Triassic radiolarians, similar to those from TM3. The research was carried out in the frame of the Japan-Thai 'Shan-Thai' IGCP 434 working group. For two consecutive years, 2001-2002, our team conducted a week-long field work in the Mae Sot and Umphang areas, Tak Province, northwestern Thailand.

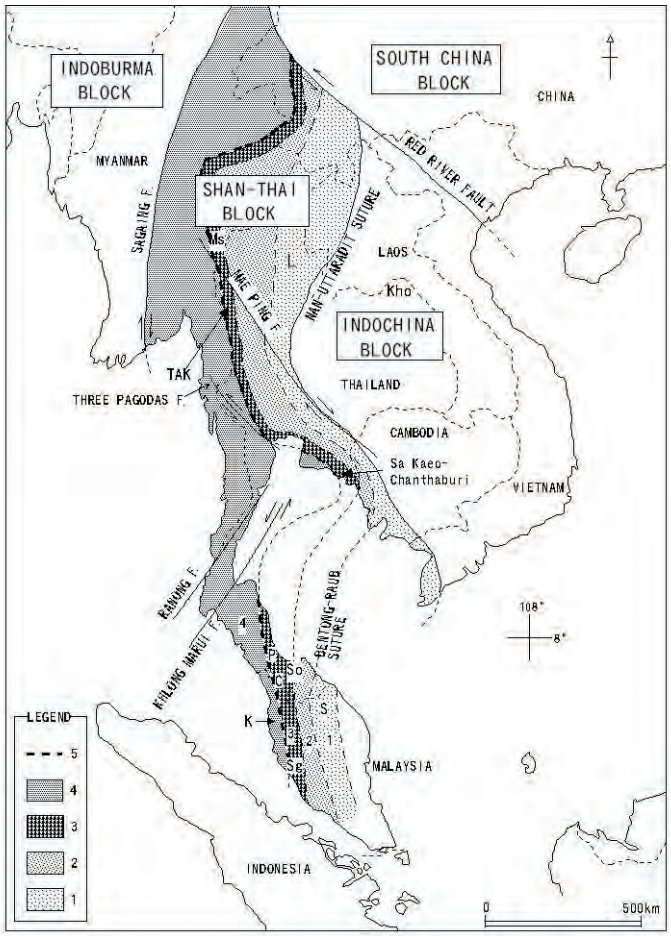

Fig. 1. Tectonostratigraphic terranes of SE Asia. After Hirsch et al. (2005a,b); modified after Hada et al. (1997); Ueno (1999); Bunopas et al. (2002); Chonglakmani et al. (2001); Gondwana-Tethys Divide after Myo Min et al. (2001). Triassic basins after Chonglakmani & Grant-Mackie (1993) and Meesook et al. (2002). Legend 1: Sukhothai Zone; 2: Inthanon Zone; 3: Mae Sariang Zone; 4: 'Western zones' (Tengchon-Tenasserim and Phuket); 5: Gondwana-Tethys Divide (GTD): Triassic basins of K: Kodiang Limestone; Kho: Khorat Group; L: Lampang-Phrae Basin; Cc: Chaiburi Formation; So: Songkhla Basin; Ms: Mae Sariang Basin; P: Phatthalung Basin; S: Semantan Formation; Sg: Semanggol Formation; TAK: study section.

2. GEOLOGICAL OUTLINE

SE Asia consists of four major tectonic terranes, the names of which sometimes vary: South China, Indochina, Shan-Thai and West Burma. The main difficulty consists in unraveling end-Middle Permian from Late Triassic Palaeo-Tethyan scars.

The Shan-Thai consists primarily of a metamorphic craton and Late Paleozoic – Early Mesozoic sediments. Its eastern boundary in the Nan-Uttaradit suture zone, originally a Lower Permian basin containing radiolarian cherts and serpentinite, ending in siliciclastic turbidites and occluded in late Middle Permian (Helmcke, 1984), marks the main suture between Shan-Thai and Indochina terranes (Barr & Mac Donalds, 1987: Carey et al., 1995). East of it, the Phetchabun fold and thrust belt (Helmcke, 1984) includes further ophiolites of a Permian oceanic seaway that closed in the Late Middle Permian. Its Mesozoic cover consists of continental Carnian–Norian deposits of the Khorat Group (Chonglakmani et al., 2001).

The Shan-Thai is subdivided into several zones from E to W (Fig.1: Hirsch et al., 2005a,b). Among them, **The Mae Sariang Zone** extends along the NS-trending Tertiary strike-slip valley of Mae Nam Yuam in NW Thailand. It consists of Permian and Triassic ribbon-cherts and pelagic limestone that Hahn & Siebenhuner (1982) and Fontaine & Suteethorn (1988) attribute to the Shan-Thai Terrane. The pelagic and synorogenic siliclastics in the Mae Sariang - Kanchanaburi Basin suggest an end-Triassic orogeny. Above the pelagic sequence, follow synorogenic siliciclastic turbidites, which for Chonglakmani et al. (1991) witness a strong Triassic orogenic event that dissected the Shan Thai Terrane. The latter would thus consist of metamorphic complexes situated during Early Permian in a warm climate, alongside which Gondwana derived terranes docked during a Triassic orogenic event. A conglomerate with radiolarite pebbles yielding radiolarians determines the age of the Mae Sariang orogeny. The region east of Mae Sariang might be regarded as the Paleo-Eurasian margin of Paleotethys while the region west of Mae Sariang has a Gondwanian origin (Caridroit et al., 1993). Sediments that are similar to Mae Sariang are found in the Semanggol Formation (Sashida et al., 1995), east of the Langkawi Island, Malaysia. Fontaine & Suteethorn (1988) first mentioned pelagic limestone along the highway Tak - Mae Sot. Only a narrow belt in the West is built up of Gondwana derived terranes, which docked during the Middle to Late Triassic.

The 'Western zones' of Gondwanian origin yield glacio-marine sediments. They consist to the North of the Baoshan craton, which is topped by Asselian oolitic limestone with *Pseudoshwagerina*. Separated from the latter by the Nujiang fault, the Tengchong-Tenasserim Zone encompasses crystalline

pebbles of glacial-marine origin, as young as Stephano-Asselian, covered by late Early Permian limestone. The Phuket Zone represents the Western units further south.

3. TRIASSIC STRATIGRAPHY OF THE MAE SARIAG ZONE

Recently, microfossil dating has clarified the detail distribution and stratigraphy of Triassic formations in Thailand and Malaysia (e.g. Sashida & Igo, 1999; Metcalfe et al., 1999; Hada et al., 1999). The Mae Sariang Zone contains rocks of Triassic chert-, carbonate-, and turbiditic facies that originate from the pelagic oceanic as well as synorogenic nature.

3.1. Turbiditic facies

From the Mae Sariang and Kanchanaburi Basins, a sequence of presumably Lower to Upper Triassic is found. In the Mae Sariang area, the Mae Sariang Formation consists of a sequence of shale, sandstone and conglomerate, intercalated with chert and limestone. *Daonella* and *Halobia*, allow its correlation with the similar rocks in the Lampang Group. The turbiditic facies of the Mae Sariang Zone is characterized by *Daonella sumatrensis*. At 34 km of the Tak - Mae Sot road, mudstone with *Halobia*, wood fragments and poorly preserved radiolarians occur (Meesook personal communication). In the Mae Sot Basin, along the Thai-Myanmar border, the over 900 m of shale and sandstone of the Mae Sariang Formation contain limestones at their to that yield *Jovites, Juvavites* and *Choristoceras*, brachiopods, bivalves and algae (Tamura et al., 1975; Chonglakmani & Grant-Mackie, 1993).

3.2. Chert facies

In NW Thailand, intensely folded chert and siliceous black shale formations in the north of Chiang Mai were informally named as "Fang Chert" (Bunopas, 1981). Caridroit et al. (1990), Caridroit (1991, 1993), and Sashida et al. (1993) reported the occurrence of Paleozoic and Lower Mesozoic radiolarians from the siliceous clastic rock sequences in North Thailand. Upper Permian to Middle Triassic radiolarians were reported from the chert beds at Ban Huai Tin Tang, near the Thai-Myanmar border, north of Chiang Mai. Among them, Triassic radiolarians belong to the *Parentactinia nakatsugawaensis* and *Eptingium manfredi* assemblages of Anisian age (Sashida & Igo, 1999). At km 34 of the Tak - Mae Sot road, bedded-chert yields well-preserved radiolarians (Ishida et al., 2004). In the Sa Kaeo-Chanthanaburi area, east Thailand, red bedded-chert of the Chanthaburi chert-clastic sequence (Hada et al., 1999) yields *Eptingium manfredi* assemblage at Trat, near the Gulf of Thailand (Sashida & Igo, 1999). In Peninsular Thailand, the turbidites of the Na Thawi Formation are imbricated with the Chaiburi limestone (see below) and chert. These correlate with the deep marine and oceanic Mae Sariang facies (Chonglakmani, 2002). The thin-bedded chert at Khao Chiak yields the *Entactinia nikorni* assemblage together with upper Spathian to lower Anisian conodonts *Neospathodus homeri* and *N. timorensis* near Phatthalung (Sashida & Igo, 1999).

In the Semanggol area in Kedah (Malaysia), Teoh (1991) subdivided Paleozoic and Mesozoic of the Sungai Tiang area of central Kedah into the Mahang (Lower Silurian), Kubang Pasu (Carboniferous), and Semanggol (Middle to Upper Triassic) formations. Burton (1973) subdivided the formation into the Lower Chert, Middle Rhythmite, and the Upper Conglomerate members. Sashida & Igo (1999) extracted upper Middle and Upper Permian radiolarians from the lower Chert Member. As illustrated in the review paper of Sashida & Igo (1999), the Triassic in the Alor Setar (Alor Star) region consists of a sequence of chert followed by turbidites and covered by conglomerates, depicted alongside the Kodiang limestone. Koike (1973) described conodonts.

3.3. Carbonate facies

Most limestones in the Phatthalung area were viewed as Permian (Ratburi Limestone). Igo et al. (1988) and Sashida & Igo (1992) have reported lower Middle Triassic conodonts and upper Lower Triassic radiolarians from the limestone at Khao Chiak, now described as the Chaiburi Formation (Ampornmaha, 1995). The Chaiburi Formation is subdivided into following three members in ascending order.

Phukhaothong Member, 66 m of bedded to massive, light gray dolomites with some chert nodules, yielding the conodonts *Neospathodus kummeri* Sweet and *Neospathodus waageni* Sweet (Dienerian to Smithian);

Chiak Limestone Member: 300 m of gray to dark gray bedded-limestone, with many chert layers, nodules and lenses intercalated in laminated-limestone beds. Laminated lime-mudstone yield radiolarians, ostracods, gastropods and echinoids. The lower part can be dated by the conodonts *Neospathodus timorensis* (Nogami), *Neospathodus kockeli* (Tatge), *Neogondolella burgarica* (Budurov & Stefanov) as Spathian to middle Anisian. Gradually changing into bioclastic wackestone follows

Phanomwang Limestone Member: a 90 m thick mostly massive limestone, including coral reef-limestone, yielding calcisponges, scleractinian corals, mollusks, echinoids, crinoids and foraminifers, the age of which is Carnian. Sardsud (2002) confirmed Late Triassic three conodont zones: *Epigondolella abneptis* subsp. A, *E. a.* subsp. B, and *E. postera* zones that represents lower – middle Norian.

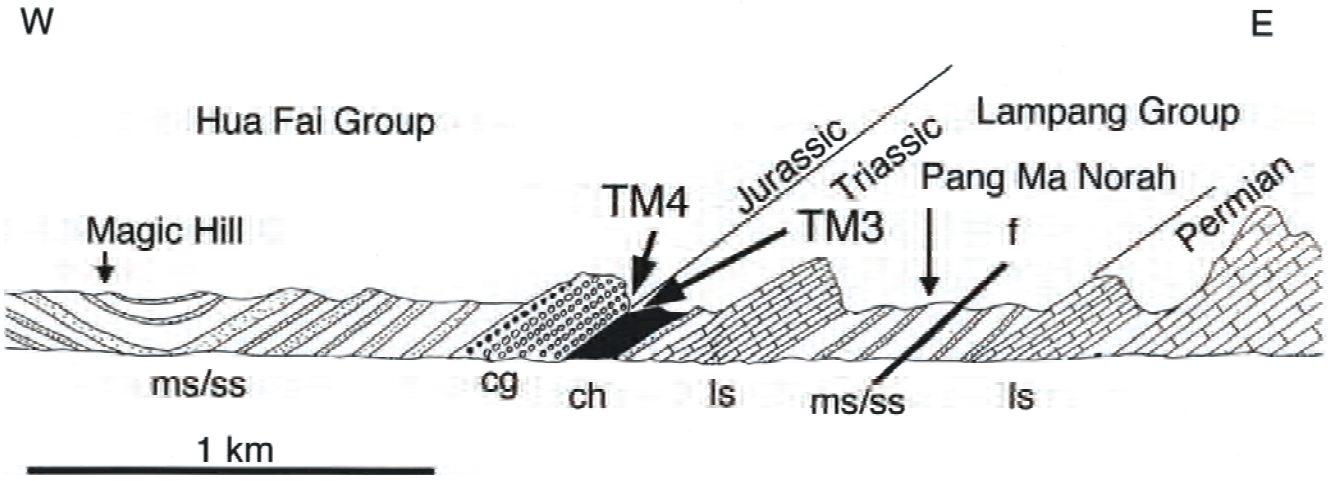

Fig. 2. Stratigraphic position of the TM3 chert and TM4 base-conglomerate in the Section along the Tak - Mae Sot highway, NW Thailand; ch: chert; ls: limestone; ms/ss: alternation of mudstone and sandstone; cg: conglomerate.

4. TRIASSIC – JURASSIC ROCKS IN THE MAE SOT AND UMPHANG AREAS

In both the Tak-Mae Sot and Umphang areas, the nature of the Permian and Triassic contacts as well as the relation between chert beds and *Halobia* bearing turbidites of Carnian age remains unclear. In the Mae Sot Basin, marine Jurassic rocks are well exposed.

The marine Lower Jurassic **Hua Fai Group** (Meesook & Grant-Mackie, 1996), 900 m in thick, is exposed along the unsealed road to the Huai Mae Sot power station 10 km east of Mae Sot and along Huai Mae Sot. The group consists of limestone-marl-mudstone-dominated sequences which have yielded bivalves and ammonites macrofaunas. The base is estimated to unconformably overlie on the underlying Triassic strata, and the top of the group is interrupted at the fault-bounded margin of the Tertiary basin. The group is subdivided into following three formations in ascending order.

Khun Huai Formation: 140 m thick from the basal conglomerate, is consists of limestone-marl dominated sequences interbedded with mudstone. In the type section, the lower part of the formation is assumed to be unconformable on marine Triassic strata because of the presence of a limestone-chert conglomerate (TM4) between the two. This contact is located about half-way between the Weir and Ban Kun Huai. Early Toarcian ammonite *Dactylioceras* sp. dates the formation. The upper part conformably overlain by the Doi Yot Formation.

Doi Yot Formation: 370 m thick is composed of mudstone with interbedded limestones. Occurrence of *Onychoceras* sp., *Pseudolioceras* sp. and *Leioceras* sp. indicates Late Early Toarcian – Early Aalenian.

Pha De Formation: 390 m, consisits mainly of limestone-marl dominated thinnning-upwards sequences. Late Aalenian – early Bajocian by the occurrence of ammonites *Graphoceras* sp., *Eutmetoceras* sp., and *Docidoceras* sp.

The section along the Tak - Mae Sot highway, NW Thailand, is topped by the pre-Jurassic chert (TM3) containing much fine vitritic-tuff, and yielding radiolarians of Middle to Late Triassic age (cf. Ladinian to Norian). It is overlain by the base-conglomerate (TM4) and continental-shelf deposits of the Jurassic Khun Huai Formation of the Hua Fai Group (Fig. 2). Along the Mae Sot -Umphang road, at km 138-139, a cherty acid tuff (MU-1) is similar to TM3 and yields Middle Triassic radiolarians. Lithology and microfossil content provide clues as to the age of the TM3 chert and both the origin and age of the clasts within the TM4 conglomerate.

TM3: The chert unit is composed of 5 to 10 cm thick, dark-gray to black well-laminated bedded sequences. The TM3 chert commonly contains a large amount of fine vitric tuff as well as radiolarian shells. From the top of the sequence, four horizons, TM3-1 (topmost), TM3-2 (2m below), TM3-3 (4m below), and TM3-4 (7m below) were sampled for microfossils.

TM4: The unit is a poorly-sorted conglomeratic breccia formed by a kind of gravity flow. The conglomerate is mainly composed of varicolored clasts of limestones and cherts. The clasts are subangular to subrounded, and the matrix contains much reddish silt. The maximum size of gravels exceeds 20 cm. The chert fragments are well-laminated, dark gray to black and reddish-brown in color, commonly less than 3cm in diameter, and contain much vitric tuff materials and radiolarians. The difference of the color probably depends on the effect of weathering because they are basically the same texture and the reddish-brown colored fragments are stained. The limestone fragments, usually less than 5 cm in diameter, vary yellowish,

reddish and grayish in color. The yellowish fragments, dominantly included in the conglomerate, are wackestone with many numbers of thin small bivalve shells. The second ones are grayish packstone and grainstone that the clasts are dominated by crinoid stems. The third ones are reddish packstone with bioclasts of echinoids and corals, and some ooids. The other limestone fragments are some gray lime-mudstones. Among them, limestone fragments contain Early and Late Triassic conodonts, whereas the chert fragments contain Middle and Late Triassic radiolarians (Fig.3).

5. MICROFOSSILS FROM THE TM3 CHERT

TM3-1: The uppermost horizon of the chert sequence yields *Canoptum rhaeticum* Kozur & Mostler, 1981, *Canoptum* sp., *Livarella densiporata* Kozur & Mostler, 1981. From the range of the species found in the TM3-1, the horizon is Upper Norian to Rhaetian.

TM3-2: 2m below the top of the sequence yields *Sarla natividadensis* Pessagno, 1979, *Castrum perornatum* Blome, 1984, and *Japonocampe* aff. *nova* (Yao, 1982). Co-occurrence of *S. natividaensis* and *C. peronatum* indicates middle Norian horizon.

TM3-3: 4m below the top of the sequence, the chert yields *Castrum perornatum* Blome, 1984, *Pararuesticyrtium* cf. *mediobulbosum* Tekin, 1999, *Corum* sp., *Pachus multinodosus* Tekin, 1999, and Spine D2 of *Spongostylus carnicus* Kozur & Mostler, 1979. Based on the co-occurrence of the species, the horizon TM3-3 belongs to Lower Norian.

TM3-4: The 7m below the top of the sequence yields *Triassocampe deweveri* (Nakaseko & Nishimura, 1979), *Triassocampe postdeweveri* Kozur & Mostler, 1994. Co-occurrence of the two species indicates the TM3-4 belongs to lower Ladinian.

Thus, the upper part of the TM3 chert ranges from upper Middle to Upper Triassic (Fig. 3).

6. MICROFOSSILS FROM THE TM4 GRAVELS

6.1. Radiolarians

Abundant of latest Middle to Late Triassic radiolarians were extracted from the chert clasts of the TM4 unit (Fig. 3).

Early Norian - Rhaetian: *Canoptum rhaeticum* Kozur & Mostler, 1981 is known from the Lower Norian (*navicula* Subzone of *spatulatus* A.Z.) to Rhaetian of the Zlambachgraben, Austria (Kozur & Mostler, 1981). Sugiyama (1997) extended the range of this specific group from Upper Norian (TR8C) to Lower Jurassic (Hettangian/Sinemurian).

Latest Carnian - early Norian: *Latium mundum* Blome, 1984, *Capnodoce antiqua* Blome, 1983, *Corum regium* Blome, 1984, *Pararuesticyrtium* (?) *anatoliaensis* Tekin, 1999, *Dicapnuchosphaera elegans* Tekin, 1999, *Pachus multinodosus* Tekin, 1999, *Capnuchosphaera tricornis* De Wever, 1982, *Castrum perornatum* Blome, 1984, *Capnuchosphaera lea* De Wever, 1979, Spine D3 of *Spongostylus* sp. aff. *S. carnicus* Kozur & Mostler, 1979, *Spongostylus carnicus* Kozur & Mostler, 1979 in Tekin, 1999, Spine D2 of *Spongostylus carnicus* Kozur & Mostler, 1979, Spine D1 of *Spongostylus tortilis* Kozur & Mostler, 1979. They are regarded as cosmopolitan in low latitude Upper Triassic.

Latest Ladinian – early Carnian: An additional species, *Annulotriassocampe sulovensis* (Kozur & Mock, 1981) in Kozur & Mostler (1981) is older. This species ranges from late Ladinian (*M. cochleata* / ? *P. priscus* Subz.) to early Carnian in the Sugozu Measured Section of the Antalya Nappes, Turkey, East-Central Oregon, USA, and Busuanga Island, Philippines (Tekin, 1999).

6.2. Conodonts

Early Norian, late Carnian, late Anisian, and Olenekian forms were extracted from the limestone gravels in the TM4 conglomerate (Fig. 3).

Early Norian: *Norigondolella navicula* (Huckriede, 1958), *Ancyrogondolella spatulata* (Hayashi, 1968), *Ancyrogondolella quadrata* (Orchard, 1991). The fauna in the TM4 conglomerate has a similarity to the Early Norian Hisaidani fauna of Tethyan affinity, characterized by the specific predominance *of Ancyrogondolella spatulata, A. quadrata* and *A. triangularis* (Ishida & Hirsch, 2002).

Late Carnian: *Metapolygnathus carpathicus* (Mock,1979), and *Metapolygnathus polygnathiformis* (Budurov & Stefanov, 1965). *M. carpathicus* belongs in the *Tropites subbulatus* Zone and the lower *Klamathites macrolobatus* Zone (uppermost Carnian: mid-upper Tuvalian) of Slovakian Karst (Mock, 1979). The range of *M. polygnathiformis* is late Carnian (late Julian to latest Tuvalian).

Late Anisian: A specimen was identical to *Cratognathodus* cf. *cuspidatus* Koike, 1982b. *Cratognathodus cuspidatus* has originary descrived by Koike (1982b) from the dark gray thin-bedded biomicritic limestone member of the Bukit Kalong Limestone in Kedah, West Malaysia. Based on the co-occurrence of *Neospathodus kockeli*, *Neogondolella bulgarica* and *Gladigondolella tethydis*, the fauna is indicative to late Anisian.

Olenekian: *Platyvillosus costatus* (Staesche, 1964) sensu Koike (1988), *Platyvillosus hamadai* Koike, 1982a, and *Platyvillosus* sp. 1. *P. costatus* occurs in the middle part of the Campil beds (Upper Scythian) of the St. Vigil, South Tyrol, Italy (Staesche, 1964). *P. hamadai* is firstly reported from the lower part of the Gunong Keriang Limestone in the Peninsular Malaysia with co-occurrence of Dienerian to upper Smithian conodonts of *Neospathodus dieneri* Sweet, and *N. pakistanensis* Sweet as well as *P. costatus* (Koike, 1982b). The co-occurrence of *P. hamadai* and *P. costatus* was also reported from the

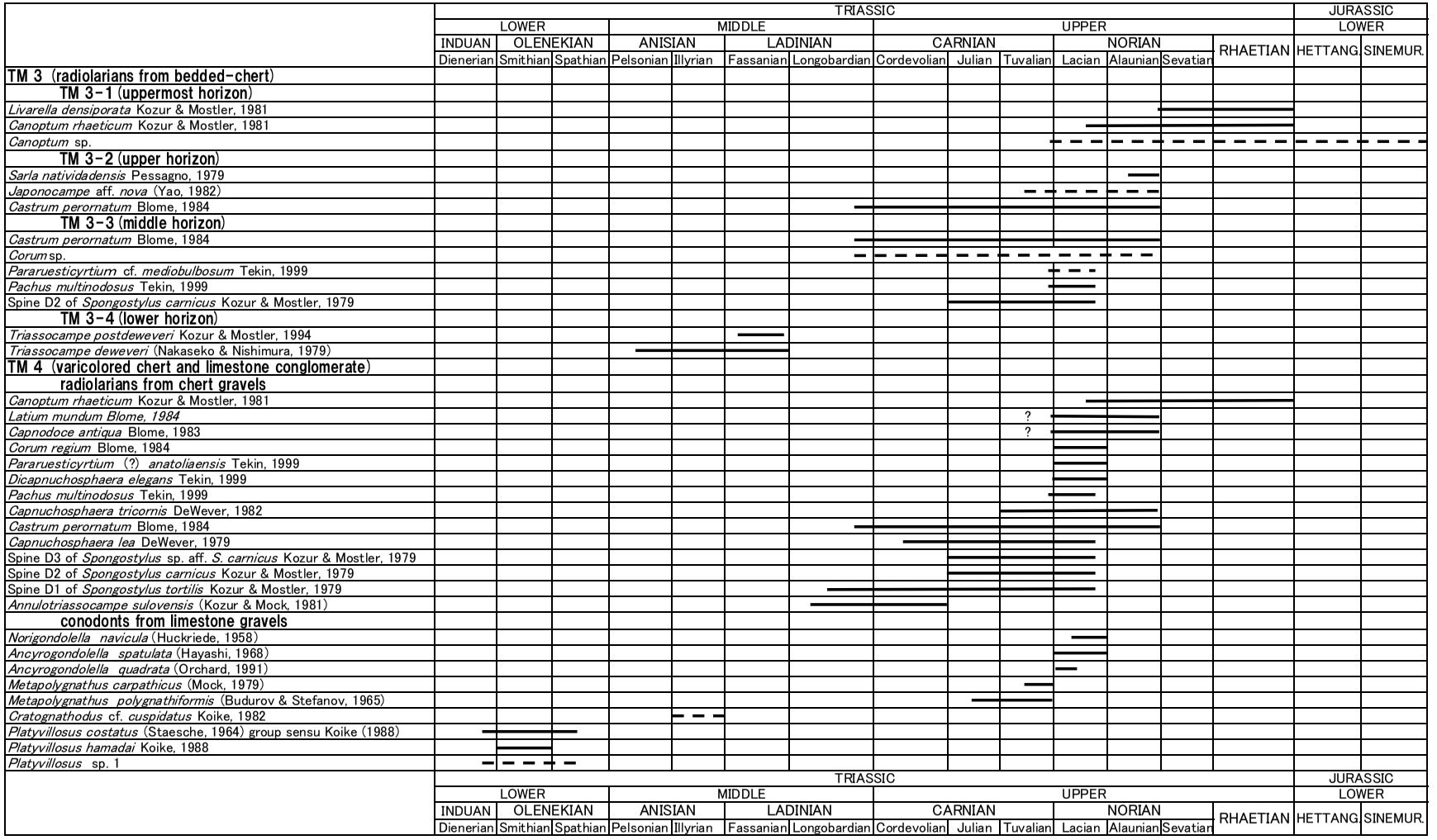

Fig. 3. List and range of microfossils from the TM3 chert and gravels in TM4 conglomerate

Neospathodus dieneri – N. conservatives Zone (Smithian) of the lower part of the Taho Limestone (Koike, 1982b).

7. AGE AND PROVENANCE OF THE TM4 GRAVELS

While the age of the gravels may vary, all of them are Triassic. Chert and limestone lithologies correspond to age groups, suggesting a stratigraphical sequence at their origin. Chert gravels are uppermost Ladinian – lower Carnian, lower Norian, and mid-upper Norian – Rhaetian. Limestone gravels are Olenekian, lower Anisian, upper Carnian – lower Norian, and middle – upper Norian. Among them, lower Norian gravels are probably dominant, encompassing both chert and limestones.

The ages of the gravels of siliceous pelagic lithofacies are thus mostly upper Triassic (uppermost Ladinian – lower Carnian, and Norian – Rhaetian), while those of the carbonate lithofacies are Olenekian, upper Anisian, and upper Carnian – lower Norian.

7.1 Chert gravels

The radiolarian assemblage from the chert gravels in the TM4 conglomerate can be compared with that of the TM3 chert-sequence. Both latest Carnian - Norian – Rhaetian species. Among them, *Canoptum rhaeticum* (Norian - Rhaetian), *Castrum perornatum* (uppermost Ladinian - middle Norian), *Pachus multinodosus* (uppermost Carnian – lower Norian), and Spine D2 of *Spongostylus carnicus* (upper Ladinian – lower Norian) are common in both TM3 and TM4. Based on the dominant occurrence of specimens and specific numbers, Lower Norian chert gravels are contained abundantly in the chert gravels of TM4 conglomerate. Especially, almost of the chert fragments, the reddish blown-colored stained ones as well as dark-gray to black-colored ones in TM4 conglomerate contain vitric-tuff material of the same lithology as the TM3 chert beds. Therefore, the chert gravels in the TM4 conglomerate were probably derived from a bedded-chert, equivalent to that of TM3.

Therefore, at the end of Triassic time, pre-Jurassic siliceous pelagic facies has docked, and widery eroded to form the Lower Jurassic shallow-marine cover formations, like continental-shelf deposits of the Toarcian - early Bajocian Hua Fai Group in the Shan-Thai Terrane. The first discovery of Late Triassic (Norian - Rhaetian) radiolarian faunas from bedded-cherts, next to the Middle Triassic and older ones, adds another element to the reconstruction of the sequence of the Mae Sariang Zone. The pelagic origin of the siliceous clasts suggests that an ocean was still present shortly before the end of the Triassic, to which the Mae Sariang orogeny brought an end. This final closure of the Paleo-Tethys took place due West of the Nan-Uttaradit Suture of the Indochina Block and the Sukhothai Terrane, amalgamating the eastern and western parts of the Shan-Thai Block. It may be noteworthy that the Triassic radiolarian faunas of the Shan-Thai Block are characteristically Tethyan low latitude faunas.

7.2. Limestone gravels

The provenance of the limestone clasts in the TM4 conglomerate from a nearby source still remains problematic. Three time intervals, Olenekian, upper Anisian, and upper Carnian - lower Norian are indicated by conodonts (Fig. 3).

One of the possible match of the ages of TM4 limestone pebbles in the Mae Sariang Zone are the Chaiburi Formation in Peninsular Thailand, yielding Early, Middle and Late Triassic conodonts and late Early Triassic radiolarians from a limestone of Khao Chiak near Phatthalung (Igo et al., 1988; Sashida & Igo, 1992; Sardsud, 2002). Ladinian and Carnian ages has not yet been confirmed.

It is also possible to estimate depending on their distance, if rocks from across the Gondwanian – Tethyan Divide (GTD) at the closure of the Mae Sariang Terrane by the docking of the 'Western zones' have been a part of the erosive event that has led to the formation of the TM4 breccia. In northwest Peninsular Malaysia, the Kodiang/Chuping limestones yield Olenekian, Anisian, Ladinian, Carnian and Norian conodont faunas (Ishii & Nogami, 1966; Nogami, 1968; Koike, 1973, 1982b; Metcalfe, 1990).

The possible derivation of limestone clasts in the TM4 conglomerate from limestone of the type of the Chaiburi Formation or Si Sawat Limestone in the Mae Sariang Zone, and further from the Kodian Limestone in the 'Western zone' should be retained as it may well elucidate the question about the provenance of the Triassic conodont-bearing limestone clasts, found in the base-conglomerate of the Toarcian-Aalenian continental-shelf deposits of the Hua Fai Group that seals the Mae-Sariang Zone.

8. CONCLUSIONS

(1) Microfossil ages of siliceous pelagic sediments in the Mae Sariang Zone and in overlying conglomerate elucidate the timing of the Palaeo-Tethyan closure that is sealed by the continental-shelf deposits of the Toarcian-Aalenian Hua Fai Group.
(2) The section along the Tak - Mae Sot highway, NW Thailand, topped by the pre-Jurassic chert (TM3) containing much fine vitritic-tuff, suggests the presence of an ocean until shortly before the end-Triassic Mae Sariang orogeny.
(3) Lithology and microfossil content provide clues as to the age of the TM3 chert and both the origin and age of the clasts within the TM4 base-

conglomerate.

(4) This first finding of -youngest age- Late Triassic (Norian - Rhaetian) radiolarian faunas from the bedded-cherts (TM3) in the Mae Sariang Zone, next to the Middle Triassic and older radiolarian faunas, adds another element to the reconstruction of the sequence now comprised in the Mae Sariang Zone, W of the Nan-Uttaradit Suture.

(5) The examination of the limestone clasts within the TM4 base -conglomerate suggests their provenance from limestone intervals within the Mae Sariang sequence. Such limestones are possibly found at Si Sawat (Kantchanaburi) and in the Chaiburi Formation (Phatthalung). Another possibility is to estimate like the Kodiang Limestone (Olenekian to Norian) as an provenance, if rocks from across the Gondwanian – Tethyan Divide at the closure of the Paleo-Tethyan (Mae Sariang Zone) by the docking of the 'Western zones', have been a part of the erosional event that has led to the formation of the TM4 breccia.

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