Vol. 1 No. 2 page 26-32 2015

RESEARCH & KNOWLEDGE

Research Article

Upper Devonian (Famennian) conodonts from radiolarian cherts, Loei Terrane, Loei Province, Northeast Thailand

Clive Burrett[1, 3, *], Hathaithip Thassanapak[2] and Mongkol Udchachon[2, 3]

[1]School of Physical Sciences, University of Tasmania, Sandy Bay, Box 79, Hobart, Tasmania, 7001 Australia
[2]Applied Palaeontology and Biostratigraphy Research Unit, Department of Biology, Faculty of Science, Mahasarakham University, Kantarawichai, Mahasarakham 44150, Thailand
[3]Palaeontological Research and Education Centre, Mahasarakham University, Kantarawichai, Mahasarakham 44150, Thailand

(Received 17 October 2015; accepted 18 December 2015)

Abstract - Conodonts from radiolarian cherts in the Loei Terrane of Loei Province, Northeast Thailand, include *Palmatolepis triangularis*, *P. minuta minuta*, *P. minuta wolskae* and polygnathids and indicate a Famennian crepida Zone age. These cherts are about 20 my younger than Givetian reef limestones and are unlikely to have been deposited in a major ocean but rather in a deep marine basin close to a volcanic arc.

Keywords: Conodont, Devonian, palaeoenvironment, tectonics, Indochina Terrane, chert.

1. Introduction

The Loei Terrane is a complex orogenic belt that constitutes the western margin of the Indochina Terrane and extends from Laos southwards to Thailand and then swings eastwards into Cambodia (Fig.1), (Burrett *et al*., 2014). The Loei Terrane contains assemblages of igneous, metamorphic and sedimentary rocks ranging from Silurian to Triassic in age and with deformation in the Palaeozoic and Triassic (Bunopas, 1982; Khin Zaw *et al*., 2014).

In Loei Province, NE Thailand, Devonian sedimentary rocks (Fig. 2) were deposited close to an active volcanic arc that was initiated in the Late Silurian and extended to the Triassic (Intasopa and Dunn, 1994; Kamvong *et al*., 2014; Khositanont *et al*., 2008; 2013; Panjasawatwong *et al*., 2006; Salam *et al*., 2014). Givetian patch reefs are found as north-south trending belts which now outcrop at the summit of hills (Fontaine and Tantiwanit, 1987; Fontaine, 1990; Fontaine and Sutheethorn, 2000; Fontaine *et al*., 2005). The Givetian reefs overlie, thin bedded limestone containing a Givetian conodont fauna which in turn conformably overlies fossiliferous shales, siltstones, fine quartz arenites and minor volcaniclastics (Fig. 3). The fine siliciclastics yield trilobites (a harpetid, a phacopid and proetids), abundant brachiopods (orthids and large rostrate strophomenids), gastropods, bivalves and rare tentaculitids and represent a benthic assemblage that lived in moderately deep shelf seas. Radiolarian cherts are widespread in the lowland areas, occur as scattered outcrops and are strongly and disharmonically folded (Fig. 4). In many localities, cherts are closely associated with mafic volcanic rocks and in a few localities with rhyolites. Although, these cherts were originally thought to have been deposited contemporaneously with the Givetian reefs, with the limestones later forming synclinal cores (Chairangsee *et al*., 1990), it is now known that all reliable radiolarian chert dates are Upper Devonian or Tournaisian (Sashida *et al*., 1993; Saesaengseerung *et al*., 2007 a, b; Udchachon *et al*., 2011). Mainly because of severe outcrop limitations, structural studies have not been carried out and it is possible that the younger cherts are either faulted against or folded with the older limestones (Fig. 3).

2. Samples and results

We have sampled the radiolarian chert (Fig. 4) using standard HF treatment techniques. Samples yield abundant Upper Devonian radiolarians, sponge spicules and sample CNA 4 also contains moderately well preserved, though corroded and pitted, conodonts. The conodont fauna consists of abundant *Palmatolepis* and less common *Polygnathus*.

Palmatolepis triangularis (Fig. 5a) ranges from the triangularis to the lower crepida Zone, and *P. minuta wolskae* (Fig. 5c) and *P. minuta minuta* (Fig. 5b, d) range through the crepida Zone (Austin *et al*., 1985; Ziegler, 1977; Ziegler and Sandberg, 1990). A crepida Zone age is therefore indicated for radiolarian chert sample CNA 4.

A *Polygnathus* with a broad elliptical platform is present (Fig. 5 f, g) and is close to *P. vialovi* Zvereva, 1986, from the Upper Devonian of the Russian Platform (Ziegler *et al*., 2000; Zvereva, 1986). Another *Polygnathus* (Fig. 5 h, i) is similar to the Upper Devonian *P. dengleri* Bischoff and Ziegler, 1957. Our specimens are closest to those from Alaska identified as *P*. aff. *P. dengleri* by Savage and Funai (1980).

*Author for correspondence: cfburrett@gmail.com

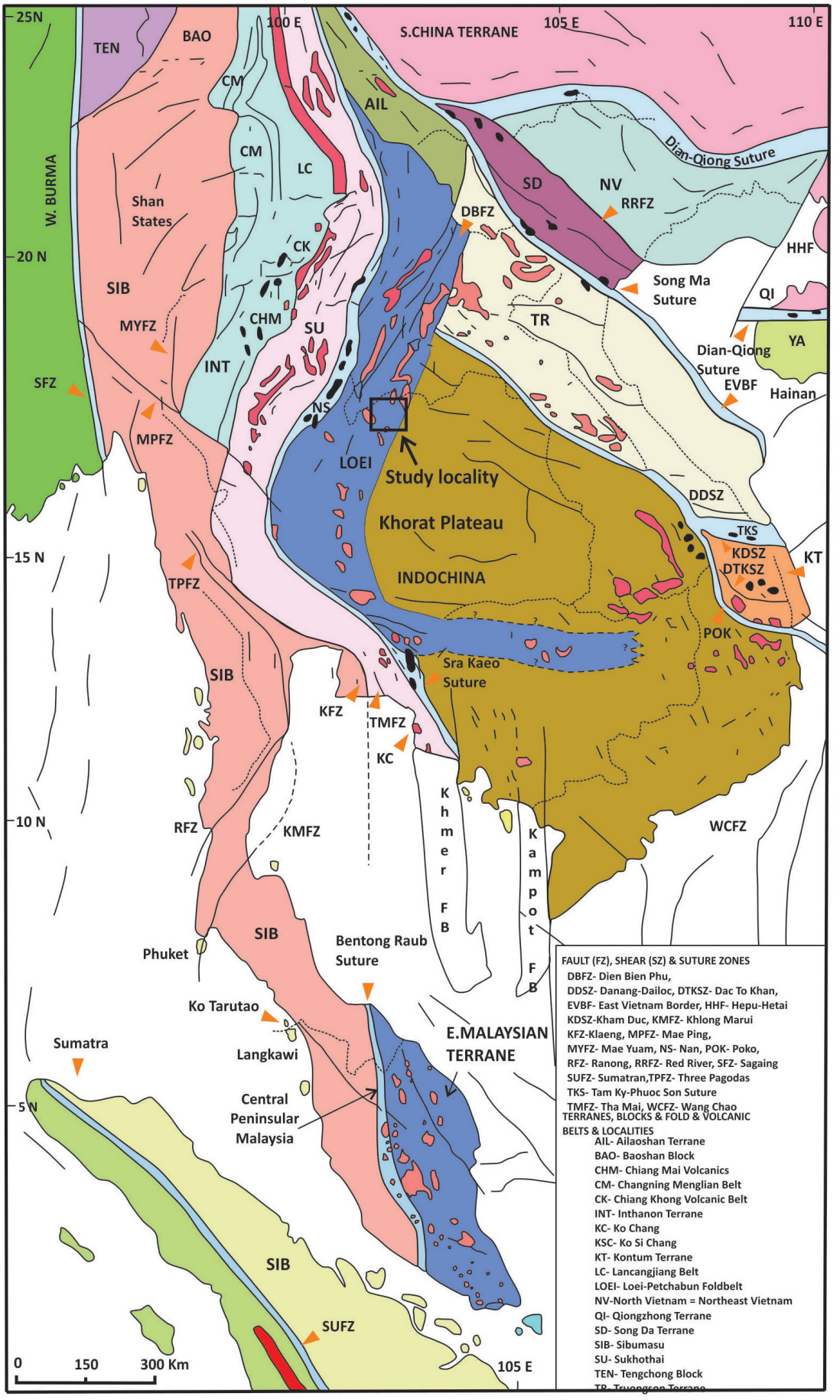

Figure 1. Sketch map showing extent of the Loei Terrane in SE Asia (after Burrett *et al*., 2014).

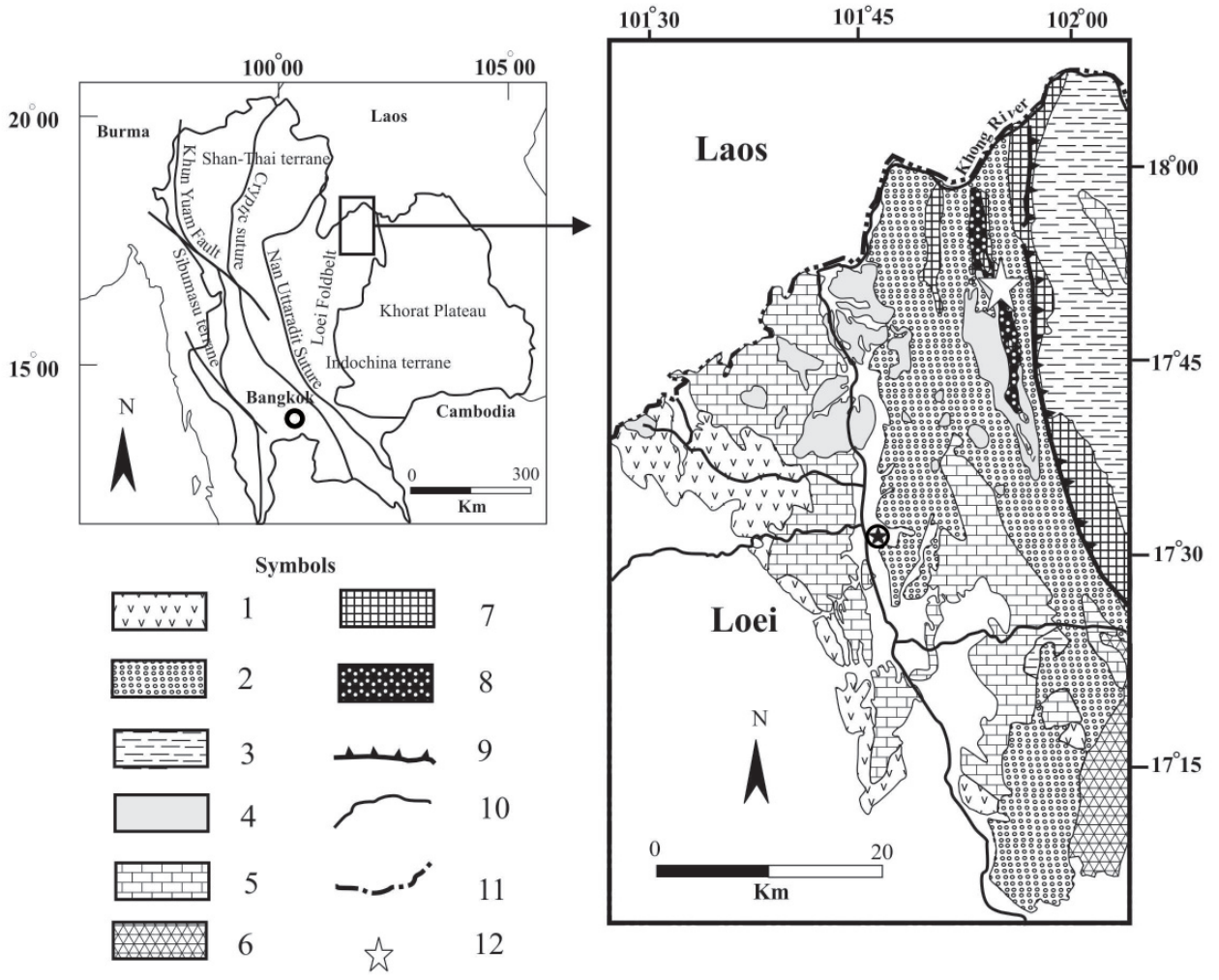

Figure 2. Simplified geological map of Loei, NE Thailand showing the distribution of sedimentary sequences and volcanic rocks. The study section is located to the east of Loei. 1–Permo–Triassic volcanic rocks including rhyolite, andesite, tuff, agglomerate; 2–Carboniferous rocks including conglomerate, sandstone, shale, slate, chert and limestone; 3–Permo–Triassic rocks including sandstone, argillaceous limestone, rhyolitic tuff, shale, limestone, and chert; 4–Permo–Triassic granite; 5–Permian rocks including limestone, shale, sandstone; 6–Triassic rocks including sandstone, siltstone, mudstone; 7–Devonian rocks including chert, shale and tuff; 8–Devonian–Carboniferous volcanic rocks including basalt, andesite, tuff; 9–thrust fault; 10–road, 11– border between Lao PDR and Thailand; 12– study locality at Ban Chom Noi, Pak Chom District, Loei Province (after Udchachon *et al*., 2011).

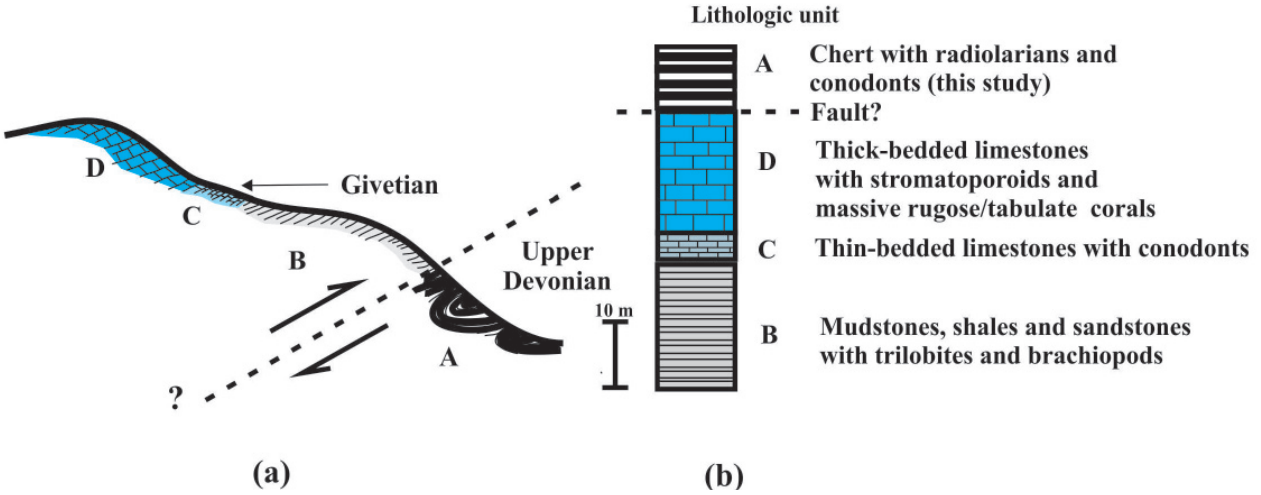

Figure 3. Generalised stratigraphic column showing postulated fault contact between Givetian shallow marine sedimentary rocks and Upper Devonian conodont-bearing radiolarian chert.

Figure 4. Photograph of disharmonically folded Upper Devonian chert at Ban Chom Noi, Pak Chom District, Lat.17° 45' 49.42" N, Long. 101° 56' 18.35" E, showing sampling points. Geological hammer as scale.

3. Palaeoecology and palaeoenvironment

The conodonts belong to the basinal, but not deepest basin, *Palmatolepis-Polygnathus* biofacies (Sandberg and Dreesen, 1984; Dreesen *et al*., 1986; Savoy and Harris, 1993). Many of the *Palmatolepis* specimens are small and were probably juvenile, which may indicate deposition at a considerable distance from land, as was suggested for Upper Devonian conodonts from radiolarian cherts in the Inthanon Terrane of northern Thailand (Randin *et al*., 2006). However, on the basis of chert geochemistry, Udchachon *et al*. (2011) conclude that the Loei cherts were not deposited in a major ocean basin but rather in a basin relatively close to a continental margin. Adjacent and interbedded mafic and less common, rhyolitic volcanics and volcaniclastics suggest proximity to a volcanic arc.

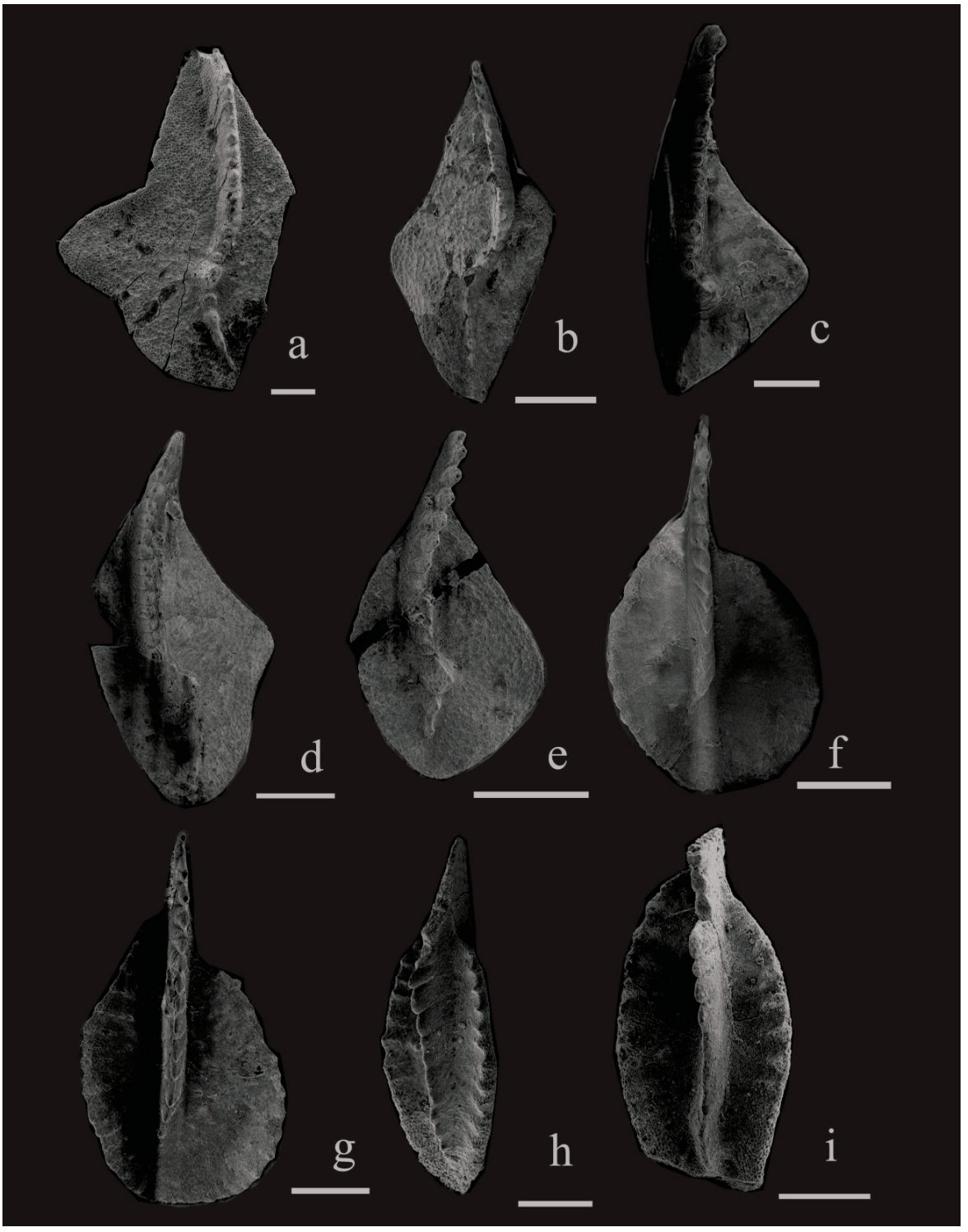

Figure 5. Conodonts from sample CNA 4. All illustrated specimens are stored in the collections of the Palaeontological Research and Education Centre, Mahasarakham University, Mahasarakham, Thailand and given PRC numbers. Scale bar = 20 μm. (a) *Palmatolepis triangularis* individual figured specimen number PRC 250 (total of 38 specimens for this species, including all non-Pa elements from this sample). (b) *Palmatolepis minuta minuta*. Figured specimen number PRC 251(15 specimens total for this taxon). (c) *Palmatolepis minuta wolskae*. Figured specimen number PRC 252 (20 specimens total for this taxon). (d) *Palmatolepis minuta minuta*. Figured specimen number PRC 253. (e) *Palmatolepis* sp. 'juvenile' form. Figured specimen number PRC 254 (63 specimens of unassigned 'juvenile' *Palmatolepis*). (f) *Polygnathus* aff. *vialovi* Zvereva, 1986. Figured specimen number PRC 255 (6 specimens total for this taxon). (g)*Polygnathus* aff. *vialovi* Zvereva, 1986. Figured specimen number PRC 256. (h) *Polygnathus* aff. *dengleri* Bischoff and Ziegler, 1957. Figured specimen number PRC 257 (14 specimens total for this taxon). (i) *Polygnathus* aff. *dengleri* Bischoff and Ziegler, 1957. Figured specimen number PRC 258.

4. Conclusions

The Upper Devonian to Tournaisian age of the Loei radiolarian cherts is confirmed by the conodonts identified herein. This shows that the radiolarian cherts were deposited neither before nor contemporaneously with shallow water Givetian reefs but rather represent widespread deep water conditions about 20 million years after the Givetian (Becker *et al*., 2012). The Famennian cherts were deposited in a deep water basin but not in a major ocean basin.

Acknowledgements

We thanks Professors Chongpan Chonglakmani and Natthawirpj Silatana for their helpful reviews.

References

Austin, R., Orchard, M. and Stewart, I. 1985. Conodonts of the Devonian System from Great Britain. In: Higgins, A. and Austin, R. (Eds.), A Stratigraphical Index of Conodonts. Ellis Horwood, Chichester, pp. 93-166.

Becker, R. T., Gradstein, E. M., and Hammer, O. 2012. The Devonian Period. In: Gradstein, F.M., Ogg, J., Schmitz, M. and Ogg, G. (Eds.), The Geologic Time Scale, Elsevier, Amsterdam, pp. 559-601.

Bischoff, G. and Ziegler, W. 1957. Die Conodontenchronologie des Mitteldevons und des tiefsten Oberdevons. Abhundlungen Hessichen L-Amt. Bodenforschungen 22, 1-136.

Bunopas, S. 1982. Palaeogeographic history of Western Thailand and adjacent parts of Southeast Asia. Geological Survey of Thailand Paper 5, Royal Thai Department of Mineral Resources, Thailand, pp. 1-810.

Burrett, C., Khin Zaw, Meffre, S., Lai, C., Khositanont, S., Chaodumrong, P., Udchachon, M., Ekins, S. and Halpin, J. 2014. The configuration of Greater Gondwana – Evidence from LA ICPMS U-Pb geochronology of detrital zircons from the Palaeozoic and Mesozoic of Southeast Asia and China. Gondwana Research 26, 31-51.

Chairangsee, C., Hinze, C., Macharoensap, S., Nakornsri, N., Silpalit, M. and Sinpool-Arunt, S. 1990. Geological Map of Thailand 1:50,000, Explanation for the sheets Amphoe Pak Chom, Ban Na Kho, Ban Huai Khop, Nam Som. Geologisches Jahrbuch Reihe A 73, 3-55.

Dreesen, R., Sandberg, C. A. and Ziegler, W. 1986. Review of Late Devonian and Early Carboniferous conodont biostratigraphic models applied to the Ardenne Shelf. Annales de la Societe Geologiques de Belgique, 109, 27-42.

Fontaine, H., 1990. Some Devonian corals and stromatoporoids from Northeast Thailand. In: Chairangsee, C., Hinze, C., Macharoensap, S., Nakornsri, N., and Sinpool-Arunt, S. 1990, Geological Map of Thailand 1;50,000, Explanation for the sheets Amphoe Pak Chom, Ban Na Kho, Ban Huai Khop, Nam Som. Geologisches Jahrbuch Reihe A 73, 57-79.

Fontaine, H., Salyapongse, S., Suteethorn, V., Tian, P. and Vachard, D. 2005. Sedimentary rocks of the Loei Region, Northeast Thailand: stratigraphy, paleontology, sedimentology. Bureau of Geological Survey, Department of Mineral Resources, Bangkok, pp. 165.

Fontaine, H. and Sutheethorn, V. 2000. Devonian and Carboniferous corals found at Ban Na Klang, Loei province, Northeast Thailand. Journal of the Geological Society of Thailand 1, 27 – 33.

Fontaine, H. and Tantiwanit, W. 1987. Discovery of widespread and very fossiliferous Devonian beds in Northeast Thailand. CCOP Newsletter 12, 25-26.

Intasopa, S. and Dunn, T. 1994. Petrology and Sr-Nd isotopic systems of the basalts and rhyolites, Loei, Thailand. Journal of Southeast Asian Earth Sciences 9, 167-180.

Kamvong, T., Khin Zaw, Meffre, S., Maas, R., Stein, H. and Lai, C. 2014. Adakitic porphyries in the Loei and Truongson Belts, Thailand and Laos: Their genesis and implications for geodynamics and metallogeny. Gondwana Research 26, 115-184.

Khin Zaw, Meffre, S., Lai. C., Burrett, C., Santosh, M., Graham, I., Manaka, T., Salam, A., Kamvong, T. and Cromie, P. 2014. Tectonics and metallogeny of mainland Southeast Asia- A review and contribution. Gondwana Research 26, 5-30.

Khositanont, S., Panjasawatwong, Y., Ounchanum, P., Thanasuthipak, T., Khin Zaw and Meffre, S. 2008. Petrochemistry and zircon age determination of Loei-Phetchabun Volcanic belt. Proceedings of the International Symposia on Geoscience Resources and Environments of Asian Terranes, (GREAT 2008), Bangkok, Thailand, pp. 272-278.

Khositanont, S., Khin Zaw, Meffre, S., Panjasawatwong, Y., Ounchanum, P. and Thanasuthipitak, T. 2013. Geotectonic and geochronology of volcano-plutonic rocks in the Loei-Petchabun Fold Belt. In: Senebouttalath, C. and Roibang, P. (Eds.), Lao-Thai Geology Beyond the Bounds, Proceedings of 2nd Lao-Thai Technical Conference on Geology and Mineral Resources. Department of Geology and Minerals, Vientiane, Lao PDR, pp. 15.

Panjasawatwong, Y., Khin Zaw, Chatramee, S., Limtrukun, P. and Pirarai, K. 2006. Geochemistry and tectonic setting of the Central Loei volcanic rocks Pak Chom area, Loei northeastern Thailand. Journal of Asian Earth Sciences 26, 77-90.

Randin, C., Wonganan, N., Caridroit, M., Perret-Mirouse, M. and Degardin, J. 2006. Upper Devonian –Lower Carboniferous conodonts from Chiang Dao cherts, northern Thailand. Revista Italiana di Paleontologia e Stratigrafia 112, 191-206.

Saesaengseerung, D., Sashida, K. and Sardsud, A. 2007a. Late Devonian to Early Carboniferous radiolarian fauna from the Pak Chom, area Loei Province, northeastern Thailand. Paleontological Research 11, 109-121.

Saesaengseerung, D., Sashida, K. and Sardsud, A. 2007b. Devonian to Triassic radiolarian faunas from Northern and Northeastern Thailand. In: Tantiwanit, W.

(Ed.), International Conference on Geology of Thailand: Towards Sustainable Development and Sufficiency Economy (GEOTHAI 2007), Royal Thai Department of Mineral Resources, Bangkok, 54-71.

Salam, A., Khin Zaw, Meffre, S., McPhie, J. and Lai, C. 2014. Geochemistry and geochronology of epithermal Au-hosted Chatree volcanic sequence: implications for tectonic setting of the Loei Fold belt in central Thailand. Gondwana Research 26, 198-217.

Sandberg, C. and Dreesen, R. 1984. Late Devonian icriodontid biofacies models alternate shallow water conodont zonation. In: Clark, D. (Ed.), Conodont biofacies and provincialism. Special Paper of the Geological Society of America 196, 143-178.

Sashida, K., Igo, H., Hisada, K., Nakonsri, N. and Ampornmaha, A. 1993. Occurrence of Paleozoic and Early Mesozoic Radiolaria in Thailand. Journal of Southeast Asian Earth Sciences 8, 97-108.

Savage, N. and Funai, C. 1980. Devonian conodonts of probable Early Frasnian age from the Coronados Islands of SE Alaska. Journal of Paleontology 54, 806-813.

Savoy, L. and Harris, A. G. 1993. Conodont biofacies in a ramp to basin setting (latest Devonian and earliest Carboniferous) in the Rocky Mountains of southernmost Canada and northern Montana. United States Geological Survey Open File Report 93-184, 1-34.

Udchachon, M., Thassanapak, H., Feng, Q. and Chonglakmani, C. 2011. Geochemical constraints on the depositional environment of Upper Devonian cherts, Loei, Northeastern Thailand. Frontiers of Earth Science 5, 178-190.

Ziegler, W. 1977. Catalogue of Conodonts, vol 3. Schweizerbart'sche Verlag, Stuttgart, pp. 574.

Ziegler, W., Ovnatanova, N. and Kononova, L. 2000. Devonian polygnathids from the Frasnian of the Rheinishes Schiefergebirge, Germany and the Russian Platform. Senckenbergiana Lethaea 80, 593-645.

Ziegler, W. and Sandberg, C. A. 1990. The Late Devonian Standard Conodont Zonation. Courier Forschungsinstitut Senckenberg 121, 1-115.

Zvereva, E. V. 1986. A new conodont species from the Upper Devonian of the Kama Urals. Paleontologicheskyi Sbornik 23, 52-54.