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THE UPPER PALAEOZOIC PEBBLY ROCKS IN SOUTHERN THAILAND

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ABSTRACT

The pebbly rocks in Thailand have been found widely distributed in the marine Kaeng Krachan Formation. Stratigraphically, the Kaeng Krachan Formation can be correlated to the Mergui Series and the Singa Formation of Burma and Malaysia respectively. They are typically exposed along the western part of the Thai Peninsula. The formation consists mainly of pebbly mudstones, laminated mudstones and turbidites. Being a significant features of the formation, the laminated mudstone is characterized by showing well-developed fine lamination with numerous scattered clasts which vary from pebble to boulder size. The composition of the clasts includes quartzite, limestone, granite and possible gneissic granite. In some localities they show an alternation of very fine grained layers and relatively coarser grained, poorly sorted layers with a number of clasts that show dropstone-like structure. The pebbly mudstones found associated with the laminated mustone is petrographically characterized by being poorly sorted and containing clasts of granite, possible gneissic granite, slate, quartzite and limestone. Stratification is usually absent or indistinct in the pebbly mudstone, but is well-defined at Ko Pi Pi, south of Phuket Island. The size of clasts varies from pebble to boulder and the shape of the clasts ranges from subangular to well rounded. The number of subangular clasts is greater than that of subrounded and well rounded types. A few well polished and facetted cobbles have been collected. This pebbly mudstone is much like the rocks described as diamictite which are found in the Gondwana System in Australia, S. Africa, Brazil, Antarctica and India.

Turbidites in the Kaeng Krachan Formation clearly show load casts, graded bedding and slump structures. The formation is conformably overlain by the Permian Ratburi Limestone and contains bryozoan and brachiopod fossils of

lower Permian age near the top and some brachiopods considered to be upper Carboniferous age in the lower part. However, the base of the formation is still not known. These pebbly rocks are obviously of marine origin, and on the basis of the stratigraphy range from upper Carboniferous to lower Permian.

In this paper the stratigraphy of various localities where the pebbly rocks have been found such as Kaeng Krachan, Takua Pa, Phang Nga, Ko Yao Noi, Krabi and Phuket Island are briefly discussed. In the light of the field evidence, stratigraphy and petrographical data, three major origins of the pebbly rocks in southern Thailand are feasible: (1) Turbidity current and slump deposits: (2) Ice rafted deposits: and (3) Tillite deposits. If they are glaciogenic, the glacial marine environment, particularly the distal glacial marine environment including the continental shelf and slope, would have played an important role in their deposition.

INTRODUCTION

The Kaeng Krachan Group/or the Phuket Group/or in the text the Andaman Group is widely exposed on Phuket Island and neighbouring parts of the mainland in south Thailand. The type locality is along the western coast of the Phuket Island and Phang Nga (Mantajit, 1979). Pebbly mudstones possibly assignable to this formation have been reported as far north as 15^{0}N lat. near the Burmese border (Koch, 1973). This sequence can be correlated to the Singa Formation of Malaysia and the Mergui Series of Burma. The same sequence have been stratigraphically defined as Kaeng Krachan Group by Piyasin (1975) from the area of Kaeng Krachan damsite and also have been defined by Mitchell et al., (1970) as Phuket Group from the area of Phuket. However, the present authors feel that the rocks of Kaeng Krachan Group are not applicable to those of southern Thailand. Similarly, the Phuket Group that was defined by Mitchell et al. (1970) do not show any stratigraphcial order, and bryozoan bed are not applicable as there are more than one bryozoan horizon. Thus the term Andaman Group has been introduced (Mantajit, 1979).

Considering this group of related units as a whole, its outcrop has a maximum N-S length of about 1,800 km and a maximum width of about 180 km in the Mergui-Phetchaburi region.

This paper is aimed at description of pebbly mudstone found in Southern Thailand.

STRUCTURAL FRAMEWORK AND STRATIGRAPHIC SETTING

These tilloid-bearing units occur within an orogenic belt extending from the southern Malay Peninsula northward at least into southwest China and sometimes referred to as the "Yunnan-Malay Geosyncline". The tilloids are associated with the 'miogeosynclinal' in which the sediments are dominantly of shallow-water marine origin and in which deformation is only moderate, characterized by open folding and some thrust faults. The tilloid-bearing units

have generally suffered only very slight metamorphism, shown as a weak cleavage.

Exposures of gneissic rocks thought to represent a Precambrian cratonic basement are known in northwest Thailand and Burma. The sedimentary sequence in the belt generally starts with Cambrian quartzose sandstones and extends through the entire Paleozoic and into the Triassic, rarely Jurassic. Orogenic deformation occurred mainly in late Triassic.

LITHOSTRATIGRAPHIC DESCRIPTION OF PEBBLY MUDSTONE UNITS

Detailed stratigraphy and character of these pebbly mudstone-bearing units are in general poorly known because of their poor exposure, paucity of fossils and primary sedimentary structures and monotonous appearance. Characteristically, however, they are poorly sorted, muddy, dark grey clastic sediments, poorly bedded to vaguely laminated in the portions containing megaclasts.

The best-know section is undoubtedly at the Andaman Group type location on Phuket Islands of southern Thailand. This section was studied in detail by Mantajit (1979) and the following description and the section appearing as Fig 1. are based largely on this work. The pebbly mudstone sequence is comformably overlain by the fossiliferous Permian limestones.

It is due to the fact that there were different lithofacies for each sequence in the Andaman Group, so it can be found that the sequence of Kaeng Krachan is different from the sequence of Phuket. Similarly, in the Phuket and Krabi areas, the pebbly mudstone sequences are different from each other in both palaeontology and lithology. Thus the Andaman Group can be classified into two distinct formations namely Phuket Formation and Ko Yao Noi Formation.

Figures 1 and 2 show stratigraphic sequence of Phuket and Ko Yao Noi Formations respectively (after Mantajit, 1979).

The pebbly mudstones are generally structureless in most places, but in Ko Pi Pi, stratification is well defined. Near the top of the Andaman Group in southern Thailand there is a highly fossiliferous interval known as the Bryozoan Bed.

BOUNDARY RELATIONS OF TILLOID-BEARING UNITS

The Singa Formation appears to be conformable with both the underlying and overlying units, and is also comformable internally, although soft sediment deformation structures, sometimes on a scale of tens of metres, involve local truncations and "unconformities". No basal contact is known of the Andaman Group, which is still thought by some to extend down to early Peleozoic, even Cambrian (Garson, et al., 1975). But these Thai units appear to be conformably overlain by the Ratburi Limestone, a Permian unit. However,

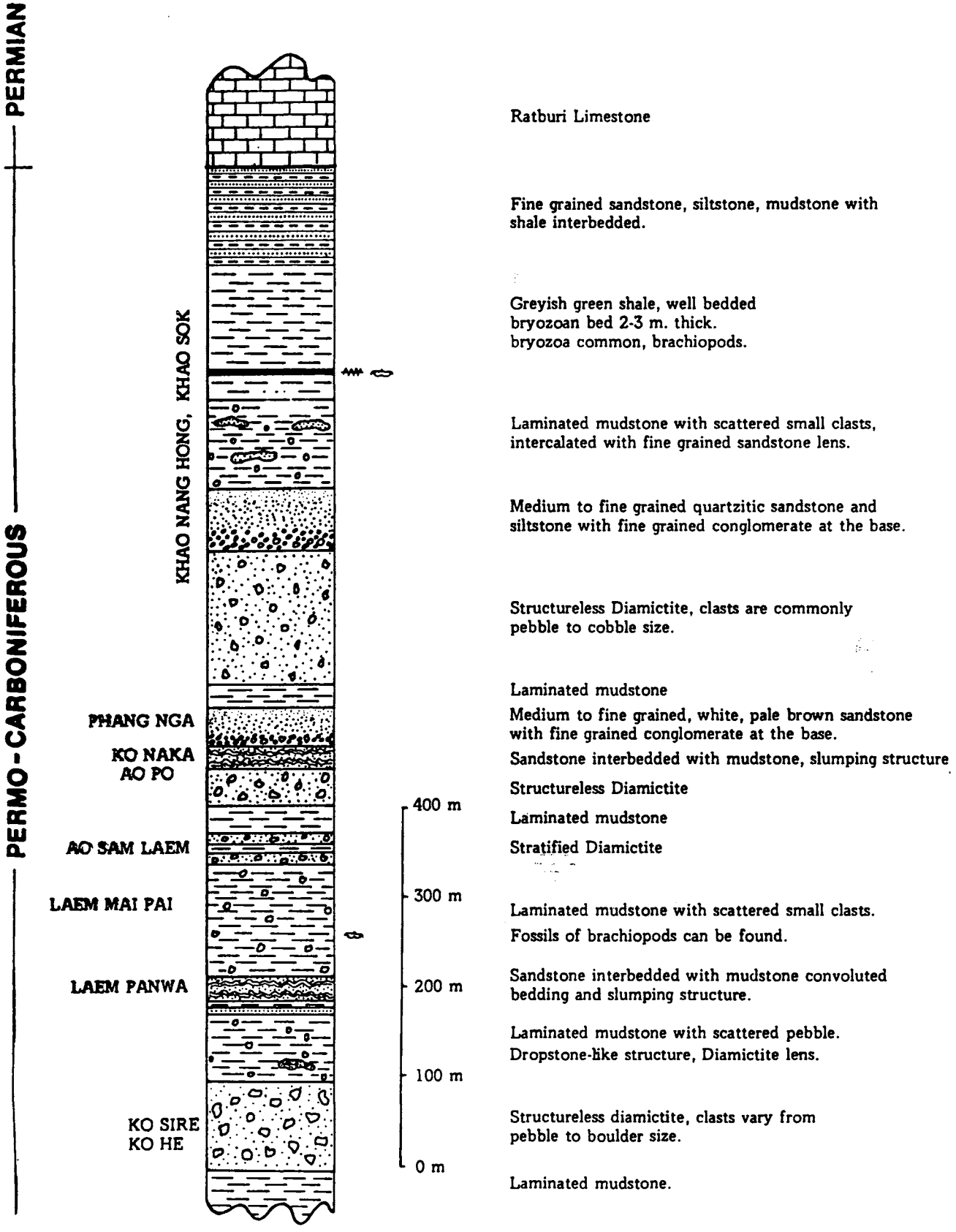

Figure 1 Stratigraphic Sequence of Phuket Formation

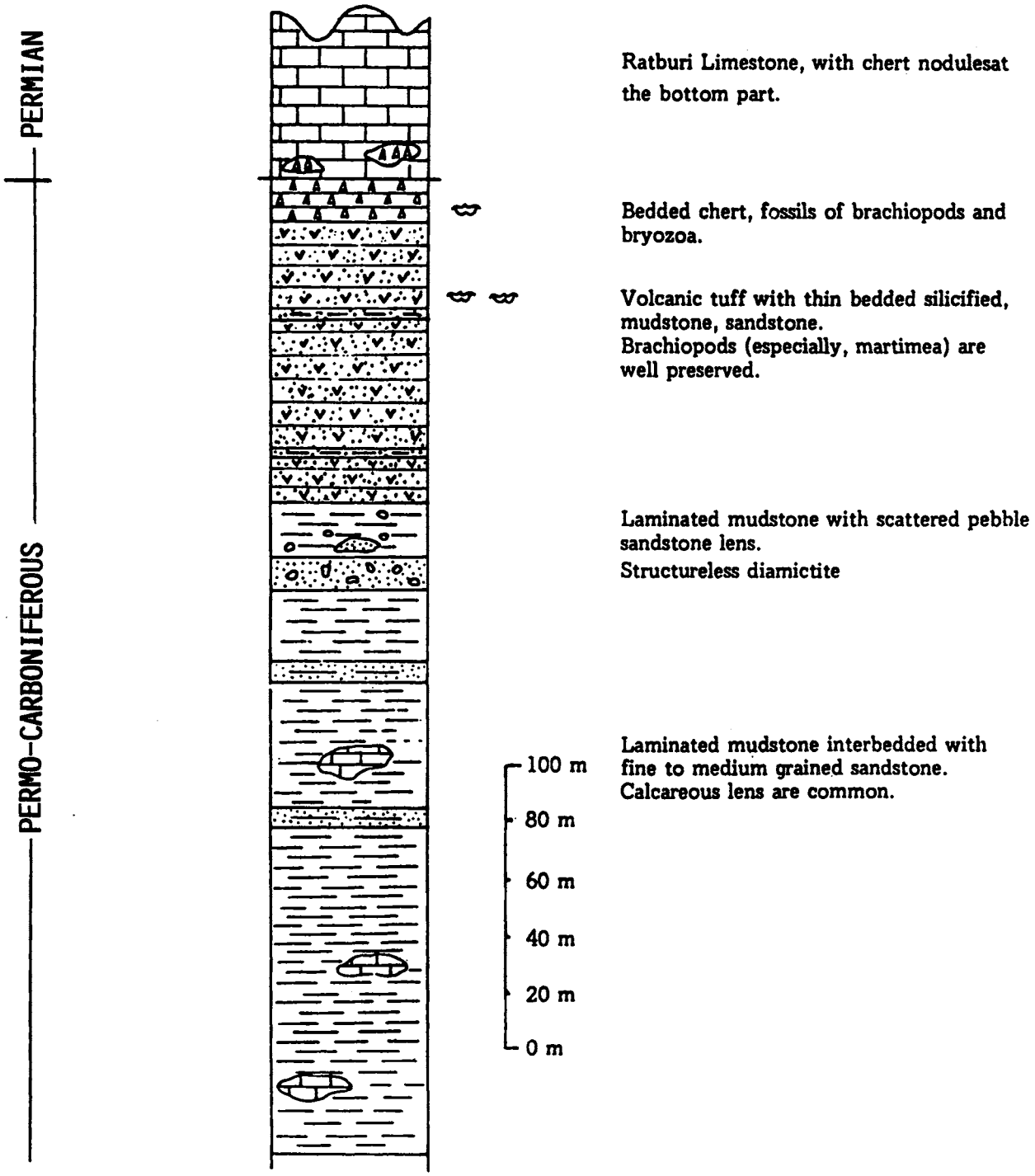

Figure 2 Stratigraphic Sequence of Ko Yao Noi Formation

according to the recent survey, it is believed that the thickness of the sequence is not exceeded 3,000 m as suggested by Garson et al., (1975) and the oldest horizon is in the Carboniferous period.

DISCUSSIONS

In general the tilloids in this belt of occurrences are poorly bedded. The common and characteristic flaky weathering is caused by a weak cleavage probably metamorphic in origin. A planar but quite vague lamination is seen in some places, and there the isolated megaclasts are strongly indicative of the dropstones. In other places vague remnants of bedding or lamination can be seen showing strong soft-sediment deformation suggestive of chaotic slumps. Sediments interbedded with the pebbly mudstones are generally better bedded, especially in the upper Phuket Formation and intervals of sharply interbedded fine and coarse clastics are on a scale of a few cm (suggestive of turbidite sequences) in the Phuket Formation. These are clearly shown at Laem Pan Wa, Phuket Island.

Primary sedimentary structures, other than the bedding types noted above, are almost characteristically absent in the tilloids of this belt. Many of the pebbly mudstone intervals are almost completely structureless, the only definite structure being the megaclasts themselves. Elsewhere the megaclasts occur in laminated sequences where they may fairly be called dropstones.

Interbedded sediments associated with the tilloids show more structures. Slump structures and organic burrows are reasonably common, especially in the Ko Sire Unit, and ripple cross-lamination occurs more rarely. Flame structures and isolated sand lenses occur in the interbedded sandstone/mudstone portions of the unit.

Parts of the Andaman Group are reported to show locally abundant slump structures and organic burrows, with less common ripple cross lamination. The sharply intebedded intervals in the Phuket Group which have been described as turbidites show graded bedding, convolute lamination, flute molds and load structures.

No glacially modified surfaces such as boulder pavements and striated bedrock, are known to underlie any of the tilloids in this belt.

DESCRIPTION OF STONES

Abundance:

Megaclasts occur generally scattered in the tilloid intervals, with abundances ranging from very low (single stones in otherwise barren exposures of considerable size) to only moderate (small pebbles locally to perhaps 100/m^2;

larger stones always much rarer). Size analysis of a sample of pebbly mudstone showed about 9% by volume of clasts larger than 2 mm (2/3 of that consisted of pebbles 5-10 cm) while about 21% was sand and 70% silt and clay sizes.

Sizes:

Most of the megaclasts in these units are small pebbles less than 1 cm in size, but in some localities boulders and cobbles are present. Stones of 5-15 cm are not rare in the Andaman Group. The largest megaclasts reare granites measuring over 1 m in the Phuket Island, Ko Pa Yam in Ranong province.

Composition:

The most common type of stone is generally called quartzite, but these are at least in some cases merely well-cemented quartz sandstones. Subordinate are grey limestone, sometimes with poorly preserved shelly fossils, vein quartz, and acid plutonic rocks including biotite-granite and trondhjemite. Rarely reported are megaclasts of shale, mudstone, chert, biotite-gneiss, and diorite.

The trondhjemite boulder in the Singa Formation yielded a Precambrian K/Ar age (Stauffer & Snelling, 1977).

Shape:

The shape of clasts generally ranges from subangular to sub rounded type. Some of boulders investigated are very angular. The member of subangular type is greater than that of subrounded. Facetted clasts have been collected. Laminated quartzite and some granitic clasts show the highest degree of angularity. It would be noted here that striations in the clasts are not clear.

Orientation of stones:

The stones seem to be generally unoriented. An apparent alignment of long axes of pebbles at some localities in the Andaman Group was attributed to the effects of the rock cleavage by Garson, et al., (1975, p. 12).

OTHER CHARACTERISTICS OF THE TILLOID UNITS

The matrix of the tilloids under discussion is generally a dark grey to almost black sandy mudstone, very poorly sorted even disregarding the scattered megaclasts. It contains varying amounts of sandy materials and locally verges on being a muddy sandstone. Some exposures show a flat lamination or layering not sharply marked, while others are structureless apart from occasional wisps of deformed bedding suggestive of slumping.

There is usually a definite though somewhat weak cleavage expressed by 'flaky' weathering and, where the relationship can be determined, subparallel to the bedding.

AGE

The Phuket Group in south Thailand is similarly overlain by the Ratburi Limestone with definitely Permian and probably Artinskian to Kungurian faunas (Garson, et al., 1975). About 100-200 m below the base of the Ratburi Limestone, but above the highest pebbly mudstone (tilloid) horizon, is a 5 m fossiliferous horizon known as the Bryozoan Bed which contains a Lower Permian fauna (Young & Jantaranipa, 1970).

In summary, it would appear that the tilloid horizons in this belt may span essentially the whole of the Carboniferous.

INTERPRETATION OF ORIGIN AND PALAEOENVIRONMENT

No definite interpretation of the tilloids or pebbly mudstones in this belt can yet be made. They are certainly not tillites, and the rare fossils in them and in interbedded facies show that the depositional environment was marine. But beyond this one cay only say that they may be simply slope deposits resedimented by mass flow, or glacio-marine deposits with dropstones. The abundant slump structures and associated sequences suggestive of turbidites, as in the Phuket area, would support a mass flow origin. On the other hand, the extremely wide spectrum of grain sizes and the presence of megaclasts in laminated, unslumped sequences support a glaciomarine origin. The variety and abundance of trace fossils, which include long straight burrows cutting through slump-folded laminae, argue for relatively shallow water and very early soft sediment deformation, and may be more consistent with a glacially-influenced origin.

The paleogeography of the basin of deposition is still doubtful. Garson, et al., (1975) inferred a westward gradation from shallow to deeper.

INTERPRETATION OF PALEOCLIMATES

The rich faunas of the Permian calcareous rocks overlying the tilloid-bearing units in Malaya and Thailand have generally been interpreted to indicate warm-water conditions. Permian floras in the region also support a tropical environment.

There is no direct evidence of paleoclimate for the times of deposition of the pebbly mudstones. However, the relative abundance of carbonates is much lower in the Carboniferous (and Devonian) than in either the overlying Pormian or the underlying Ordorician-Silurian, which may at least suggest less tropical conditions.

It would be noted that feldspar in the granitic clasts are generally fresh, so the clasts might have been deposited in rather arid zone or rather cold climate.

CONCLUSION

In conclusion, according to the field evidence, stratigraphy and petrographical data, three major origins of the pebbly rocks/diamictites in southern Thailand are feasible:

1. Turbidity current and slump deposits
2. Ice rafted deposits and
3. Tillite deposits

If they are glacionic, the glacial marine environment, particularly the distal glacial marine environment including the continental shelf and slope would have played an important role in their depositions.

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