

## Earliest Triassic Conodonts of Gua Panjang, Merapoh, Pahang and their Bearing towards Permian-Triassic Mass Extinction in Malaysia

(Konodon Berusia Awal Trias di Gua Panjang, Merapoh, Pahang dan Pengaruh ke Arah Kepupusan Besar-besaran Berusia Perm di Malaysia)

NELISA AMEERA MOHAMED JOEHARRY, MOHD SHAFEEA LEMAN\*, CHE AZIZ ALI & KAMAL ROSLAN MOHAMED

### ABSTRACT

*A single sample from the logged section at eastern side of Gua Panjang limestone hill, southwest of Kampung Kubang Rasa Village, Merapoh, has yielded 5 very important conodont species. They are Hindeodus parvus erectus, Hindeodus parvus parvus, Hindeodus latidentatus latidentatus, Hindeodus latidentatus praeparvus, Hindeodus postparvus, Hindeodus euryptge and Isarcicella staeschi. These Early Triassic conodonts were obtained in a bioclastic dolostone sample, located 2.5 m above bioclastic grainstone which yielded Late Permian foraminifera. The conodonts found were given Conodont Alteration Index (CAI) scale of 5, consistent with the heating of Main Range granitoid during Indosinian Orogeny. Limestone harbouring basal Triassic conodonts in Gua Panjang is interpreted to be deposited in an open shallow marine shelf environment.*

*Keywords: Basal triassic; Hindeodus parvus; limestone; Merapoh; Permian-Triassic Boundary*

### ABSTRAK

*Satu sampel daripada singkapan yang dilog pada jujukan timur bukit batu kapur Gua Panjang, arah barat daya Kampung Kubang Rasa, Merapoh, telah menemukan 5 spesies konodon yang sangat penting. Konodon ini adalah Hindeodus parvus erectus, Hindeodus parvus parvus, Hindeodus latidentatus latidentatus, Hindeodus latidentatus praeparvus, Hindeodus postparvus, Hindeodus euryptge dan Isarcicella staeschi. Konodon berusia dasar Trias ini ditemui pada sampel batu dolo berbioklas, terletak 2.5 m di atas jujukan batu butir berbioklas yang mengandungi foraminifera berusia Perm Akhir. Konodon yang ditemui diberikan skala 5 pada Indeks Alterasi Konodon, konsisten dengan pemanasan granitoid Banjaran Utama ketika Orogeni Indosinian. Batu kapur yang mengandungi konodon berusia dasar Trias di Gua Panjang ini ditafsirkan sebagai endapan pada sekitaran pelantar lautan cetek terbuka.*

*Kata kunci: Batas Perm-trias; batu kapur; Hindeodus parvus; Merapoh; trias asas*

### INTRODUCTION

The passing of Permian to Triassic period was one of the most critical juncture in history of life on Earth, where roughly 90% of marine life (Bambach et al. 2004; Erwin 1994; Raup 1991) and 70% of terrestrial (Maxwell 1992) forms succumbed to the largest mass extinction, known as the Permian-Triassic Mass Extinction (PTME). Although critical extinctions had occurred throughout Late Permian, the rate of extinction peaked during latest Late Permian until Early Triassic, thus can be marked by the transition of Permian to Triassic period. It is a duty for every stratigraphers to establish the position of exact strata representing this catastrophic moment across the globe, where the Palaeozoic sedimentary rock sequences pass continuously from Palaeozoic to Mesozoic rocks. Meishan section in South China which is acknowledged as the Global Stratotype Section and Points (GSSP) for the Triassic period and the landmark for Permian-Triassic Boundary (PTB) (Yin et al 2001), was dated to be  $252.6 \pm 0.2$  Ma by Mundil et al. (2004).

In Malaysia, the search for PTB started well back in 1980s, where both Permian and Triassic conodonts were found in Bukit Hantu, Kedah (Metcalf 1990a, 1984, 1981; Metcalfe & Spiller 1994). However, no specific location for PTB was named. The attention later shifts to the Central Belt, where Late Permian foraminifera fauna (Lim & Nuraiteng 1994; Nuraiteng 1993) and Middle Triassic cephalopod *Sibyllonautillus bamaensis* (Sone et al. 2010, 2008, 2004) were found at Gua Bama, near Kuala Lipis. Roughly 2 km to the northeast of Gua Bama is Gua Sei, where Metcalfe (1995) reported the findings of both Permian and Triassic conodonts. Fifty km north in Merapoh, the presence of algal boundstone (Nuraiteng 1993) and Late Permian conodonts (Metcalf & Azhar 1995) had been reported. Despite all these findings, no specific location or height constraint had been specified as the possible location for PTB in Malaysia. Hence, the search is continued in order to locate this crucial geological transition, which may be a stepping-stone for in-depth mass extinction research in this country.

This paper will describe the taxonomy of the earliest Triassic conodont fauna of Gua Panjang, Merapoh and will briefly discuss the importance of this fauna pertaining to the Permian-Triassic events in Malaysia, particularly in Central Belt of Peninsular Malaysia.

#### GEOLOGICAL SETTING

Permian and Triassic sediments scattered widely throughout the Central Belt, hence the focus on most Permian-Triassic studies (Figure 1). Multiple depositional models had been suggested to explain the sedimentation of Central Belt after the suturing between Indochina and Sibumasu blocks during Permian-Triassic. Metcalfe (2013, 2000) introduced the accretionary arc complex model, where thick carbonates were deposited as shallow-marine limestones at the fore-arc of accretionary complex during the Indosinian Orogeny. In addition, presence of nearby volcanism explains the presence of volcanoclastics in Central Belt during this time. Tjia and Syed (1996) believe that divergence of Western and Central Belt after the Indochina-Sibumasu collision had created marine environment that allow the sedimentation of Central Belt.

Kamal et al. (2016) suggested that the fore-arc buildup at the Central Belt was followed by basin segmentation during Middle Triassic. This explains the geometry of shallow and deep marine sedimentation of the Central Belt.

Gua Panjang Limestone Hill (Figures 2 & 3) in Merapoh, located at the northern part of Lipis District, at northwest Pahang, is deposited within the Permian-Triassic Gua Musang formation. Based on the naming convention by Kamal et al. (2016), Gua Panjang is deposited as a part of the Merapoh Limestone within the Gua Musang Group. Southward, Merapoh Limestone is known to overlain older Middle to Late Permian brachiopod bearing tuffaceous shale regarded as Leptodus Shale. This shale had been described by Campi et al. (2002) and Mohd (1993) as a band (or possible presence of a few bands) of fossil-rich shale layer(s) extending across Sungai Yu - Sungai Toh area. Northward of Gua Panjang towards south Kelantan, sediments deposited and fossils found of younger age were recorded. Another Gua Panjang, located in south Kelantan, which was located further north from Gua Panjang, Merapoh, yielded significant Middle Triassic conodont findings by Igo and Koike (1975).

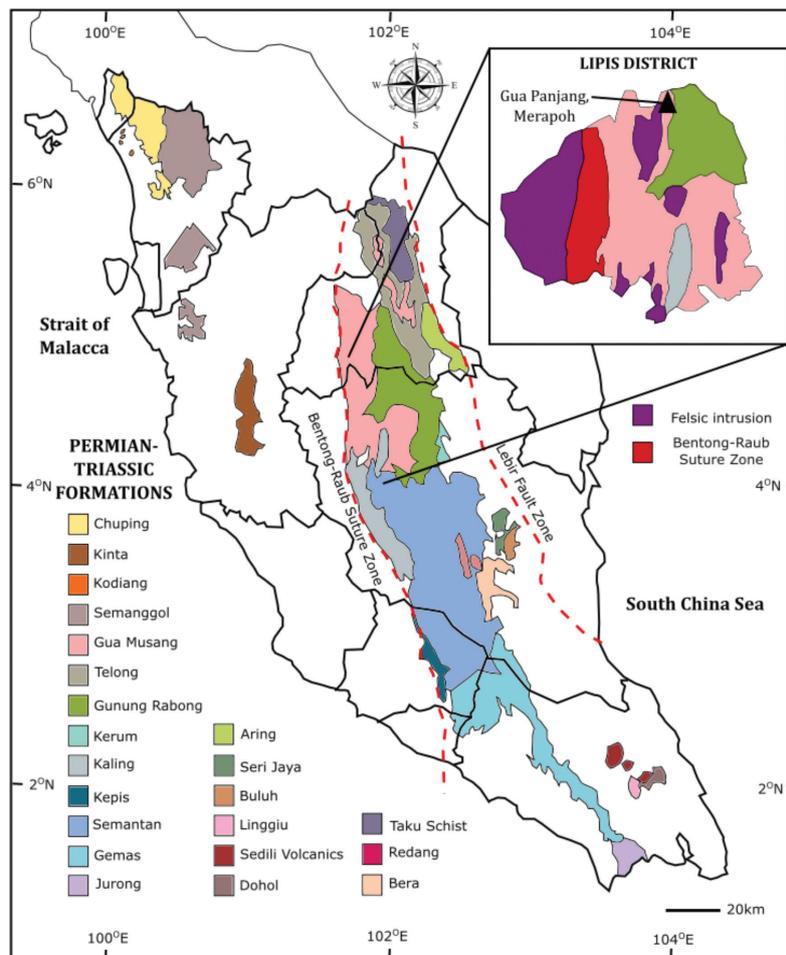


FIGURE 1. Permian-Triassic formations in Peninsular Malaysia are largely distributed across the Central Belt. Lipis District which is located in NW Pahang harbours many limestone bodies, among them is Gua Panjang in Merapoh

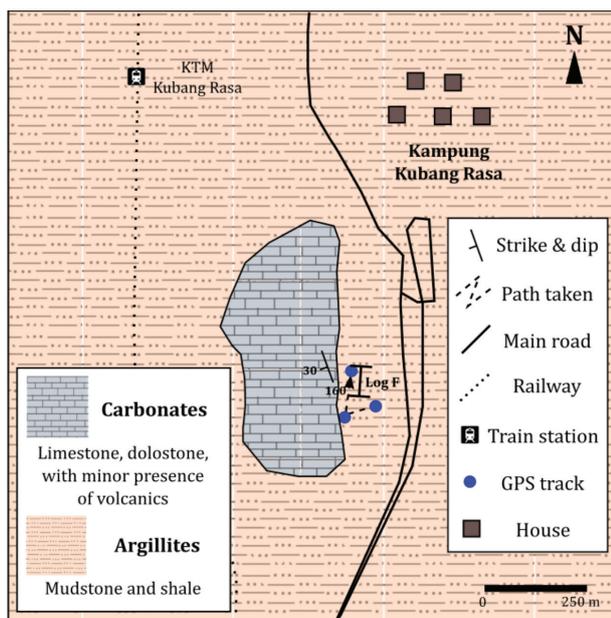


FIGURE 2. Geologic map of Gua Panjang, Merapoh, which is located at northern part of Lipis district



FIGURE 3. Eastern cliff of Gua Panjang (Merapoh) limestone hill

This finding of conodont in Gua Panjang, Merapoh, is the first record of earliest Triassic conodont found within the same sequence above latest Permian foraminifera assemblage in Malaysia, thus confining the Permian-Triassic Boundary within a short gap of 2.5 m (Nelisa et al. 2017).

#### METHODS

Limestone samples were soaked in 10% acetic acid for 2 days. The solution was then filtered through stacked sieve method using 1 mm and 63  $\mu$ m size sieves. Residues of limestone samples, which have not fully dissolved, were immersed again in newly prepared acetic solution until the whole rock samples were dissolved. Filtered samples were dried and individual conodonts were picked using fine

brush under microscope. Conodonts were then analyzed through Scanning Electron Microscope (SEM) for better observation of the conodont morphology.

#### RESULTS

5 species of Early Triassic conodonts, namely *Hindeodus parvus erectus*, *Hindeodus parvus parvus*, *Hindeodus latidentatus latidentatus*, *Hindeodus latidentatus praeparvus*, *Hindeodus postparvus*, *Hindeodus eurypge* and *Isarcicella staeschi* were found in a limestone sample at the 9.0<sup>th</sup> meter horizon (Figure 4) from the base of logged section (Log F) of Gua Panjang eastern cliff (Plate 1). 2.5 m below this horizon is a moderately bedded bioclastic grainstone harbouring Late Permian foraminifera. Color code designation of these conodonts are stated below.

The limestone samples of these conodonts were collected during this research in January 2015. Extraction and preparation process were conducted in the geochemistry and micropaleontology laboratory of Geology Programme, Universiti Kebangsaan Malaysia. Currently these samples are located in the paleontology laboratory, UKM. The followings are brief descriptions of the conodont elements observed through SEM, with notes on their stratigraphic distribution:

Phylum CONODONTA Eichenberg (1930)  
 Class CONODONTA Eichenberg (1930)  
 Order OZARKODINIDA Dzik (1976)  
 Superfamily POLYGNATHACEA Bassler (1925)  
 Family ANCHIGNATHODONTIDAE Clark (1972)  
 Genus *Hindeodus* Rexroad & Furnish (1964)  
 Species *Hindeodus parvus* Kozur & Pjatakova (1976)  
*Hindeodus parvus erectus* Kozur (1996)

*Specimen*: Plate 1 Figure 1. [UKM-KGP1]

*Description*: Cusp is slender and erect, with more than twice the height of denticles. Denticles are straight, slender, very pointed and have roughly the same size and height. These denticles are unfused at the base, with 'v' shaped spaces in between denticles. The base shows flare at posterior and anterior margin, with a slight pinch at the middle.

*Discussion* In Meishan, South China, the presence of *Hindeodus parvus erectus* marks the base of Triassic period. Prior finding of *Hindeodus parvus* has been made by Metcalfe (1995) in Gua Sei, Kampung Gua, located 50 km southeast of Gua Panjang. However, the subspecies has not been specified, whether it is a *H. parvus erectus* or *H. parvus parvus*.

*Hindeodus parvus parvus* Kozur & Pjatakova (1976)

*Specimen*: Plate 1 Figure 2. [UKM-KGP2]

*Description*: Compare to *Hindeodus parvus erectus*, the cusp is wider and taller relative to denticles. Denticles have fused base and discrete tips. These tips are chisel-like, appear blunt and not pointed, unlike *H. parvus erectus*.

Slight flare at anterior and posterior margin, with no pinch at the middle.

*Discussion:* In Meishan, the first appearance co-exist with *H. parvus erectus* during earliest Triassic.

Species *Hindeodus latidentatus* Kozur (1996)  
*Hindeodus latidentatus latidentatus* Kozur et al. (1975)  
*Specimen:* Plate 1 Figure 3. [UKM-KGP4]

*Description:* Height ratio of cusp to denticles is not as significant as in *H. parvus*. At the posterior process, 5 to 7 denticles with roughly same size are separated by 'v'-shaped spaces. Height of denticles are arranged in gradually declining manner towards posterior, just like *Hindeodus typicalis*. *Hindeodus typicalis* however, possess at least 9 denticles at the posterior process. Since the last 2 denticles were broken, the signature 'u'-shape spaces between the last 2 denticles of *H. latidentatus latidentatus* could not be observed. The posterior margin slopes abruptly to posterior tip.

*Discussion:* Range from Late Permian to Early Triassic. Had never been recorded in Lipis district of Pahang, Peninsular Malaysia.

*Hindeodus latidentatus praeparvus* Kozur (1996)  
*Specimen:* Plate 1 Figure 4. [UKM-KGP6]

*Description:* Cusp is more than twice the height of denticles and has triangular shape. The cusp and denticles points slightly to the posterior. 5 to 7 denticles with very pointed tips are roughly the same size, arranged in an arched profile, with 'v'-shaped spaces in between denticles. Absence of small denticle at distal part shows that this specimen is still in juvenile phase.

*Discussion:* Ranges from Late Permian to Early Triassic period. This species was also found in Gua Sei by Metcalfe (1995).

Species *Hindeodus postparvus* Kozur (1989)  
*Specimen:* Plate 1 Figure 5. [UKM-KGP7]

*Description:* Cusp was broken off, however the base shows broad and large base of cusp. Denticles arranged in curving arcuate shape, different from *H. latidentatus* which are declining towards posterior. Denticles are thick, fused at basal part, and have blunt, chisel-like discrete tips.

*Discussion:* Appear during middle Early Triassic in Meishan. Had never been reported in Lipis district before.

Species *Hindeodus eurygge* Nicoll et al. (2002)  
*Specimen:* Plate 1 Figure 6. [UKM-KGP10]

*Description:* Cusp is large, broad, and thick. Tip of cusp is broken. Shallow and wide flare at the middle of the base. Denticles are stubby and roughly the same size. The tips of denticles appear chisel-like and blunt. Very small denticle at the distal end shows that the specimen is in adult phase.

*Discussion:* Exist during Late Permian to Early Triassic. Had never been recorded in Lipis district before.

Genus *Isarcicella* Kozur (1975)  
 Species *Isarcicella staeschi* Dai & Zhang (1989)  
*Specimen:* Plate 1 Figure 7 & 8. [UKM-KGP12 & UKM-KGP13]

*Description:* Asymmetric due to presence of wide and inflated cup at the side of posterior process. Single accessory denticle present at one side of the posterior process - at right side for Figure 7 and left side for Figure 8. Cusp is more than twice the height of denticles. Denticles are roughly the same size.

*Discussion:* Appear during Early Triassic. Had never been recorded in Lipis district before.

## DISCUSSION

Few Triassic conodont species found in limestone of Gua Panjang, Merapoh, show similarities with those found in limestone of Gua Sei, Kampung Gua, west of Kuala Lipis (Metcalf 1995). This includes *Hindeodus parvus* and *Hindeodus latidentatus*. In other parts of Pahang, younger conodonts of Triassic period were found in Kampung Awah (Anisian age) (Koike 1973), Cheroh (Dienerian age) (Metcalf 1990b), Merapoh (Smithian age) (Igo & Koike 1975) and Kuala Lipis - Gua Musang highway (Smithian age) (Metcalf 1992), while older Late Permian conodonts were found in Raub Gold Mine (Metcalf 1991).

Color of conodonts, whether yellow, brown, black, grey or white, is the result of depth of burial, timing of burial, geothermal gradient and temperature (Epstein et al. 1974). Increment of these factors result in darker color due to increase in organic material, which can be defined based on Conodont Alteration Index, CAI (Epstein et al. 1977). Conodonts found in Gua Panjang are black in colour and can be classified as scale 5 in CAI. This is consistent with the history of Lipis district which was affected by the heat from the Main Range granitoid during the Permian-Triassic Indosinian Orogeny. Scale 5 also means that the sediment at that location had been subjected to temperature of 300 - 450°C (Metcalf 2003). The explanation is supported by findings of other black-coloured, scale 5 conodonts in Pahang, such as in Gua Sei (Metcalf 1995), Raub (Metcalf 1991) and Cheroh (Metcalf 1990b).

In both Gua Panjang (Merapoh) and Gua Sei limestones, evidence have shown that the earliest Triassic conodonts were deposited in shallow marine environment. Gua Sei is dominated by oolitic limestone which was deposited in a closed shallow marine environment, possibly in lagoon (Metcalf 1995). In Gua Panjang, Triassic conodonts were found in bioclastic dolostone, 2.5 m above Permian bioclastic grainstone, which was preceded by several meters of moderately bedded deep marine to shelf limestone signified by presence of sponge spicules and crinoid fragments. This shows that the sea level is shallowing in Lipis area as time progresses from Permian to Triassic period.

The underlying Late Permian foraminifera bearing limestone of Gua Panjang is tuffaceous in nature, with

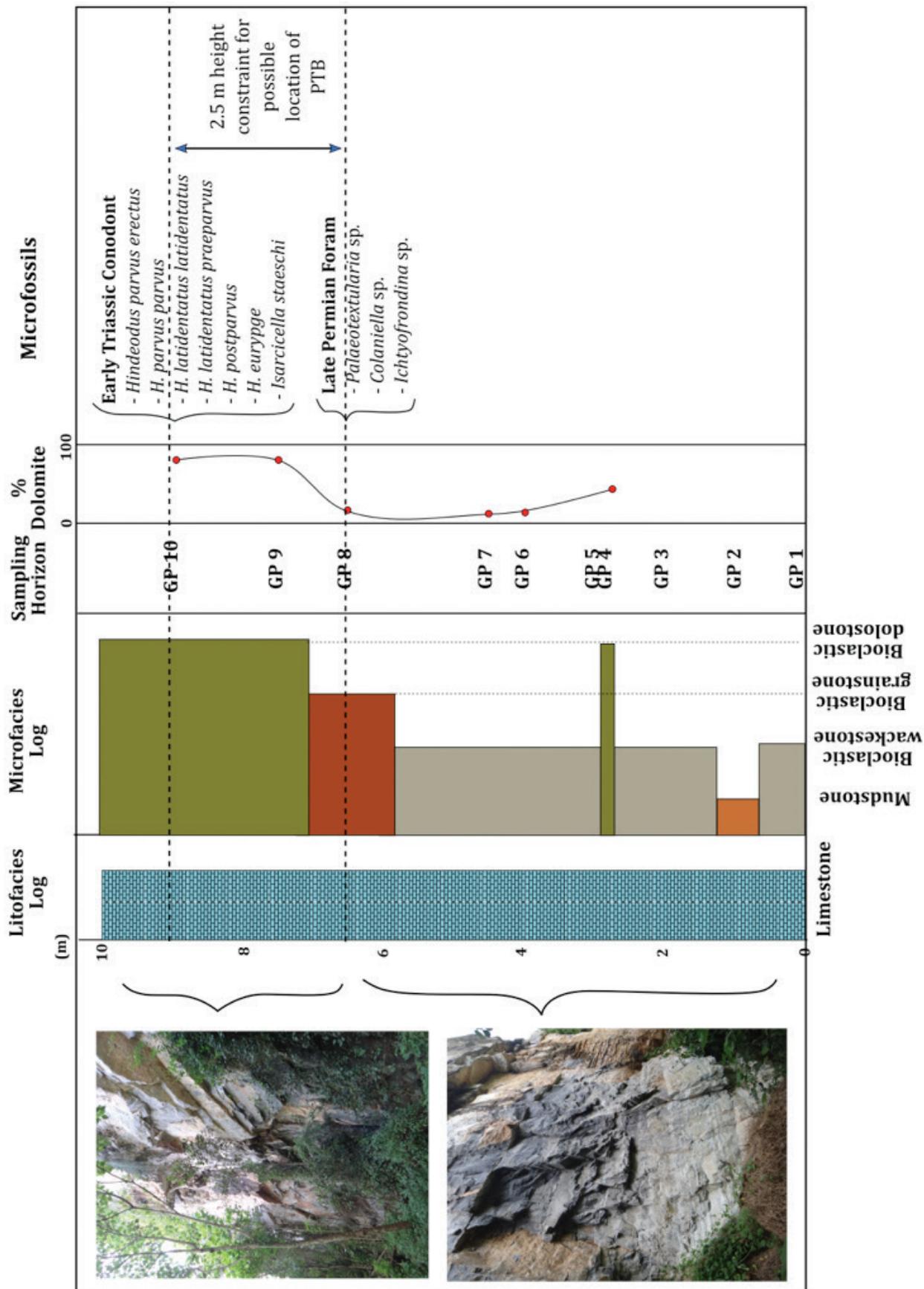


FIGURE 4. Location of conodonts in Log F of Gua Panjang, Merapoh. Earliest Triassic conodonts are located at the 9.0th m of Log F within bioclastic dolostone, which is 2.5 m above presence Late Permian foraminiferas within bioclastic grainstone

increasingly richer tuff in the underlying sequence of massive brachiopod rich tuffaceous shale (Mohd 1993). Similarly, the Gua Sei limestone is also underlain by thick to massive brachiopod rich tuffaceous shale (Mohd 1995, 1993). These volcanic activities might be one of the cause for the extinction of marine benthonic fauna, which happened gradually from as early as late Middle Permian to Late Permian in northwest Pahang (Campi et al. 2002; Mohd 1995, 1994). The latest Permian and earliest Triassic limestone at Merapoh and Gua Sei seems to be rather barren and lacked of fossils especially the benthonic fauna. Coincidentally, the sequence at the eastern cliff of Gua Panjang (Merapoh) shows that the volcanic material were significantly reduced across the PTB. However, up until now, there is no direct evidence that can be used to relate this mass extinction with volcanic activities in this region. In order to understand more about the extinction of the Permian, more detail research is needed to locate the exact location of Malaysia's first PTB within the 6.5 and 9.0 m horizon of this sequence.

#### CONCLUSION

5 species of Permian-Triassic conodonts were discovered in a single limestone sample at the 9<sup>th</sup> meter from the base of logged eastern section of Gua Panjang limestone hill, Merapoh. These are *Hindeodus parvus erectus*, *Hindeodus parvus parvus*, *Hindeodus latidentatus latidentatus*, *Hindeodus latidentatus praeparvus*, *Hindeodus postparvus*, *Hindeodus euryptge*, and *Isarcicella staeschi*. Further high-resolution sampling within 2.5 m below this sample (between height of 6.5 and 9.0 m) is crucial in order to define the first appearance datum of *Hindeodus parvus*. This will lead to the finding of the first confirmed Malaysian Permian-Triassic Boundary and enhance the understanding of Permian-Triassic Mass Extinction in Malaysia in the future. Additional sampling beyond 9.0 m horizon needs to be taken to define the Early Triassic conodont assemblage of Gua Panjang, Merapoh.

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- Nelisa Ameera Mohamed JoeHarry, Mohd Shafeea Leman\*, Che Aziz Ali & Kamal Roslan Mohamed  
Geology Programme  
Faculty of Science and Technology  
Universiti Kebangsaan Malaysia  
43600 UKM Bangi, Selangor Darul Ehsan  
Malaysia
- Mohd Shafeea Leman\*, Che Aziz Ali & Kamal Roslan Mohamed  
Institute for Environment and Development (LESTARI)  
Universiti Kebangsaan Malaysia  
43600 UKM Bangi, Selangor Darul Ehsan  
Malaysia

\*Corresponding author; email: 1mshafeea@gmail.com

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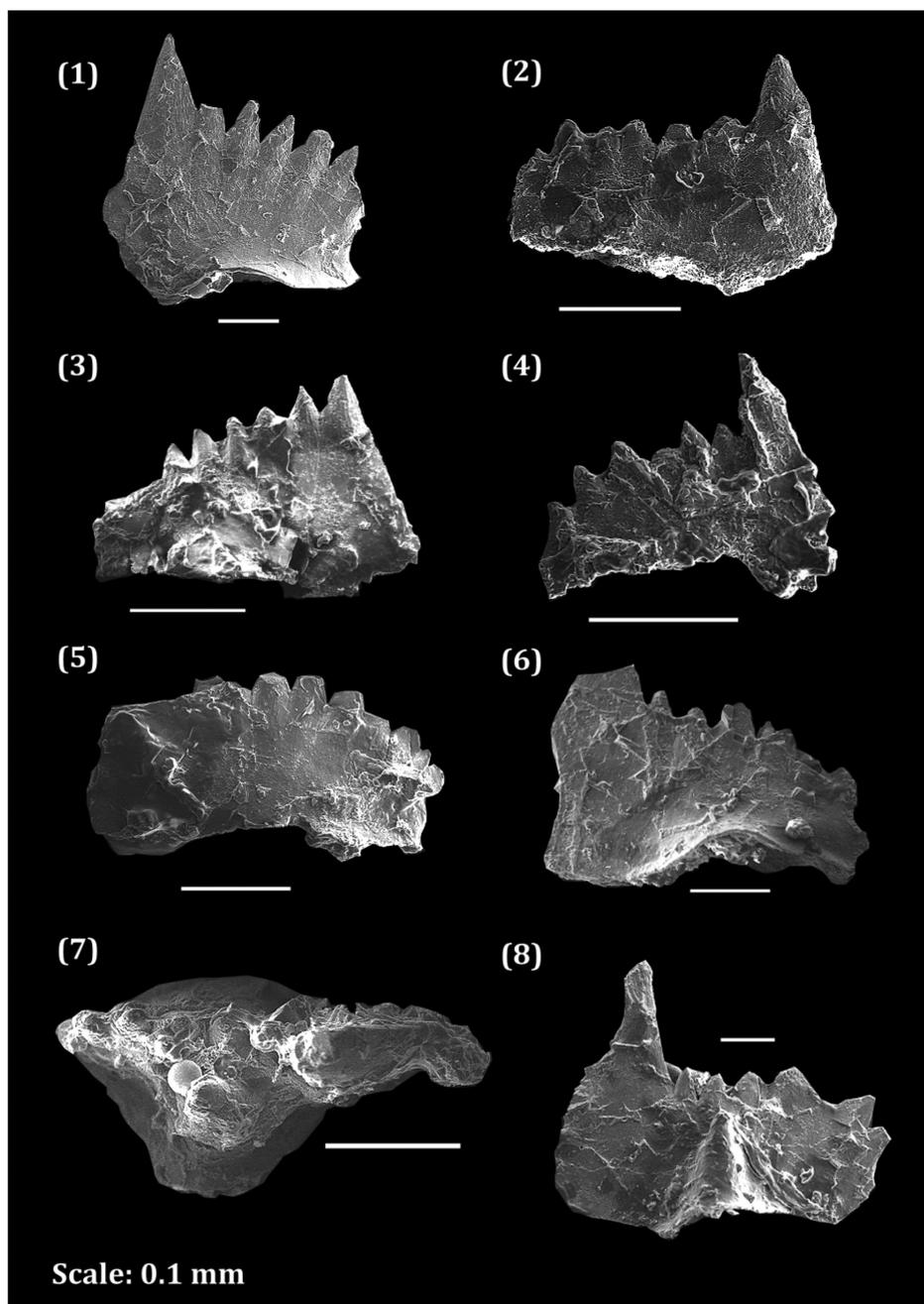


PLATE 1. Conodonts of Gua Panjang. 1. *Hindeodus parvus erectus* (lateral view); 2. *Hindeodus parvus parvus* (lateral view); 3. *Hindeodus latidentatus latidentatus* (lateral view); 4. *Hindeodus latidentatus praeparvus* (lateral view); 5. *Hindeodus postparvus* (lateral view); 6. *Hindeodus eurygge* (lateral view); 7 & 8. *Isarcicella staeschi* (top & lateral view)