



## Stratigraphy and palaeoenvironmental evolution of the mid- to upper Palaeozoic succession in Northwest Peninsular Malaysia



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### ABSTRACT

The stratigraphy of the Devonian to Permian succession in Northwest Peninsular Malaysia is revised. The Timah Tasoh Formation consists of black mudstone containing graptolites and tentaculitids indicating a Pragian or earliest Emsian age. The Sanai Limestone overlies the Timah Tasoh Formation at Sanai Hill B and contains conodonts indicating a Late Devonian (Frasnian to possibly early Famennian) age. In other places, Late Tournaisian chert of the Telaga Jatoh Formation overlies the Timah Tasoh Formation. The overlying Kubang Pasu Formation is predominantly composed of mudstone and sandstone, and can be divided into 3 subunits, from oldest to youngest: (1) Chepor Member; (2) Undifferentiated Kubang Pasu Formation; (3) Uppermost Kubang Pasu Formation. The ammonoid *Praedaraelites tuntungensis* sp. nov. is reported and described from the Chepor Member of Bukit Tuntung, Pauh. The genus indicates a Late Viséan age for part of the subunit. Dropstones and diamictites from the Chepor Member indicate a glacial marine depositional environment. The Carbo-Permian, undifferentiated Kubang Pasu Formation consists of similar interbedded mudstone and sandstone. The uppermost Kubang Pasu Formation of Kungurian age consists of coarsening upward cycles of clastics, representing a shallow marine, wave- and storm-influenced shoreline. The Permian Chuping Limestone also represents shallow marine, wave- and storm-influenced deposits. A Mid-Palaeozoic Unconformity separating Early–Late Devonian rocks from overlying Late Devonian–Carboniferous deposits probably marks initiation of rifting on Sibumasu, which eventually led to the separation of Sibumasu from Australian Gondwana during the late Sakmarian (Early Permian).

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## 1. Introduction

Northwest Peninsular Malaysia preserves a largely complete Palaeozoic succession, ranging from the Cambrian up to the Permian (Jones, 1981; Cocks et al., 2005; Meor and Lee, 2005; Lee, 2009) (Fig. 1). This paper focuses on the Devonian to Permian part of the succession. The best exposure is at a small hilly ridge (referred to as the Sanai Hills) in Kampung Guar Jentik, Perlis, which comprises Silurian, Devonian and Carboniferous rocks (Meor and Lee, 2002, 2005) (Fig. 2). Continuous quarrying of the hill, and also further south at Hutani Aji, has resulted in a progressive increase in data and understanding of the stratigraphy. A new exposure further east in Pauh, has also been recently reported, which preserves another Devonian–Carboniferous succession, in this case, represented by Mahang Formation slate being overlain by Mississippian, radiolarian-bearing chert and siliciclastics of the Chepor Member, Kubang

Pasu Formation (Basir et al., 2010). This paper aims to: (1) highlight the numerous stratigraphic, sedimentological and palaeontological discoveries made in the last four years since the last review (Lee, 2009); (2) provide a revised stratigraphy of the Devonian–Carboniferous succession in Northwest Peninsular Malaysia, and; (3) synthesise a depositional history of the mid- to upper Palaeozoic, Northwest Peninsular Malaysia succession, which represents part of the Gondwana-derived terrane of Sibumasu (Metcalf, 2011a, 2013a,b).

## 2. Development of the stratigraphic nomenclature

The early history of the stratigraphic nomenclature of the Palaeozoic succession of Northwest Peninsular Malaysia has been thoroughly documented in Meor and Lee (2005) and Lee (2009), and is therefore discussed only briefly here. Jones (1966, 1981) divided the Palaeozoic rocks of Langkawi, Perlis and Kedah into several lithostratigraphic units, from oldest to youngest: (1) the Cambrian Machinchang Formation; (2) the Ordovician to Early Devonian

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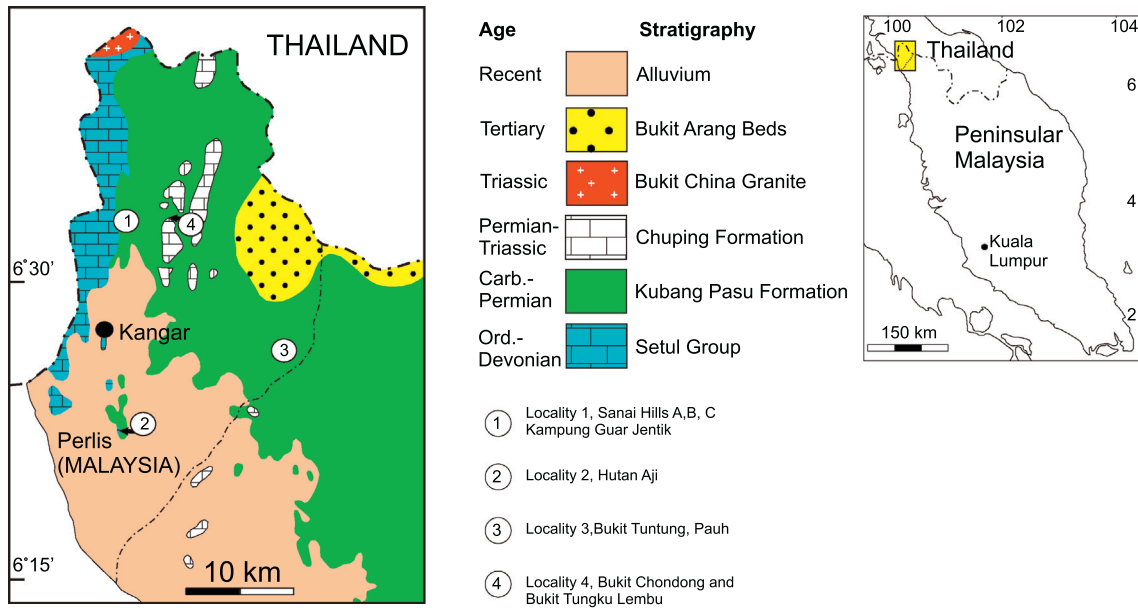


Fig. 1. Map of Northwest Peninsular Malaysia showing the main stratigraphic units and localities mentioned in this study.

Setul Formation; (3) the Late Devonian–Permian Singa Formation, exposed on Langkawi and its lateral equivalent on the mainland, i.e. the Kubang Pasu Formation, and (3) the Permian Chuping Limestone.

An unconformity was proposed between the Setul and Singa/Kubang Pasu formations, based on angular strike relations and the interpretation of the basal red pebbly beds of the Singa/Kubang Pasu formations as evidence of uplift (Jones, 1981). However, this was not universally accepted, especially since there was no observable unconformity exposed anywhere (Ahmad bin Jantan, 1973; Yancey, 1975).

A second wave of studies prompted further revision to the stratigraphy (Meor and Lee, 2002, 2005; Cocks et al., 2005). This was mainly triggered by the then new exposure of the Sanai Hills in Kampung Guar Jentik, Perlis and also by more detailed work on the older outcrops on Pulau Langgun, Langkawi. Finer scale stratigraphic relationships were identified. The Setul Formation was further divided, with its previous members upgraded to formation rank. The Setul Formation was divided into: (1) Kaki Bukit Limestone (Ordovician); (2) Tanjong Dendang Formation (Ordovician–Silurian); (3) Mempelam Limestone (Silurian), and; (4) Timah Tasoh Formation (Early Devonian). Meor and Lee (2005) attempted a division of the lower Kubang Pasu Formation into smaller formations based on biostratigraphy: the Late Devonian Chepor and Mississippian Binjal and Wang Kelian formations in Perlis and the Langgun Red Beds in Langkawi. A Late Devonian limestone was also recognised in Perlis, based on conodonts (the Sanai Limestone of Meor and Lee, 2003, 2005), overlying the Chepor Formation at Sanai Hill B. Tournaisian chert beds (Basir, 1995; Basir and Zaiton, 2001), were given the name Telaga Jatoh Formation (Meor and Lee, 2005). Red mudstone beds of supposed Viséan age were named the Wang Kelian Formation, which was then overlain by diamictites and pebbly mudstone of the Kubang Pasu and Singa formations.

Continued excavation of the northern face of Sanai Hill B in Perlis led to further confusion regarding the stratigraphy. Ong and Basir (2007) refuted the presence of a Late Devonian Sanai Limestone and interpreted the Sanai Limestone as the top part of the Silurian Mempelam Limestone. This is based on the stratigraphic position of their observed limestone underlying dacryoconarid and monograptid-bearing mudstone of the Timah Tasoh Formation.

It was further recognised that many of the stratigraphic units in the Sanai Hills were separated by thrust faults, and there were numerous repeated sections (Lee, 2009). The thrust faults are part of a fold-and-thrust belt that has been interpreted as the product of Late Triassic collision between Sibumasu and East Malaya/Indochina blocks (Barber and Crow, 2009; Ridd, 2013). Lee (2009) provided another revised stratigraphy. The suggested absence of a Late Devonian Sanai Limestone led Lee (2009) to combine the separated Chepor, Binjal and Wang Kelian formations into a single unit: the Chepor Formation (Fig. 3). Lee (2009) also introduced the term Setul Group, which encompasses the Ordovician Kaki Bukit Limestone, the Ordovician–Silurian Tanjong Dendang Formation and the Silurian Mempelam Limestone (Fig. 1).

In an attempt to resolve the confusion, Meor et al. (2013a) further modified the stratigraphic nomenclature. The Silurian and Early Devonian nomenclature remained unchanged. The Sanai Limestone was discarded. However, the Chepor Formation was reabsorbed into the Kubang Pasu Formation, based on the presence of pebbly sandstone in the Chepor Formation, which may be related to the glacial-marine dropstones of the Singa and Kubang Pasu formations (Stauffer and Lee, 1986).

The problem of the Devonian–Carboniferous succession of Northwest Peninsular Malaysia is still far from being resolved, with new data still coming out from rocks of Sanai Hill B, and also from new exposures further east (e.g. Basir et al., 2010). This paper provides an updated understanding of the stratigraphic succession (Fig. 3).

### 3. Study location and methods

This paper mainly focuses on the section exposed at Sanai Hill B, Kampung Guar Jentik, Perlis, which is part of an excavated hilly ridge trending north–south along the R121 road linking Kangar and Kaki Bukit, just south of the Timah-Tasoh Dam (Fig. 2A). Also, additional new information is provided from exposures in Hutan Aji, 5 km south of Kangar (Fig. 2C), and a new outcrop at Bukit Tuntung, Pauh, about 15 km east of Kangar (Basir et al., 2010). Detailed geological mapping was conducted on the northern face of Sanai Hill B. Fossils were collected from the localities to help in determining age and stratigraphic position. Selected well exposed sections were logged and studied in detail, using a facies analysis

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