

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

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Abstract - Conodonts from radiolarian cherts in the Loei Terrane of Loei Province, Northeast Thailand, include *Palmatolepis triangularis*, *P. minuta minuta*, *P. minuta wolskiae* 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), (Burritt *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 wolskiae* (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).

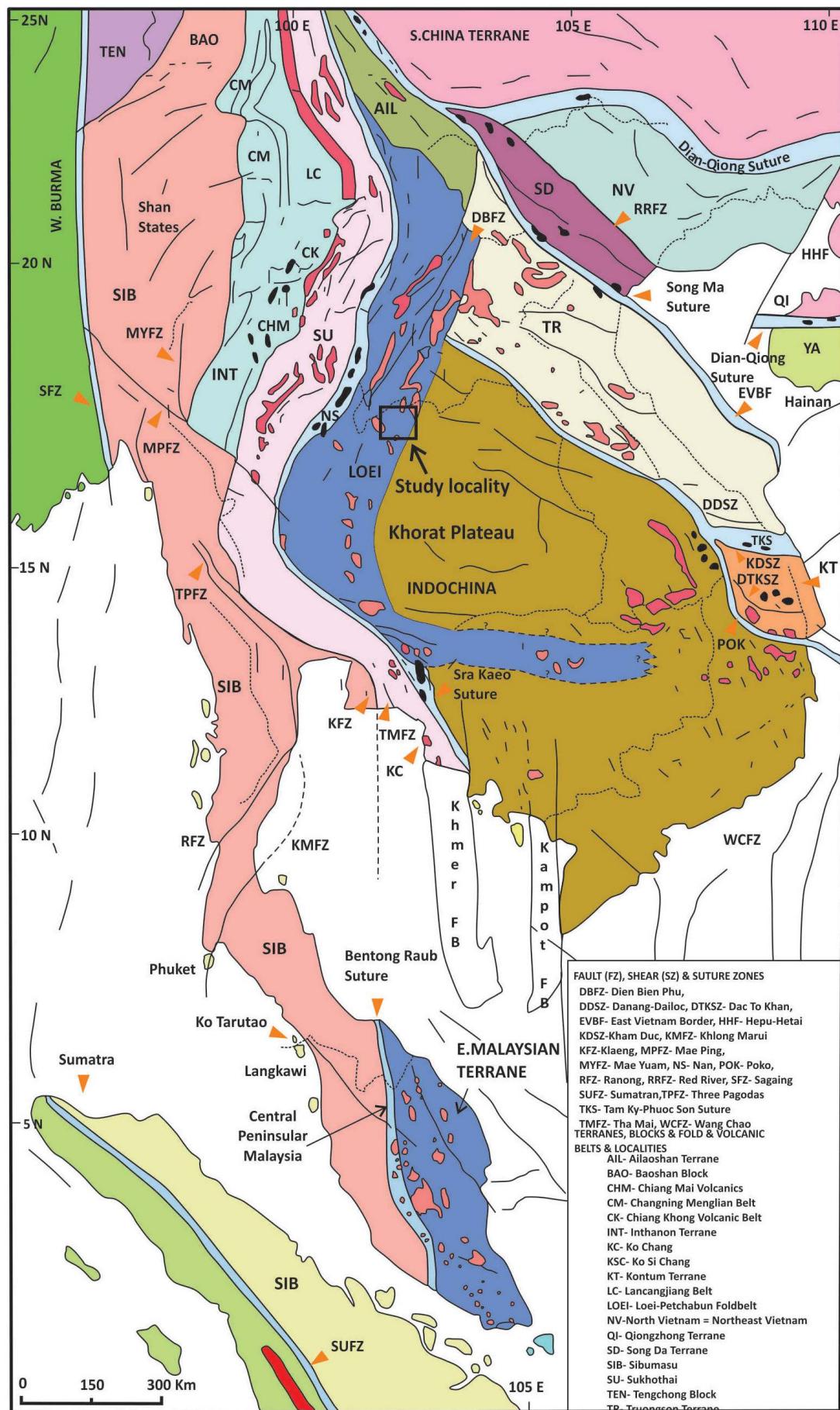


Figure 1. Sketch map showing extent of the Loei Terrane in SE Asia (after Burrett *et al.*, 2014).

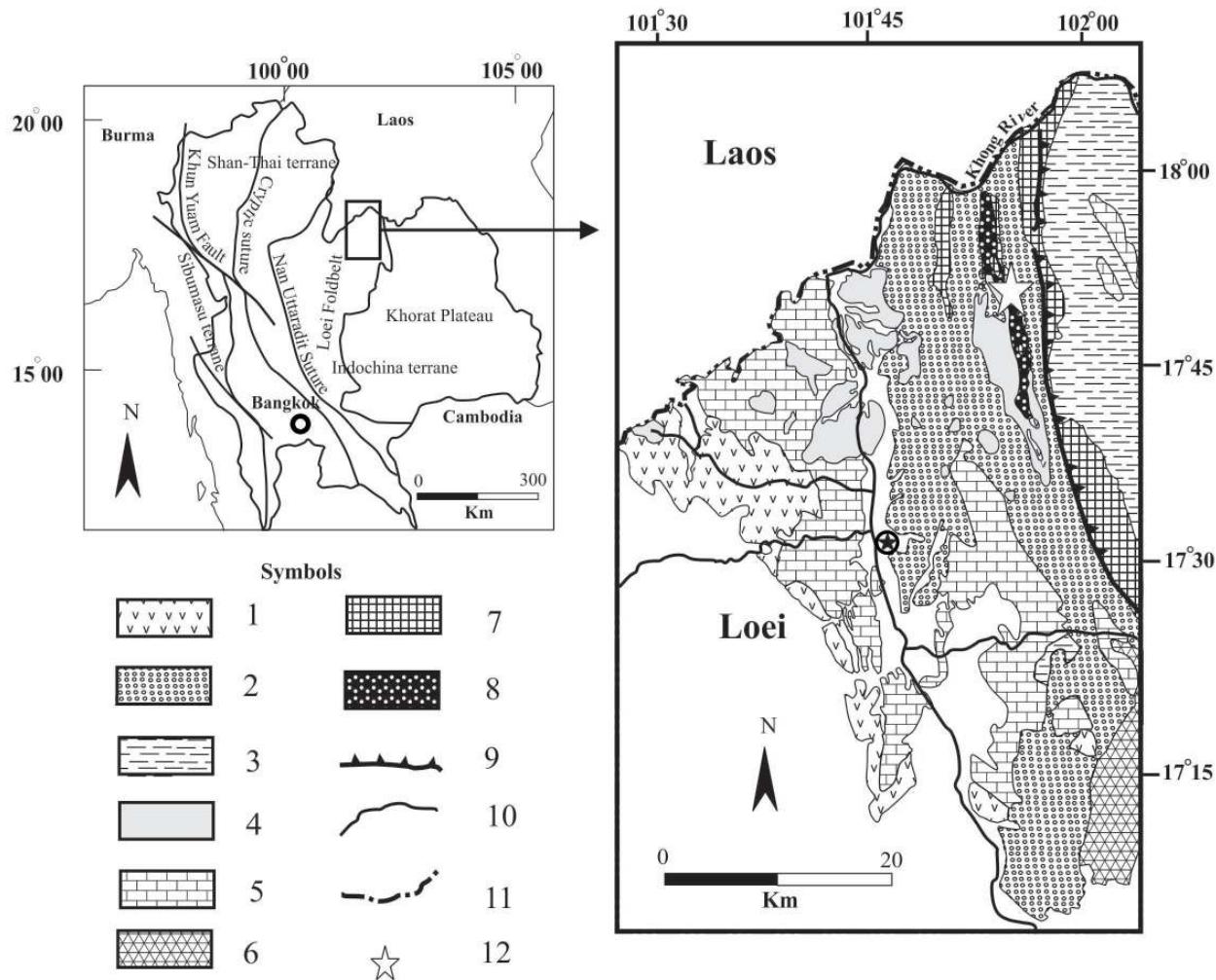


Figure 2. Simplified geological map of Loei, NE Thailand showing the distribution of sedimentary sequences and volcanic rocks. The study section is located to the east of Loei. 1–Permo–Triassic volcanic rocks including rhyolite, andesite, tuff, agglomerate; 2–Carboniferous rocks including conglomerate, 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).

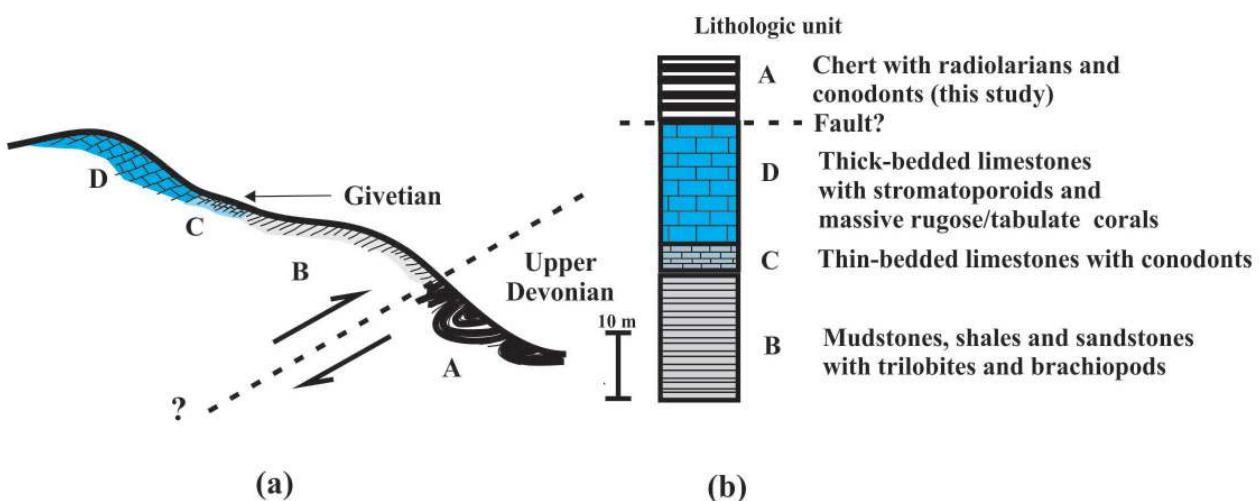


Figure 3. Generalised stratigraphic column showing postulated fault contact between Givetian shallow marine sedimentary rocks and Upper Devonian conodont-bearing radiolarian chert.



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.

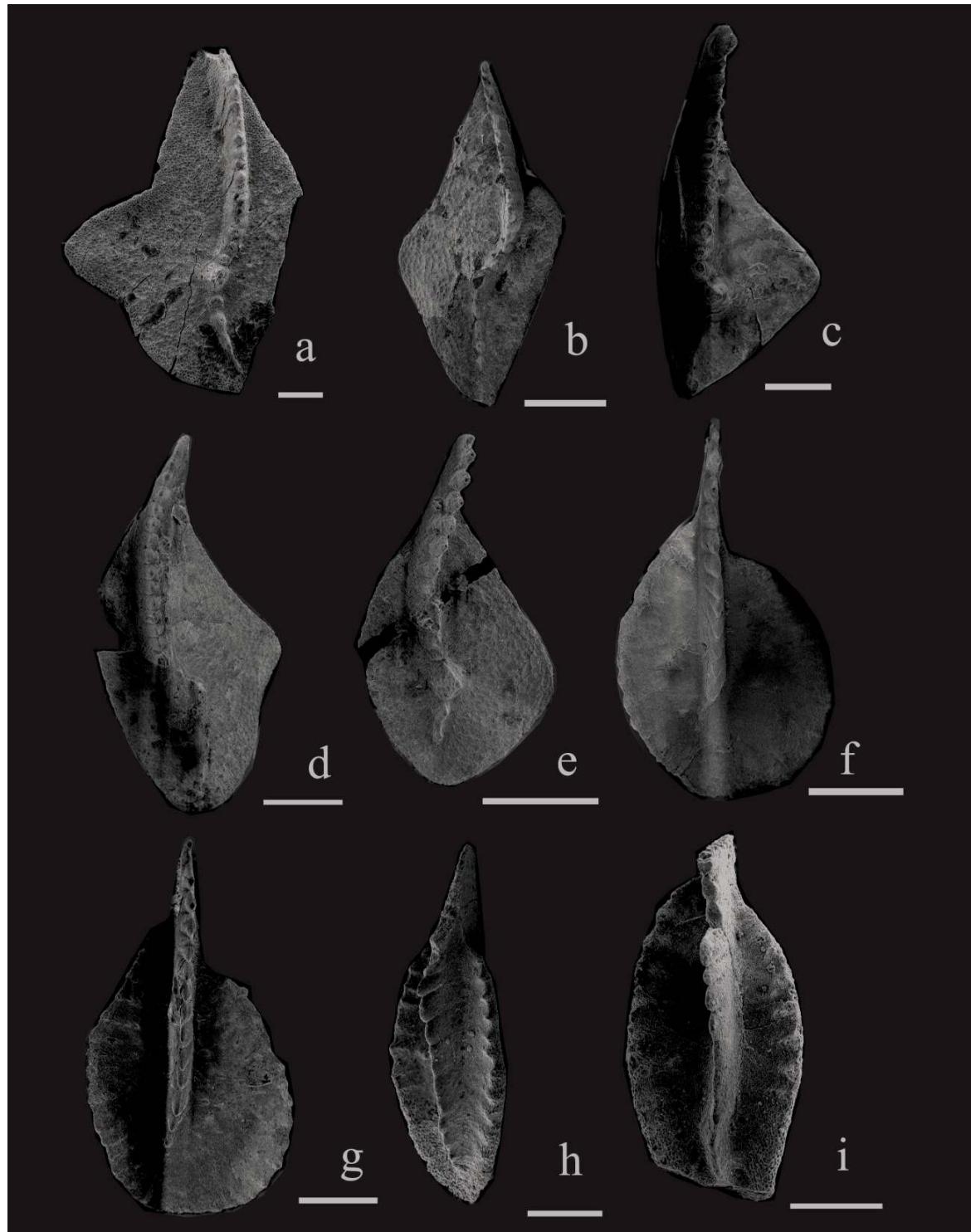


Figure 5. Conodonts from sample CNA 4. All illustrated specimens are stored in the collections of the Palaeontological Research and Education Centre, Mahasarakham University, Mahasarakham, Thailand and given PRC numbers. Scale bar = 20 μm . (a) *Palmatolepis triangularis* individual figured specimen 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.

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