Tracing the Provenance of the Devonian Limestone of Telen River, East Kalimantan

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INTRODUCTION

H. Witkamp found an outcrop with Devonian Limestone in East Kalimantan in 1925. In 1989, an expedition run by Institute of Technology Bandung (ITB) reinvestigated the outcrop and concluded that the Devonian Limestones in Telen River were boulders within a Permian formation (Arief et al., 1989). This paper gives a wider overview on the distribution of Devonian rocks in Asia Pacific region and discusses their possible origin.

Based on the distribution map of Devonian rocks in the region, the Devonian limestone in Borneo is very isolated. The closest Devonian limestones are about more than 2000 km away (Figure 1). Probably the Devonian limestone in Telen River has been separated away from its origin by significant tectonic movement. There are several theories and models related to the formation history of this area, which makes it very complex. To understand the origin of these limestones, the geology needs to be restored to their time and place of deposition of the Devonian limestone.

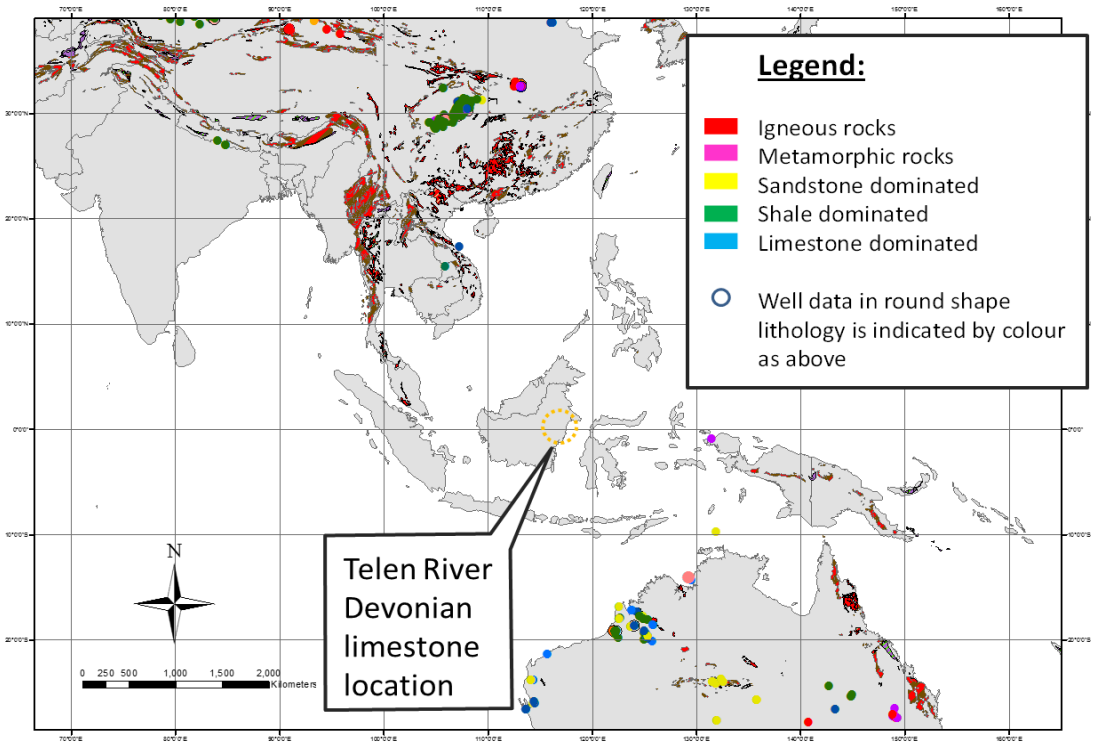


Figure 1: *Distribution map of Devonian Rocks in Asia-Pacific region, in the vicinity of Telen River, East Borneo (based on several sources e.g. IHS, Tellus etc.)*

DEVONIAN ROCK DISTRIBUTION IN ASIA PACIFIC

Currently, the majority of Devonian rocks are distributed between the Asian and Australian continent (Figure 1). A chain of Devonian igneous rocks was identified in the Himalaya region and runs through Myanmar and Thailand. There are other patches of Devonian igneous rocks in the southeast of China, north of the Hainan Island. A number of wells in mainland China encountered Devonian units which are dominated by shale. In northern Vietnam, there are Devonian sediments including limestone, sandstone, and shale as described by Thanh et al. (2013).

Devonian outcrops are scarce in the northwest part of Australia. They are a mix of different kind of sediments, such as sandstone, shale, and carbonate. In the south of the Papua mountain range, a chain of Devonian igneous rocks was identified. A well in the bird head of Papua penetrated a metamorphic basement which is interpreted as Devonian in age.

PALEO-SETTING DURING TIME OF DEPOSITION

To trace the source of Telen Devonian limestone, a tectonic restoration is required to understand the geologic setting back to the time of deposition. The conclusion taken from the Devonian Expedition 1989 is that the Devonian limestone are fragments which were deposited in a Permian clastic unit (Arief et al., 1989). Therefore, the Permian paleo-setting map is key for tracing back the origin of the Telen Devonian limestone fragments. Unfortunately, tectonic reconstruction for older stratigraphy, like Permian in this region, is particularly challenging due to limited data and complex tectonic processes. Metcalfe (2006) and Golonka et al. (2006), however, have published

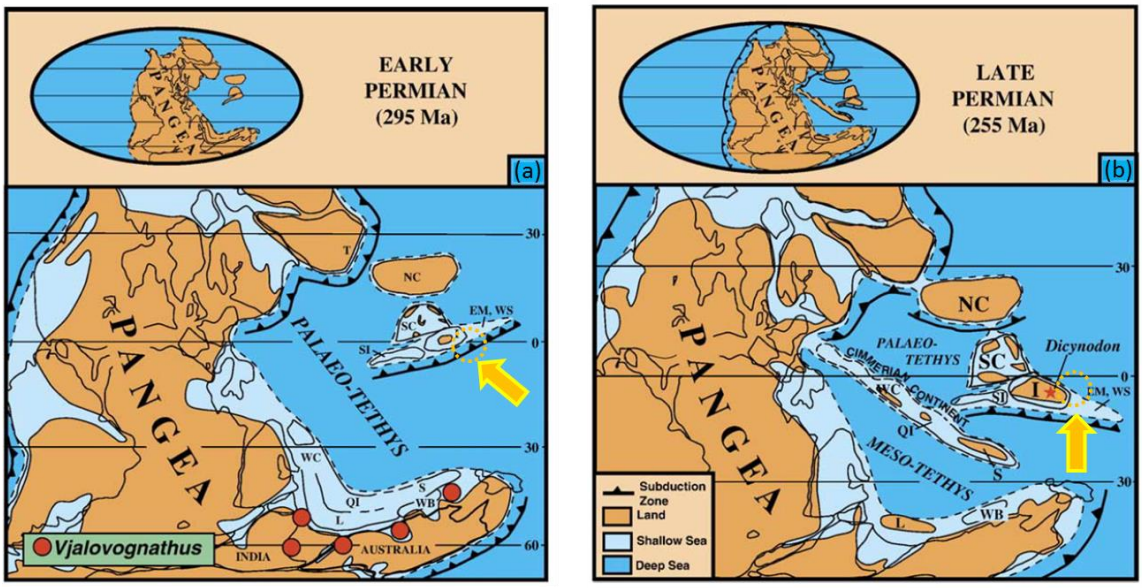


Figure 2: *Palaeogeographic reconstructions of the Tethyan region for (a) Early Permian and (b) Late Permian showing relative positions of the East and Southeast Asian terranes and distribution of land and sea. Also shown is the distribution of the Early Permian cold-water tolerant conodont Vjalovognathus, and the Late Permian Dicynodon locality on Indochina in the Late Permian.*

SC=South China; T=Tarim; I=Indochina; Em=East Malaya; WS=West Sumatra; NC=North China; SI=Simao; S=Sibumasu; WB=West Burma; QI=Qiangtang; L=Lhasa; WC=Western Cimmerian Continent (Metcalfe, 2006). The arrows indicate possible locations of the Telen Devonian limestone.

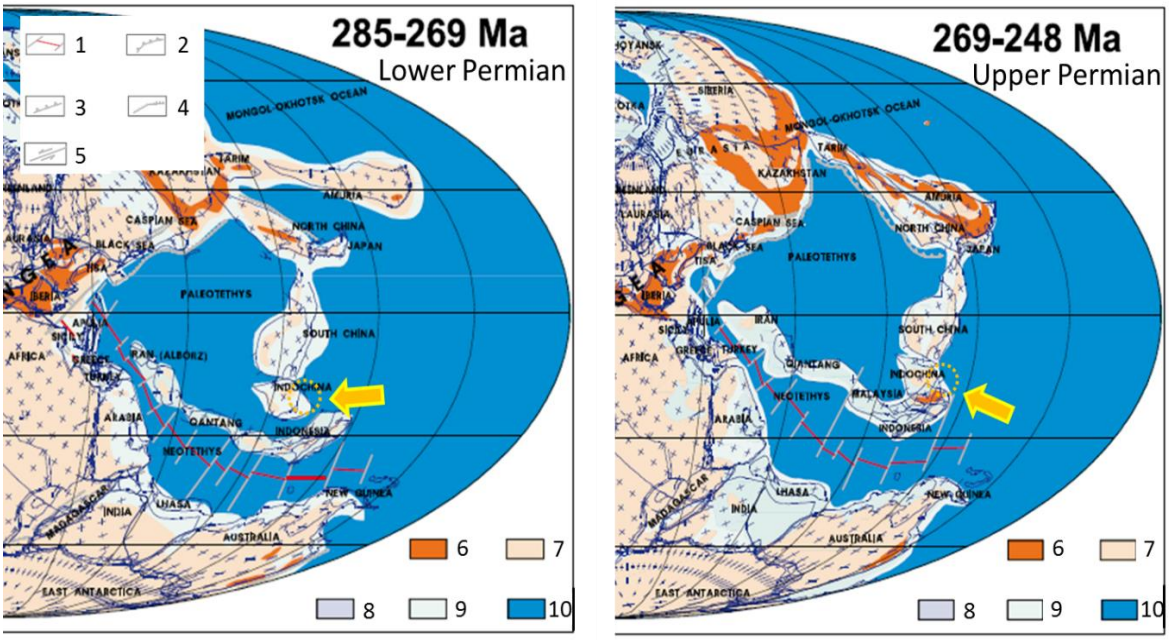


Figure 3: *Lower and Upper Permian tectonic map in Golonka et al. (2006). Legend: 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault, 6 – mountains, 7 – landmass, 8 – icesheet, 9 – shallow sea and slope, 10 – deep. Possible location of the Telen River Limestone is indicated by arrows.*

Permian paleogeographic maps which model the geological setting of the region (Figures 2 and 3). Although at present day, the Telen locality is located at almost equal distance between Asian and Australian continents, both models show that the paleo-position of Telen locality was closer to the Asian Continent. This is also supported by the present-day situation where the locality is relatively not far from Schwaner Mountain in southwest Borneo, which is known as part of the Sundaland, the southern extension of Asian Continent.

According to both Metcalfe (2006) and Golonka et al. (2006), Southeast Asian tectonic fragments e.g. Indochina and Sumatra fragments were separated

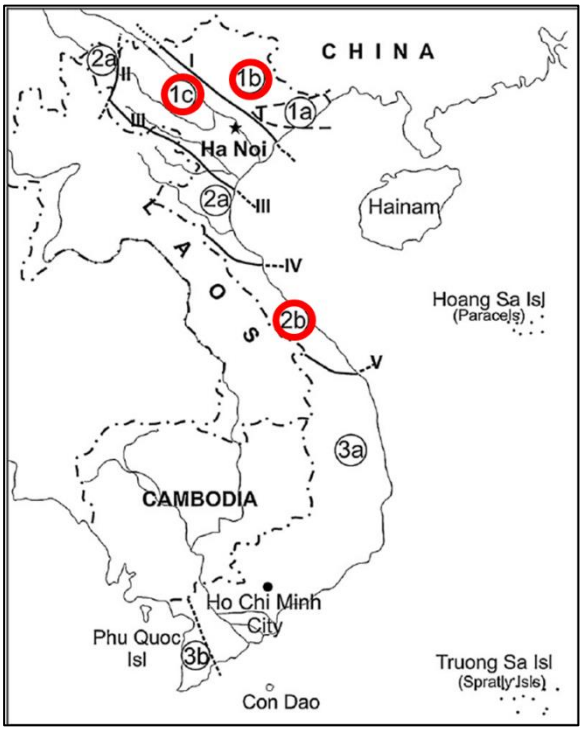


Figure 4: *Zonal distribution of the Silurian and Devonian deposits of Vietnam.*

1. Bac Bo Region: 1a. Quang Ninh Zone; 1b. East Bac Bo Zone; 1c. West Bac Bo Zone.

2. Viet-Lao Region: 2a. Dien Bien-Nghe An Zone; 2b. Binh Tri Thien Zone.

3. South Viet Nam Region: 3a. Trung Bo Zone; 3b. West Nam Bo Zone.

Regional and zonal boundaries: I. Song Chay Fault; II. Dien Bien-Lai Chau Fault; III. Song Ma Fault; IV. Rao Nay Fault; V. Tam Ky-Phuoc Son Fault.

Heliolites fossils are found in zones indicated with red circles.

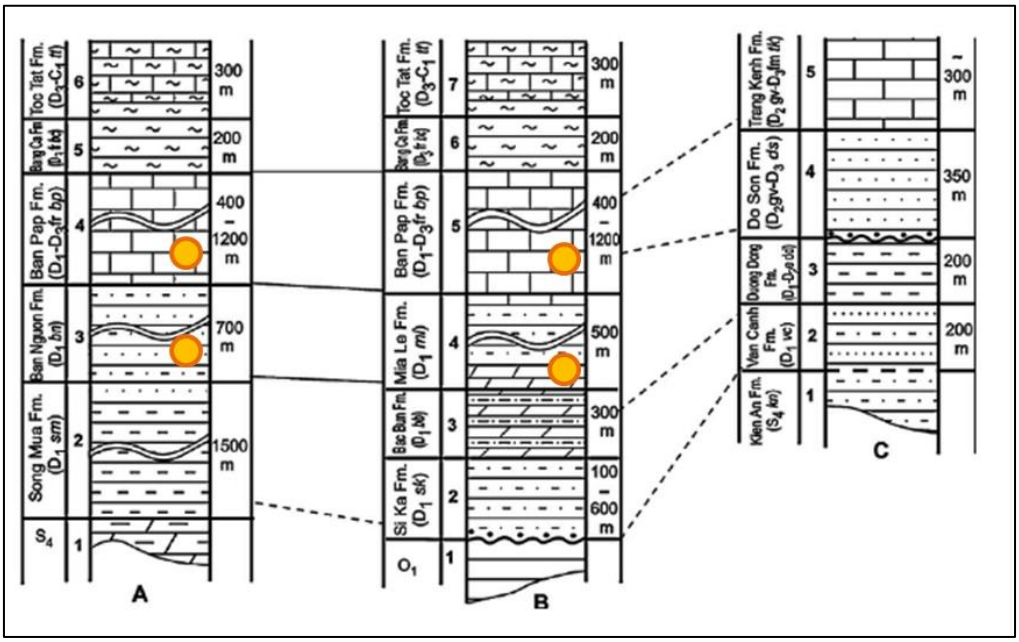


Figure 5: *Correlation of the Devonian deposits in the Bac Bo Region. (A) West Bac Bo Region, (B) East Bac Bo Region and (C) Quang Ninh Zone (Thanh et al., 2013). Yellow circles indicate where Heliolites fossils are found.*

from the Australian continent by ocean. During Permian time, the Australian continent was still part of Pangea. The possibility of the Telen Devonian limestone came from Australian continent is very limited.

POTENTIAL ORIGIN IN INDOCHINA

In the Asian Continent, the most probable source of the Devonian limestone in Telen outcrops are the Devonian formations in Northern Vietnam. These formations are Lower to Middle Devonian in age and Thanh et al. (2013) reported *Heliolites* corals within these formations. These fossils are similar to those in the Telen River as described by Rutten (1940). In their publication, Thanh et al. (2013) described the stratigraphy of the Devonian intervals in North Vietnam, which are located in Bac Bo and Viet-Lao Region (Figure 4). In these outcrops a number of *Heliolites* fossils in Devonian coral limestones were found.

In Bac Bo Region, northern Vietnam, Devonian rocks are common. Ban Pap Limestone formation range from 400 to 1200 meters occur in West and East Bac Bo region. This formation is Early to Late Devonian in age, contain Heliolithes fossils. These fossils are also found in the formation below Ban Pap. In West Bac Bo, *Heliolites vulgaris* were found in Ban Nguon Formation and in East Back Bo, *Helioites preaporosus* were found in Mia Le Formation. Both are Early Devonian in age (Figure 5).

In Viet Lao Region, the North of the Binh Tri Thien Zone has the thickest Devonian interval. *Heliolites ch H. insole* were found in Rao Chan Formation and *Heliolites porosus* were found in Ban Giang Formation. These formations are more clastic dominated and the corals are found as lenses within these formations.

CONCLUSION

Based on the paleogeographic reconstruction of Permian times when the Telen River Limestone fragments were trapped into a clastic unit, the outcrop was closer to Indochina compared to other

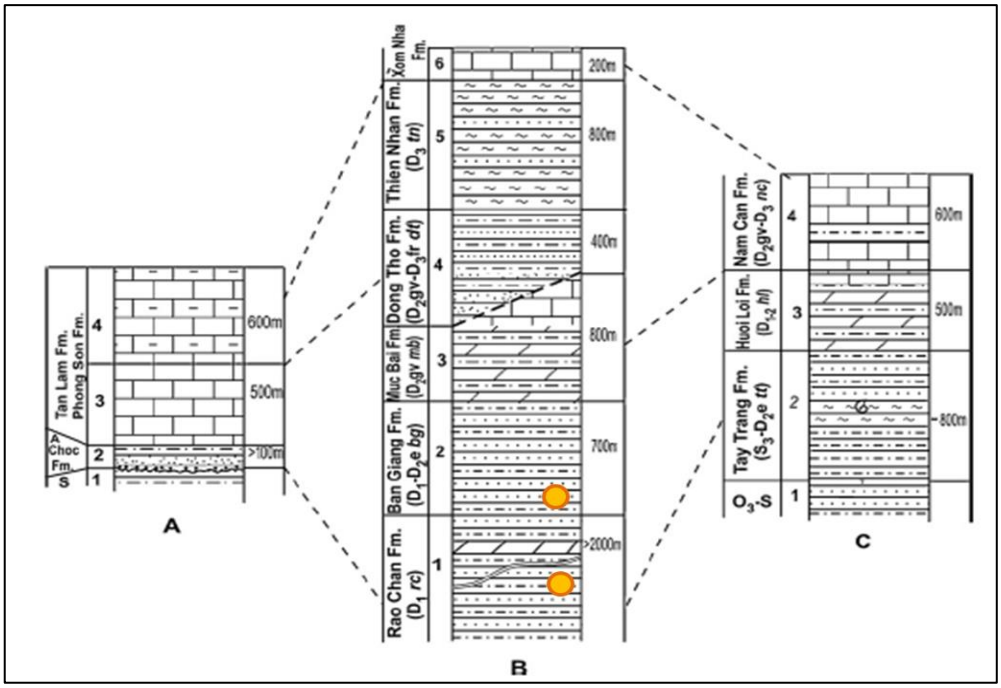


Figure 6: *Correlation of the Devonian deposits in the Viet-Lao Region. (A) South of Binh Tri Thien Zone, (B) North of the Binh Tri Thien Zone, (C) Dien Bien-Nghe An Zone. Yellow circles indicate where Heliolites fossils are found*

Devonian occurrences in Australia. Heliolites fossils, which are key indicators of the Devonian age, are common in the north of Vietnam. These observations conclude that the Devonian Limestone in Telen River could originate from the north of Vietnam. They were reworked and deposited within clastic units during Permian time.

The tectonic reconstruction, however, is very challenging and speculative. There are limited data points to support the reconstruction in this area. Most of the data came from Asia and Australian continent. Most of the tectonic models prepared for this area exclude Palaeozoic due to data limitation. New data, theory, and models will probably help to refine the reconstruction.

ACKNOWLEDGEMENTS

The author would like to thank Yusak Heryanto Setiawan and Tom Reijers for reviewing this paper. Their comments and suggestion are really appreciated.

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