

Devonian radiolarian faunas in Pai Area, Mae Hong Son Province, Northern Thailand: Paleogeographic implication

Premvadee Sanjit¹, Nutthawut Wonganan¹, Yupa Thasod^{1*}

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Abstract

The Devonian radiolarian fauna from Ban Pang Paek of Pai district, Mae Hong Son province northern Thailand are examined. Twenty-one taxa in eight genera were classified from grey to dark-grey pelagic bedded chert. There are 3 ages of fossils: The Middle-Late Devonian radiolarians are *Trilonche dihelicis*, *Trilonche echinata* (Hinde, 1899), *Stigmosphaerostylus* sp., and *Astroentactinia* sp. cf. *A. multispinosa* (Won, 1983). The Late Devonian radiolarians are *Trilonche palimbola* (Foreman, 1963), *Trilonche altasulcata* (Won, 1983), *Trilonche australis* (Aitchison, 1993), *Trilonche* sp. cf. *T. hindea* (Hinde, 1899), *Triaenosphaera* sp., *Triaenosphaera* spp., *Polyentactinia polygonia* (Foreman, 1963) *Holoeciscus* sp., and *Pylentonema paiensis* (Deflandre, 1963). The co-occurrence of *Trilonche* sp., *Stigmosphaerostylus variospina* (Won, 1983) and *Archocyrtium* sp. indicate an Late Devonian to Early Carboniferous in age.

Keywords: radiolarian, Famennian, Paleo-Tethys, Pai, Northern Thailand

Introduction

The Pai area in Mae Hong Son province is located in northwestern Thailand, approximately 110 kilometers from Chiang Mai city (Figure 1). Devonian radiolarians in Thailand have been systematically studied and reported from Chiang Dao chert and Fang Chert sequences, Chiang Mai province in northern Thailand^{1,2,3,4}, Loei province in northeast Thailand^{2,5} Kanchanaburi province in western Thailand, and some preliminary investigation in the Pai area^{2,3,4,5}. These studies have focused on the dispersal of Sibumasu (or Shan-Thai) and Indochina terranes from Gondwana, with the aim of providing constraints on the timing of their movement and final accretion. These studies have shown that the Sibumasu (Shan-Thai) -terrane collided with the Indochina terrane after prolonged subduction of the Devonian-Triassic Paleo-Tethys oceanic plate.

During the Early Devonian, the continuing development of the Paleo-Tethys Ocean altered the northeastern margin of Gondwanaland by a succession of rifting^{2,3,4,5}. The graptolite from the early Early Devonian⁶

and radiolarians from the Middle Devonian to middle Permian assemblages from the Chiang Dao area are the evidences and indicate the main Paleo-Tethys Ocean between the Sibumasu and Indochina terrances.

The aim of this study is to provide a detailed classification of radiolarians from the Pai area in Mae Hong Son province. The results of the study may provide a better understanding of the biostratigraphic distribution and the age constraints for models of the tectonic evolution of the Paleo-Tethys in mainland Thailand and Southeast Asia region.

Geologic Setting

The main Paleozoic sedimentary rocks exposed in northwestern Thailand are those of the Silurian-Devonian Mae Hong Son Formation⁷ that consists of massive and bedded sandstones, shale, chert and slate. The area also has limestone that forms many isolated karst hills. The limestone has abundant Carboniferous and Permian foraminifera, as well as other fossils. It is considered to be the limestone of the Permian Ratburi Group. However,

¹ Department of Geological Sciences, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand 50200

* corresponding author: e-mail address: yupa.t@cmu.ac.th

in some areas this limestone contains Triassic fossils, thus giving the limestone an age range of Carboniferous to Triassic^{3,4,7}.

Materials and Methods

Radiolarian chert samples were collected from Ban Pang Paek of Pai district, Mae Hong Son province or the position 303494 in Thai topographic map sheet 4647 I at kilometer 118.350, on highway 1195 (Figure 2). The rock sections show exposed bedded chert and alternations of chert, consist of grey, dark grey, and black in colors. The thickness of each individual beds generally 2 to 5 centimeters, though some are 6 to 8 centimeters. Strongly folded chert beds occur in the northern part. These chert beds are north-south trending and vertical dipping (Figure 3). The chert is mainly cryptocrystalline to microcrystalline quartz and is associated with very fine claystone.

Fourteen samples were collected for radiolarian extraction with sample numbers are 118N-1 to 118N-7 and 118S-8 to 118S-14. This area is previously regarded as part of the Late Silurian-Devonian or Carboniferous of Mae Hong Son Formation⁷ or the Carboniferous-Permian⁸.

Radiolarian Extraction and Study

Crushed rocks of a few centimeters in size are soaked in a dilute hydrofluoric acid solution (4-6% of HF) for at least twenty-four hours or longer. HF solution is used for each sample at least three times or more according to Rock facies, which are different in nature. The samples are washed and sieve by 50- μ m nylon mesh. Residue is then dried in oven. Sample containing significant radiolarian is hand-picked with fine hair through a stereomicroscope. Well-preserved radiolarian are placed on the SEM plug and coated with gold in the vacuum evaporator. The surface structure is observed and scanned with the Scanning Electron Microscope (SEM).

Results

Systematic Palaeontology

SUPERCLASS: Sarcodina

CLASS: Actinopoda

SUBCLASS: Radiolaria (Muller, 1858⁹)

ORDER: Entactinaria (Kozur and Mostler, 1982¹⁰)

FAMILY: Entactiniidae (Reidel, 1967¹¹)

TYPE GENUS: *Stigmosphaerostylus* (Rüst, 1892¹²)

GENUS: *Stigmosphaerostylus* (Rüst, 1892¹², emend. Aitchison and Stratford, 1997¹⁴)

TYPE SPECIES: *Stigmosphaerostylus notabilis* (Rüst, 1892¹²)

Stigmosphaerostylus variospina (Won, 1983¹⁴)

Figures 4B, 4D, 5A-5E

Remarks: The specimen has a thick, spherical shell, with variable pore shapes and size. There are two to six three-bladed main spines, unequal length, rather thick and wide. Spines are shorter than diameter of outer shell.

Range and occurrence: Frasnian Stage - Viséan Stage (Late Devonian – Early Carboniferous) Sample: 118S-8, 118S-14 118N-1, 118N-2, 118N-3, 118N-4, 118N-5, 118N-6, 118N-7, 118N-10 and 118N-12

Stigmosphaerostylus sp.

Figure 4E

Remarks: Specimens observed from this area are characterized by having a thick spherical shell, with variable pore shape and size. The specimen has one strong three-blade main spine, rather length and sharp.

Range and occurrence: Middle-Late Devonian (Givetian - Famennian Stage)

Sample: 118N-1, 118N-2, 118N-3, 118N-4, 118N-5, 118N-6, 118N-7, 118N-10 and 118N-12

Trilonche dihelicis

Figure 5F

Remarks: Test spherical with two concentric shells and two to three three-bladed main spines. Main spines have a robust, strongly twisted dextrally, and approximately equal in size and length

Range and occurrence: Middle-Late Devonian (Givetian - Famennian Stage)

Sample: 118S-11

Trilonche echinata (Hinde, 1899¹⁶)

Figure 5G

Remarks: Test with two concentric spherical lattice shells with six robust main spines and numerous short, fragile, rod-like by-spines arising from the outer shell. Main spines are three-bladed and are approximately of equal to the diameter of cortical shell.

Range and occurrence: Middle-Late Devonian (Givetian - Famennian Stage)

Sample: 118S-8

Trilonche palimbola (Foreman, 1963¹⁶)

Figures 4C, 5H-5M

Remarks: Test has two concentric spherical lattice shells and one to six three-bladed main spines. Main spines are variable in length and width, with three ridges and three grooves.

Range and occurrence: Late Devonian (Frasnian - Famennian Stage)

Sample: 118S-8, 118S-9, 118S-10, 118S-11, 118S-12, 118S-13, 118S-14 118N-1, 118N-2, 118N-3, 118N-4, 118N-5, 118N-6 and 118N-7

Trilonche altasulcata (Won, 1983¹⁴)

Figure 5N

Remarks: The specimen has two concentric spherical shells, with one to six main spines, length and width. Spines are strongly three-blade with three broad ridges alternating with three deep grooves.

Range and occurrence: Late Devonian (Frasnian - Famennian Stage)

Sample: 118S-8

GENUS *Trilonche* (Hinde, 1899¹⁵, emend. Foreman, 1963¹⁶; emend. Aitchison and Stratford, 1997¹³ (syn. *Entactinosphaera* Foreman, 1963¹⁶))

TYPE SPECIES *Trilonche vetusta* (Hinde, 1899¹⁵)*Trilonche australis* (Aitchison, 1993¹⁷)

Figure 4H

Remarks: The specimen has a spherical shell, six robust main spines. Main spines are strongly double

three-bladed, and are slightly tapering distally. One main spine is somewhat stronger than the other five.

Range and occurrence: Frasnian Stage - Famennian Stage (Late Devonian)

Sample: 118N-1, 118N-2 and 118N-3

Trilonche sp. cf. *T. hindea* (Hinde, 1899¹⁵)

Figure 4F

Remarks: The specimens have spherical, lattice shell and two polar main spines, which are sub-equal in length, robust and three-bladed. The main spines are slender, less twisted, one and a half to two times longer than the shell diameter and disposed at approximately 180° to the two polar spines.

Range and occurrence: Famennian Stage (Late Devonian)

Sample: 118N-1, 118N-2, 118N-3, 118N-4, 118N-5, 118N-6 and 118N-7

Trilonche sp.

Figure 4L

Remarks: The specimen has a spherical shell with three main spines. The outer lattice-shell is relatively thick with small pores. The main spines are characterized by less twisted, deep grooves, strong ridges and disposed at approximately 120° to one another.

Range and occurrence: Frasnian Stage - Viséan Stage (Late Devonian – Early Carboniferous)

Sample: 118N-1, 118N-2 and 118N-8

GENUS: *Triaenosphaera* (Deflandre, 1973¹⁸)

TYPE SPECIES: *Triaenosphaera sicarius* (Deflandre, 1973¹⁸)

Triaenosphaera sp.

Figures 5O, 5P, 5Q, 5R

Remarks: Spherical lattice shell, with double three-bladed main spines arranged at approximately 120° from each other. Three main spines are robust, unequal in length and size. Spines are strongly three-blade with three broad ridges alternating with three deep grooves. The main spines are generally thick and wide at their base and middle and taper distally.

Range and occurrence: Late Devonian (Famennian Stage)

Sample: 118S-8, 118S-11, 118S-13 and 118S-14

Trienospaera spp.

Figures 4I, 4J

Remarks: The specimens are characterized by a spherical with three main spines disposed approximately 120° from each other in the same plane. Spines are strongly double three-blade by three prominent deep grooves alternating with double, thin ridge, and separated by a very narrow deep groove. The main spines are generally wide at their base and middle and taper distally. The cortical shell has a uniform ore frame structure, with a diameter of 100 µm.

Range and occurrence: Frasnian Stage - Famennian Stage (Late Devonian)

Sample: 118N-1 and 118N-2

GENUS: *Astroentactiidae* (Nazarov, 1975¹⁹)

TYPE SPECIES: *Astroentactinia stellata* (Nazarov, 1975¹⁹)

Astroentactinia sp. cf. *A. multispinosa* (Won, 1983¹⁴)

Figure 5S

Remarks: The specimen is characterized by having a spherical shell. Main spines are numerous and are accompanied by numerous by-spines on the surface of outer shell, unequal in length and size.

Range and occurrence: Middle-Late Devonian (Givetian - Frasnian Stage)

Sample: 118S-8

FAMILY: *Polyentactiniidae* (Nazarov, 1975¹⁹)

TYPE GENUS: *Polyentactinia* (Foreman, 1963¹⁶)

GENUS: *Polyentactinia* (Foreman, 1963¹⁶)

TYPE SPECIES: *Polyentactinia craticulata* (Foreman, 1963¹⁶)

Polyentactinia polygonia (Foreman, 1963¹⁶)

Figure 5T

Remarks: The specimen has a spherical shell, three main spines arranged at approximately 120° from

each other, with three broad ridges alternating with three deep grooves. The main spines are unequal in length and size, by generally thick and wide at their base and middle and taper distally.

Range and occurrence: Late Devonian (Famennian Stage)

Sample: 118S-8

FAMILY *Ceratoikiscidae*

GENUS *Holoeciscus*

Holoeciscus sp.

Figure 4A

Remarks: The characteristic of outer shell is similar to bowl-shape that is called cavea, length 140 µm, rough, non-pores. Rectangle spines have rectangle pore in the middle shape. Also, present is two triangular spines out of shell.

Range and occurrence: Frasnian Stage – Famennian Stage (Late Devonian) Sample: 118N-1

FAMILY *Pylentonemidae* (Deflandre, 1963²⁰; emend. Cheng, 1986²¹)

GENUS *Pylentonema* (Deflandre, 1963²⁰)

TYPE SPECIES *Pylentonema antique* (Deflandre, 1963²⁰)

Pylentonema paiensis

Figure 4K

Remarks: Cephalic shell is small and sub-spherical cephalis, two three-bladed basal spines, inwardly curved feet that gradually taper and are tri-radiate in axial plan. Feet are large and longer than cephalis.

Range and occurrence: Famennian Stage (Late Devonian)

Sample: 118N-2

ORDER *Nassellaria* (Ehrenberg, 1875²²)

FAMILY *Archocyrtidae* (Kozur and Mostler, 1981²³; emend. Cheng, 1986²¹)

GENUS *Archocyrtium* (Deflandre, 1972²⁴; emend. Cheng, 1986²¹)

TYPE SPECIES *Archocyrtium riedeli* (Deflandre, 1972²⁴)

Archocyrtium sp.

Figure 4G

Remarks: The specimens consist of a small imperforate spherical cephalis. Three strong, short, curved

feet exhibit prominent ridges and grooves. The apical horn is somewhat wide and thick at base.

Range and occurrence: Famennian Stage - Viséan Stage (Late Devonian – Early Carboniferous)
Sample: 118N-1 and 118N-2

Discussion and Conclusion

The radiolarian fossils from Ban Pang Paek in the Pai area have rather high diversity. The common and readily classified species found are *Holoeciscus* sp., *Stigmosphaerostylus variospina* (Won, 1983), *Stigmosphaerostylus* sp., *Trilonche dihelicis*, *Trilonche echinata* (Hinde, 1899¹⁵), *Trilonche palimbola* (Foreman, 1963¹⁶), *Trilonche altasulcata* (Won, 1983¹⁴), *Trilonche australis* (Aitchison, 1993¹⁷), *Trilonche* sp. cf. *T. hindea* (Hinde, 1899¹⁵), *Trilonche* sp., *Triaenosphaera* sp., *Pylentonema paiensis* (Deflandre, 1963²⁰), *Archocyrtium* sp., *Astroentactinia* sp. cf. *A. multispinosa* (Won, 1983¹⁴) and *Polyentactinia* (Figure 6).

The occurrence of *Stigmosphaerostylus* sp. was reported from Chiang Dao, Chiang Mai and Pak Chom-Loei areas^{4,25}. According to Saesaengseerung and others²⁵, the interval zone of *Tlecerina* sp.-*Stigmosphaerostylus* sp. may indicate the lower Middle Devonian, however, *Tlecerina* sp. is not found in this study. Wonganan and Caridroit⁴ reported the occurrence of *Stigmosphaerostylus* sp. and *Trilonche* sp. and others from Chiang Dao. The occurrence of *Trilonche minax* is indicates the beginning of the Late Devonian⁴. The various species of *Trilonche* were found in this study but no *Trilonche minax*. The co-occurrence of *Archocyrtium* sp., *Stigmosphaerostylus variospina*, *Stigmosphaerostylus* sp., *Trilonche palimbola*, cf. *T. hindea*, and *Triaenosphaera* spp. was found from sample nos. 118N-1 and 118N-2. These fossils assemblage is estimate the Late Devonian (Frasnian-Famennian). The co-existence of *Archocyrtium* sp., and *Stigmosphaerostylus variospina* suggest that these beds are probably continuous from Late Devonian to Early Carboniferous (Tournaisian). This finding is similar to that of Pak Chom-Loei²⁵.

This distinctive radiolarian assemblage of pelagic chert containing Devonian radiolarians was dis-

tributed in northern and northeastern Thailand, southern and northwestern China^{26,27,28,29,230,31} and northwestern Australia^{17,32,33,34,35,36}. These evidences suggest they were deposited and accumulated in the same oceanic regime, the Paleo-Tethys ocean.

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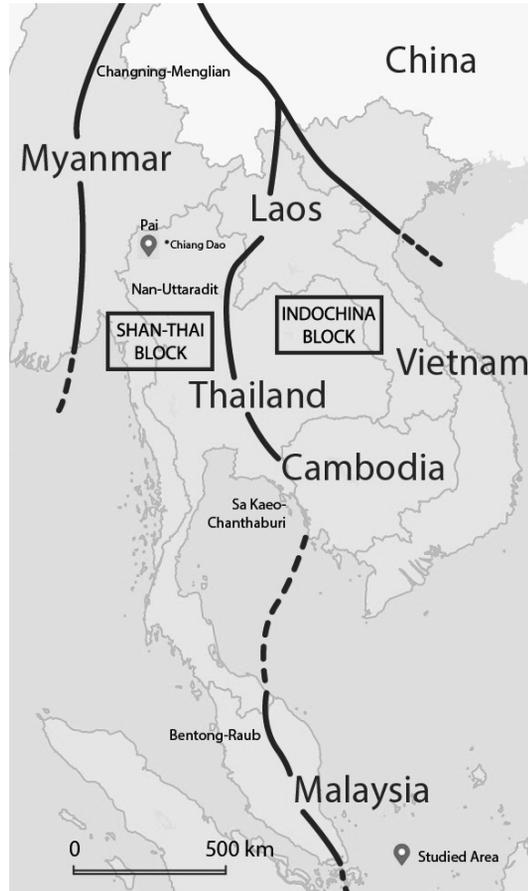


Figure 1 Tectonic subdivision of mainland Southeast Asia and Pai locality³⁷.

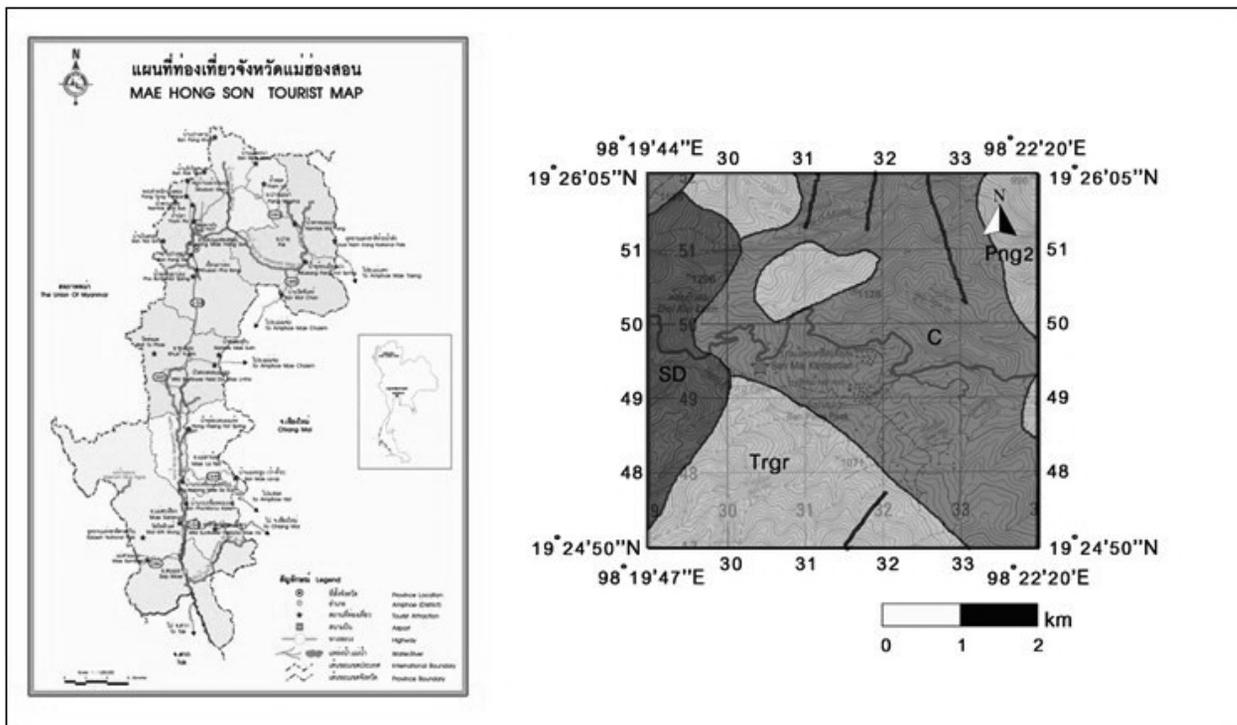


Figure 2 (A) Geologic map of Ban Pang Paek area, showing the distribution of rock units and sampling location and (B) Topographic Map showing the locality of Pai section exposed at Ban Pang Paek area, northwest of Pai city³⁸ (modified from the topographic map scale 1 : 50,000 sheet number 4647).



Figure 3 (A) The studied section in Ban Pang Paek of Pai district, Mae Hong Son province. (B) The Well-bedded chert with folding. (C) Well-bedded chert intercalated with shale.

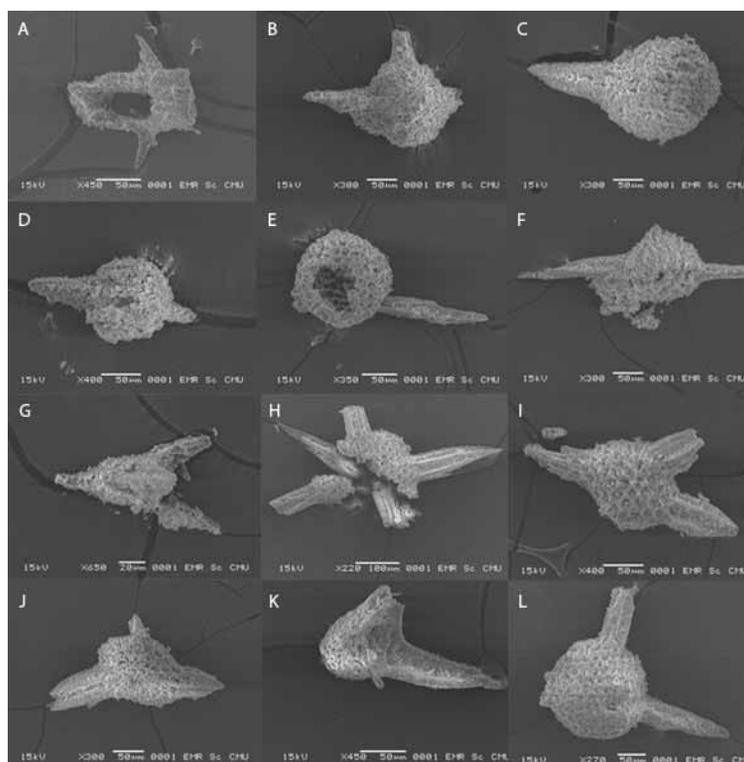


Figure 4 Late Devonian radiolarians from north part section, Pai area, Mae Hong Son Province, northern Thailand. All figures are scanning electronic micrographs. A. *Holoeciscus* sp. (118N-1); B,D. *Stigmosphaerostylus variospina* (Won, 1983) (118N-1); C. *Trilonche palimbola* (Foreman, 1963) (118N-1) E. *Stigmosphaerostylus* sp. (118N-1); F. *Trilonche* sp. cf. *T. hindea* (Hinde, 1899) (118N-2); G. *Archocyrtium* sp. (118N-1); H. *Trilonche australis* (Aitchison, 1993) (118N-2); I,J. *Triaenosphaera* sp. (118N-2) (118N-1); K. *Pylentonema paiensis* (118N-2); L. *Trilonche* sp. (118N-2).

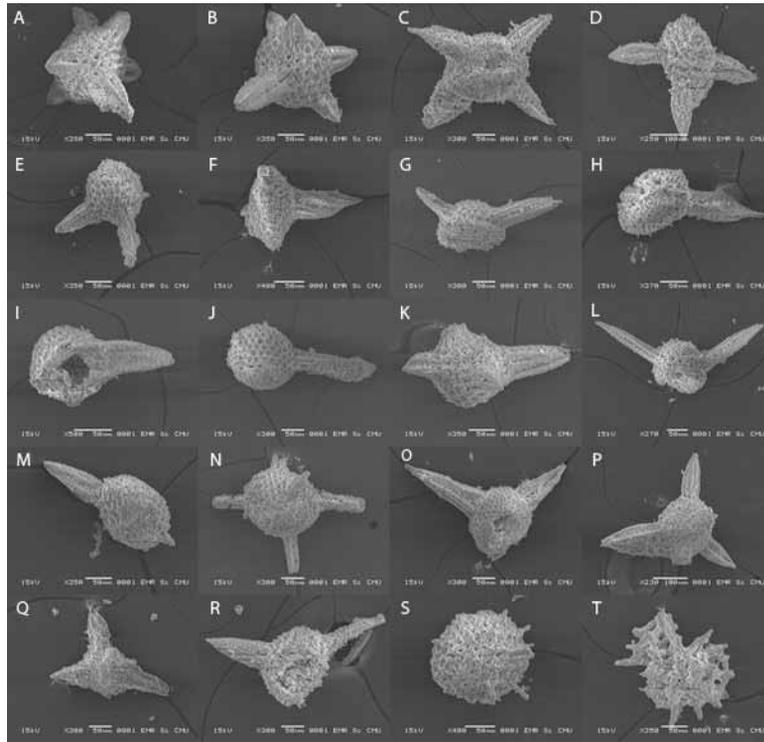


Figure 5 Middle to Late Devonian radiolarians from the south part section, Pai area, Mae Hong Son Province, northern Thailand. All figures are scanning electronic micrographs. A-E. *Stigmosphaerostylus variospina* (Won, 1983) (118S-8; 118S-14); F. *Trilonche dihelicis* (Won and Caridroit, 2002) (118S-11); G. *Trilonche echinata* (Hinde, 1899) (118S-8); H-M. *Trilonche palimbola* (Foreman, 1963) (118S-8; 118S-9; 118S-10; 118S-11; 118S-12; 118S-13; 118S-14); N. *Trilonche altasulcata* (Won, 1983) (118S-8); O-R. *Triaenosphaera* sp. (118S-8; 118S-11; 118S-13; 118S-14); S. *Astroentactinia* sp. cf. *A. multispinosa* (Won, 1983) (118S-8); T. *Polyentactinia polygonia* (Foreman, 1963) (118S-8).

Middle Devonian	Late Devonian		Age	Taxa
Givetian	Frasnian	Famennian		
	—————			<i>Stigmosphaerostylus variospina</i>
	—————			<i>Stigmosphaerostylus</i> sp.
	—————			<i>Trilonche dihelicis</i>
	—————			<i>Trilonche echinata</i>
	—————			<i>Trilonche palimbola</i>
	—————			<i>Trilonche altasulcata</i>
	—————			<i>Trilonche australis</i>
		—————		<i>Trilonche</i> sp. cf. <i>T. hindea</i>
	—————			<i>Trilonche</i> sp.
	—————			<i>Triaenosphaera</i> sp.
	—————			<i>Astroentactinia</i> sp. cf. <i>A. multispinosa</i>
	—————			<i>Polyentactinia polygonia</i>
		—————		<i>Holoeciscus</i> sp.
		—————		<i>Pylentonema paiensis</i>
		—————		<i>Archocyrtium</i> sp.

Figure 6 Middle to Late Devonian Radiolarian assemblages and stratigraphic distribution of the characteristic taxa from the study sections.