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STRATIGRAPHY OF THE TARUTAO AND MACHINCHANG FORMATIONS

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ABSTRACT The Cambro-Ordovician Tarutao and Machinchang Formations each consists of about 3000 m of predominantly clastic deposits which are part of the miogeosynclinal shelf sediments of the southern Yunnan-Malayan Geosyncline. These two equivalent formations have no known base and each can be differentiated into three members (ie. lower, middle and upper) with the middle member further subdivided into three submembers.

The lower member (450 m+ in Tarutao; 1620m+in Langkawi) is a coarsening upward sequence of rhythmically interlayered graded siltstones and mudstones interbedded with thicker bedded clayey sandstones. Rare cross-bedding, small load structures, ripple marks, slumped bedding and small burrows are found in this member. This member is interpreted to be an offshore shelf deposit affected by occasional storms.

The middle member consists of abundantly cross-bedded, medium to thick beds of coarse to fine sandstones, conglomerates and rare coarse acid tuffs and fine heavy mineral bands in its lower submember (500 m+ in Tarutao; 575 m in Langkawi) which is interpreted as estuarine channel lag deposits cutting upper shoreface deposits. The middle submember (700 m+ in Tarutao; 340 m in Langkawi) is of thin to medium, wavy-bedded, fine to medium grained cross-bedded sandstones with occasional pebbly, argillaceous and fine tuffaceous intercalations. It is interpreted as an upper estuarine facies. The upper submember (750 m in Tarutao; 700 m+ in Langkawi) is of fine to very fine grained, thick straight-bedded sandstones with thin to thick intervals of very fine acid tuffs and is increasingly argillaceous upsection. The sandstones are usually parallel laminated or low angle planar cross-bedded with occasional heavy mineral and fragmentary trilobite and brachiopod fossil bands. This submember is interpreted as upper shore face to beach deposits belonging to a series of barrier-beach complexes.

The upper member (575 m in Tarutao; 420 m in Langkawi) is a fining upward sequence of siltstone, mudstone (some tuffaceous) and very fine sandstone with minor thin limestone intercalations. Trilobite and brachiopod fossils of Uppermost Cambrian to Lowermost Ordovician age and various types of shallow-marine trace fossils are present in this member. It is interpreted as an open back-barrier lagoon deposit. It grades upwards into the shelf limestones of the Setul and Thung Song Formations.

The overall interpretation of the facies sequence is that of a high-destructive, wave-dominated delta which had built over an offshore shelf deposit to produce a series of barrier-beach sands aligned parallel to the shore line with subdued channel sands cutting across them.

INTRODUCTION

The Cambro-Ordovician sediments of the equivalent Tarutao and Machinchang Formations are exposed in the western part of Ko Tarutao, Thailand and the northwestern part of Pulau Langkawi, Malaysia, respectively (Figure 1).

This paper is based mainly on the author's investigations carried out from November, 1977 to April, 1981 as an M.Sc. Project (C.P. Lee, unpublished thesis) sponsored by the University of Malaya. Much help was also provided by Professor H. Sawata who was formerly attached to the Geological Research Project, Prince of Songkhla University, Haad Yai in the field inverstigation of Ko Tarutao.

PREVIOUS WORK

There are two major publications on the Tarutao Formation. The first is a compilation edited by Mantajit (1980) for use as a field guide to the geology of Ko Tarutao for the joint geological excursion by geologists of the Geological Societies of Thailand and Malaysia from 31st March to 2nd April, 1980. It includes a comprehensive note on the geology of Tarutao Island by Bunopas and others (1980). Bunopas (1974) had also dealt with the geology of Tarutao in some detail in his paper on the Lower Paleozoic rocks in Thailand. The second is the report on the Lower Paleozoic Formations of Tarutao Islands by Teraoka et al. (1982).

The major publication on the Machinchang Formation is by Jones (1981) as part of his memoir on the geology and mineral resources of Perlis, North Kedah and the Langkawi Islands.

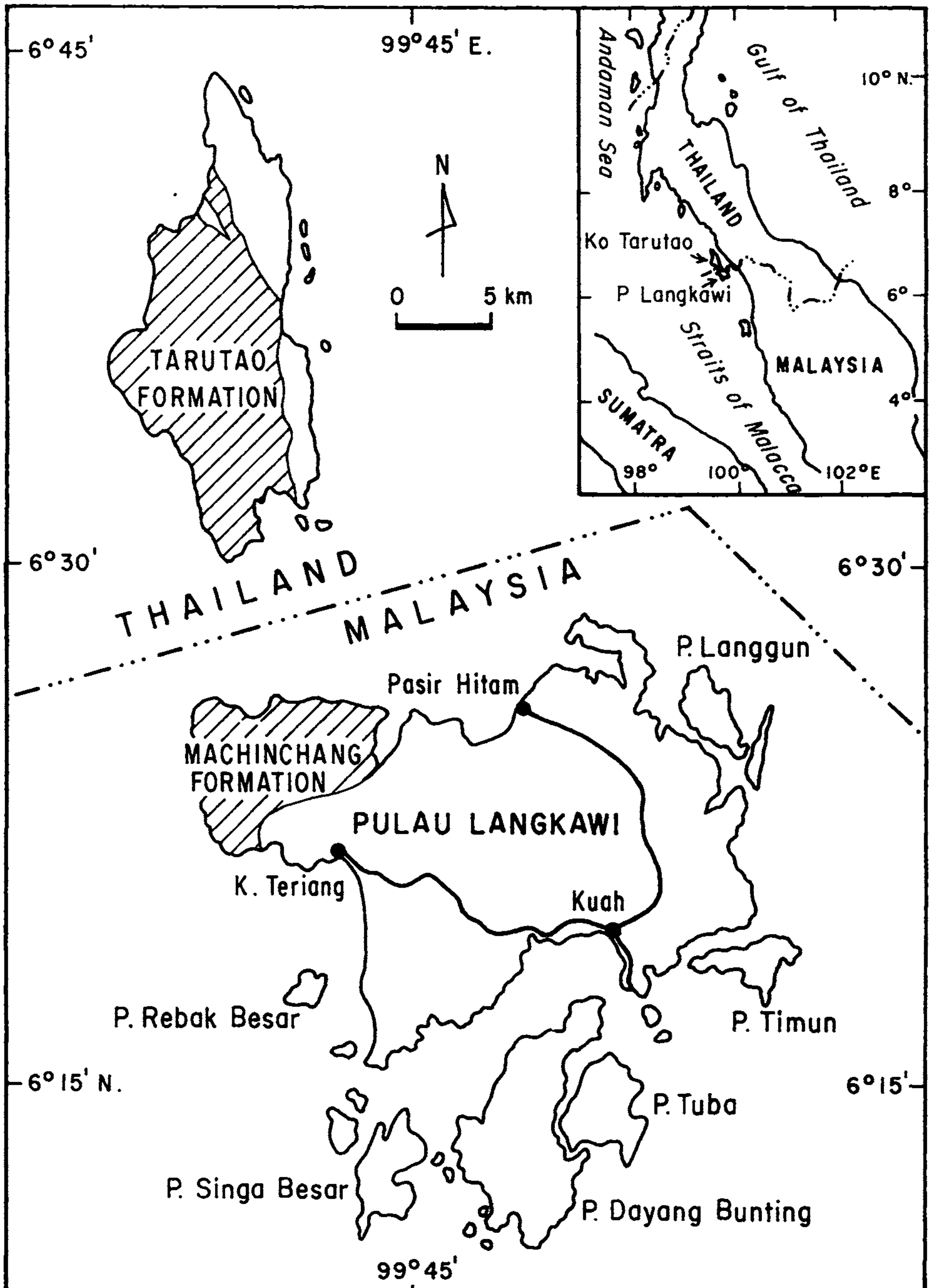


Fig. 1. Location map of the Tarutao and Machinchang Formations.

PALEONTOLOGY AND AGE

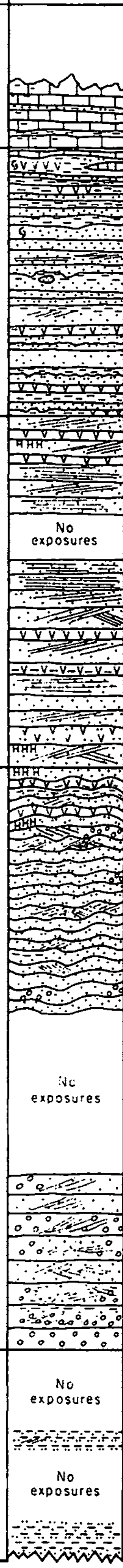
Kobayashi (1957) assigned a Late Cambrian age for the fossils collected from the Tarutao Formation and sent to him by Saman Buravas based on the presence of *Pagodia thaiensis, Saukiella tarutaoenasis* and *Corenocephalus planulatus*. However, Jones (1968) mentioned that Kobayashi communicated to him personally that a sandstone unit near the top of the succession contained trilobites of the Ordovician genus *Asaphus* and therefore, the topmost beds could possibly be of an early Ordovician age. Kobayashi however, made no mention of this in his 1973 paper on "The Early Stage of the Burmese - Malayan Geosyncline." Koch (1973) mentioned that the date of the Tarutao faunnule given as Upper Cambrian by Kobayashi (1964) has probably to be corrected to Lowermost Ordovician. The probable occurrence of graptoloid fossils which would then give an Ordovician age to part of the Tarutao Formation was reported by Bunopas (1974, 1980) but the author (Lee, 1980) believes that they were *Dictyodora* trace-fossils. The author discovered stromphomenids in the lower part of member MF 3 (Figure 2) and this together with the probable occurrence of *Northorthis* in submember MF 2-3 (Figure 2) shows that the age of the upper parts of the Tarutao Formation is Ordovician. This was further confirmed by the presence of Upper Tremadoc conodonts from limestone lenses in the upper Tarutao Formation reported by Teraoka et al., (1982) and also the Tremadoc trilobites *Pseudokainella, Rossaspis* and other long ranging typically Ordovician genera in the upper part of the Tarutao Formation by Strait and Burrett (in press).

In stark contrast to the rich fossil finds in the Tarutao Formation, the Machinchang Formation has yielded very few and very poorly preserved body fossils of mainly fragmentary trilobites and brachiopods from just a few localities in its uppermost parts.

No definite body fossils older than latest Cambrian has been found in the Tarutao and Machinchang Formations. Therefore, based on the great thickness of the formations, it is probable that the lowest strata are of an appreciably earlier Cambrian age. The trace-fossil *Phycodes pedum* found by the author in unit MF 2-1 near the southernmost tip of Ko Tarutao has been recognised as a Cambrian form by Seilacher (personal communication, 1979).

GENERAL STRATIGRAPHY AND DISTRIBUTION OF UNITS

The overall stratigraphy of the Tarutao and Machinchang Formations are summarized in Figures 2 and 3 respectively. These two equivalent formations have no known base and each can be differentiated into three lithostratigraphic units, namely the lower, middle and upper members designated by MF 1, 2 and 3 respectively. The middle member can be further subdivided into three submembers designated by MF 2-1, MF 2-2 and MF 2-3. The areal distribution of these units mainly through extrapolation of the contacts inland from the coast and photogeological mapping and the major structural features affecting them are shown in Figures 4 and 5. It can be seen that both the Tarutao and Machinchang strata are distributed on the flanks of roughly northwest-southeast and north-south trending asymmetrical anticlines truncated by some large faults.



System	Formation	Unit	Thickness	Description of unit
ORDOVICIAN	THUNG SONG FM.			Dark grey argillaceous limestone with red and green calcareous mudstone horizons
ORDOVICIAN	TARUTAO FORMATION	MF 3	575 m	This limestone lenses and bands interbedded with mudstone and siltstone and tuffs in upper part of the unit. Wavy bedding, slump and load structures and ripple marks present. Thin to medium wavy bedded fine brownish micaceous sandstone interbedded with siltstone, mudstone and shale. Load and slump structures and fossils present in some horizons. Thin to thick parallel bedded fine clayey sandstone with low angle cross-bedding, interbedded with thin beds of mudstone and purple or greenish white fine grained acid tuff and tuffaceous mudstone. Ripple marks, fossils including strophomenids and trace fossils, load structures found in several horizons.
ORDOVICIAN / CAMBRIAN	TARUTAO FORMATION	MF 2-3	750 m	Thick straight bedded purplish fine micaceous sandstone with a few very thin argillaceous layers Parallel laminated and cross-bedded (including some herring bone sets) Several thin to thick beds of fine grained acid tuff and tuffaceous mudstone at various levels. Fossils and fine heavy mineral laminae found in some beds. *(Nothorthis?)* About 4 m thick band of fine greenish white acid tuff and tuffaceous mudstone with fine silty intervals located near base of unit.
CAMBRIAN	TARUTAO FORMATION	MF 2-2	1200 m	Thin to medium thick wavy bedded fine to coarse light brown cross-bedded quartzite, sandstone and siltstone with occasional purple and green interbeds of fine acid tuffs and tuffaceous mudstones. Heavy mineral bands are found in some beds. Occasional beds of pebbly sandstone.
CAMBRIAN	TARUTAO FORMATION	MF 2-1		*(Phycodes pedum)* Thin beds of pinkish grey pebbly sandstone, conglomerate and sandstone (quartzite) with abundant large compound sets of cross-bedding, herring bone cross-bedding, graded bedding and channeling.
CAMBRIAN	TARUTAO FORMATION	MF 1	450 m+	Thinly (cm) bedded greenish brown micaceous mudstone with minor brownish siltstone and muddy sandstone intervals with rare cross-bedding.

Fig. 2. Stratigraphy of Tarutao Formation.

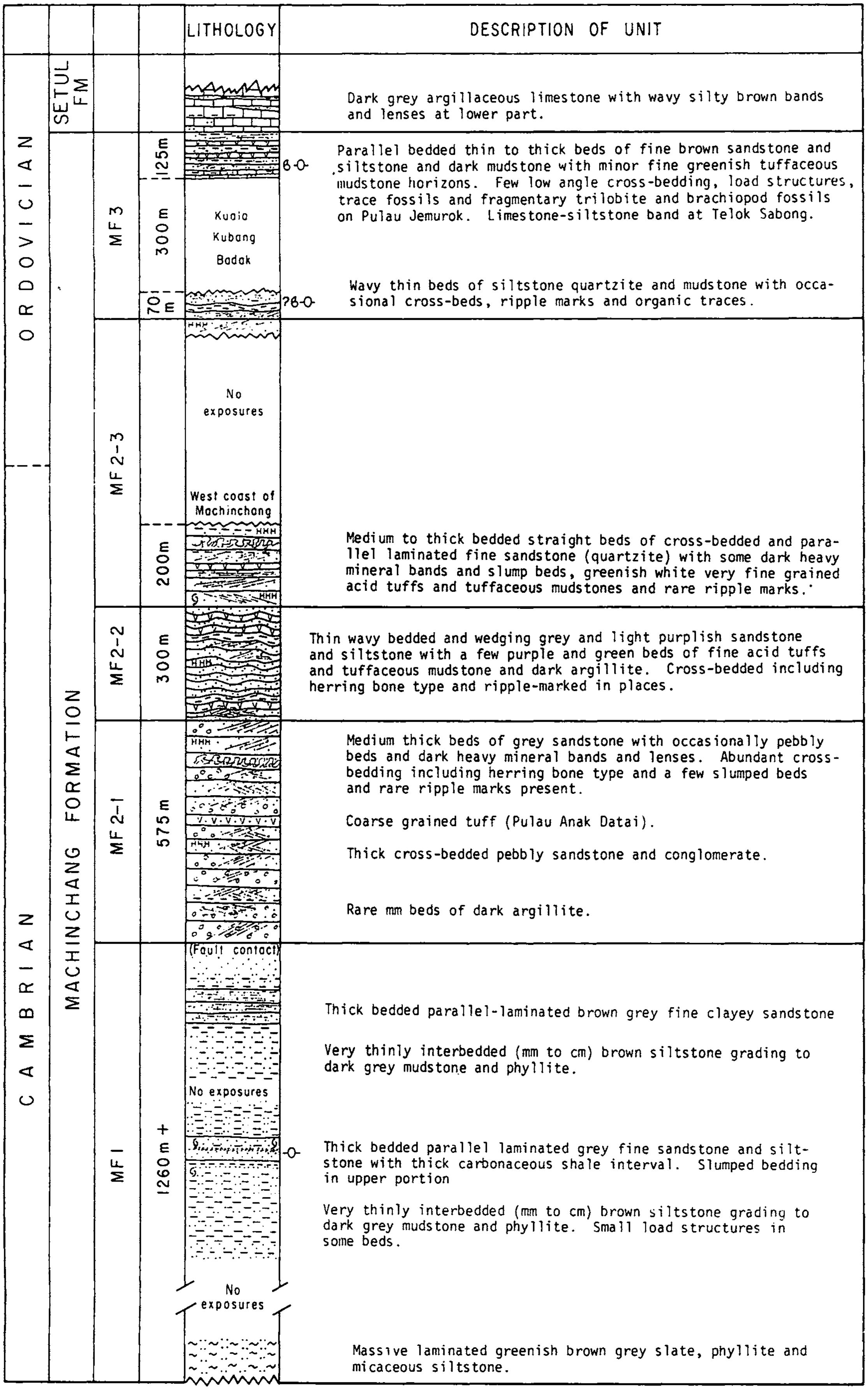


Fig. 3. Stratigraphy of Machinchang Formation.

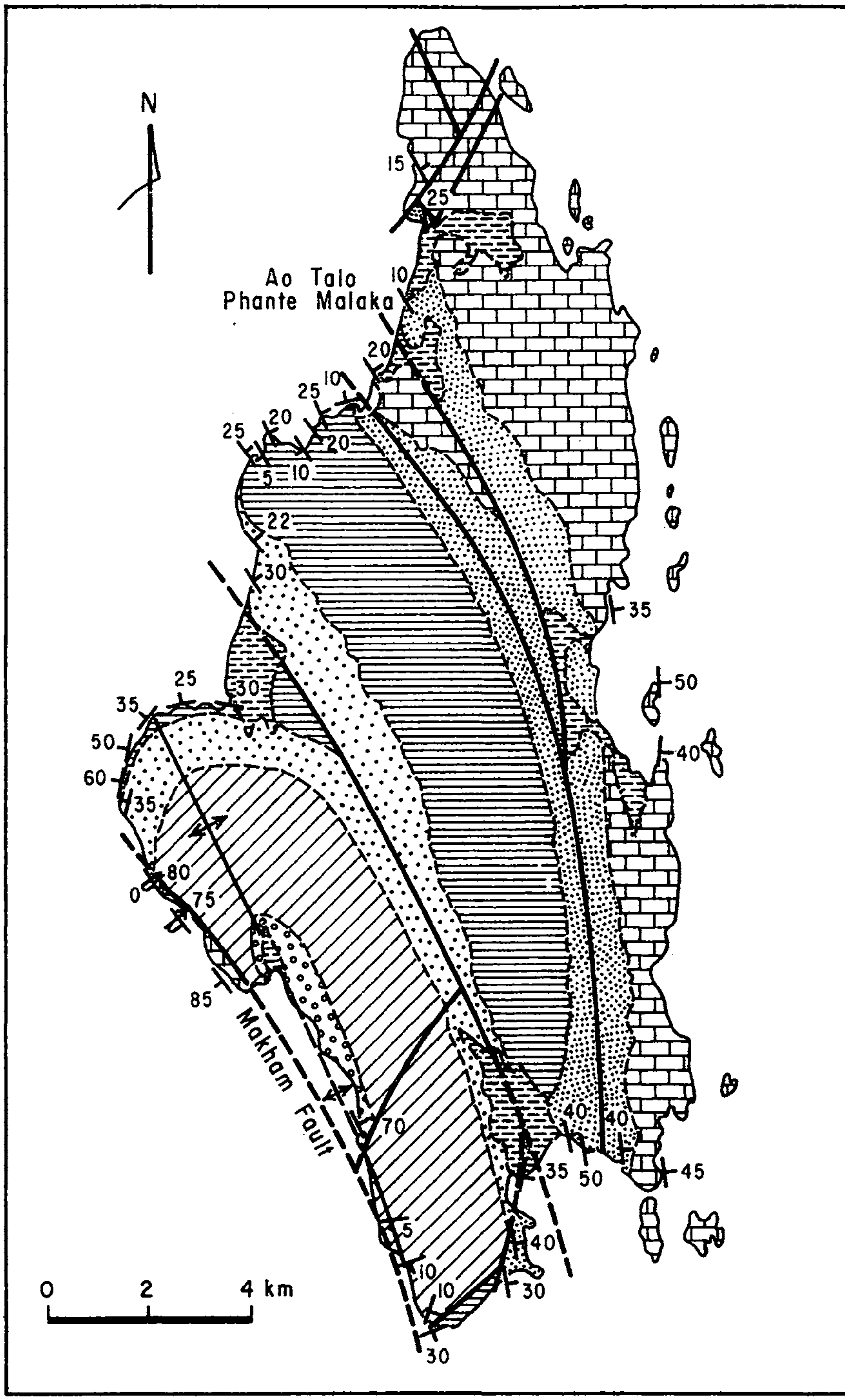


Fig. 4. Geological sketch map of Ko Tarutao.

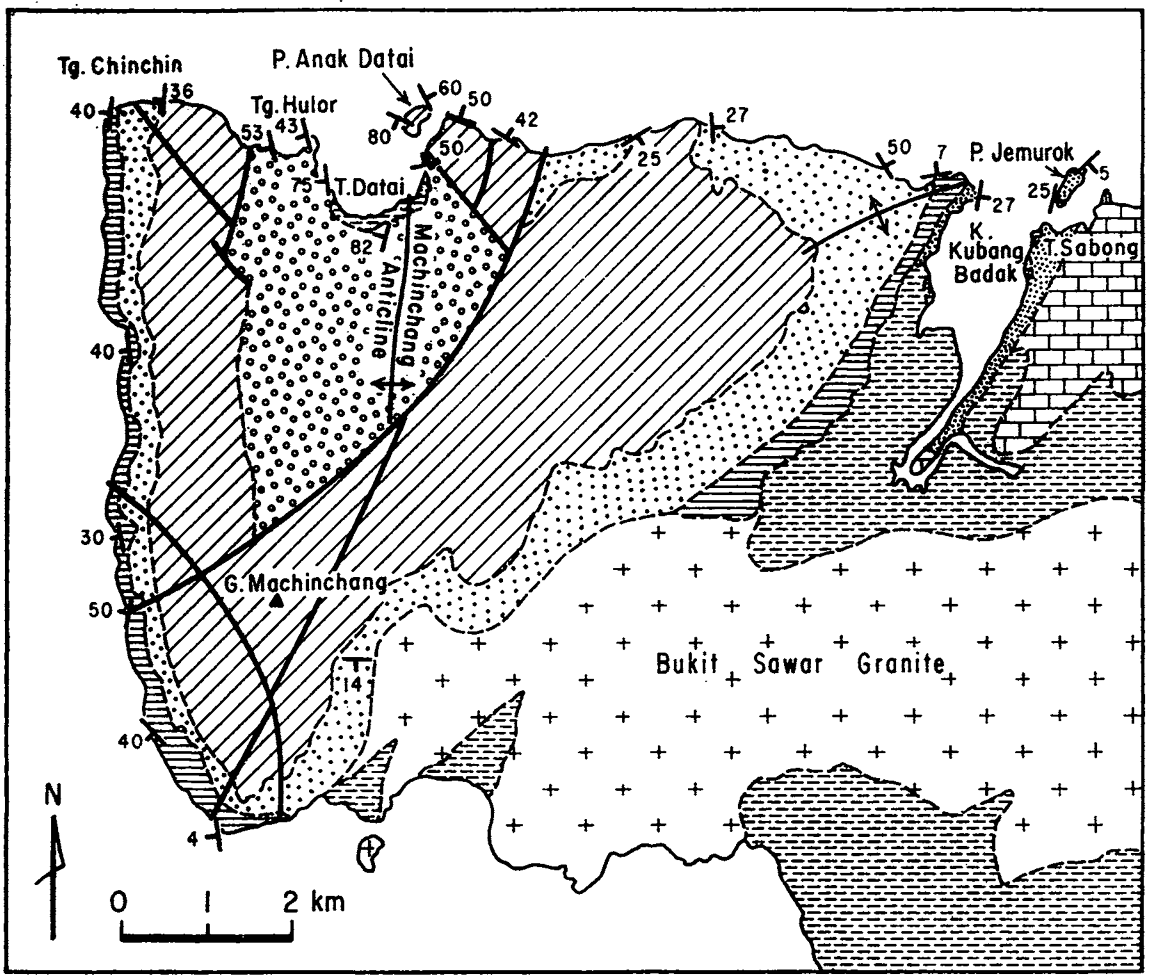


Fig. 5. Geological sketch map of Machinchang, Pulau Langkawi.

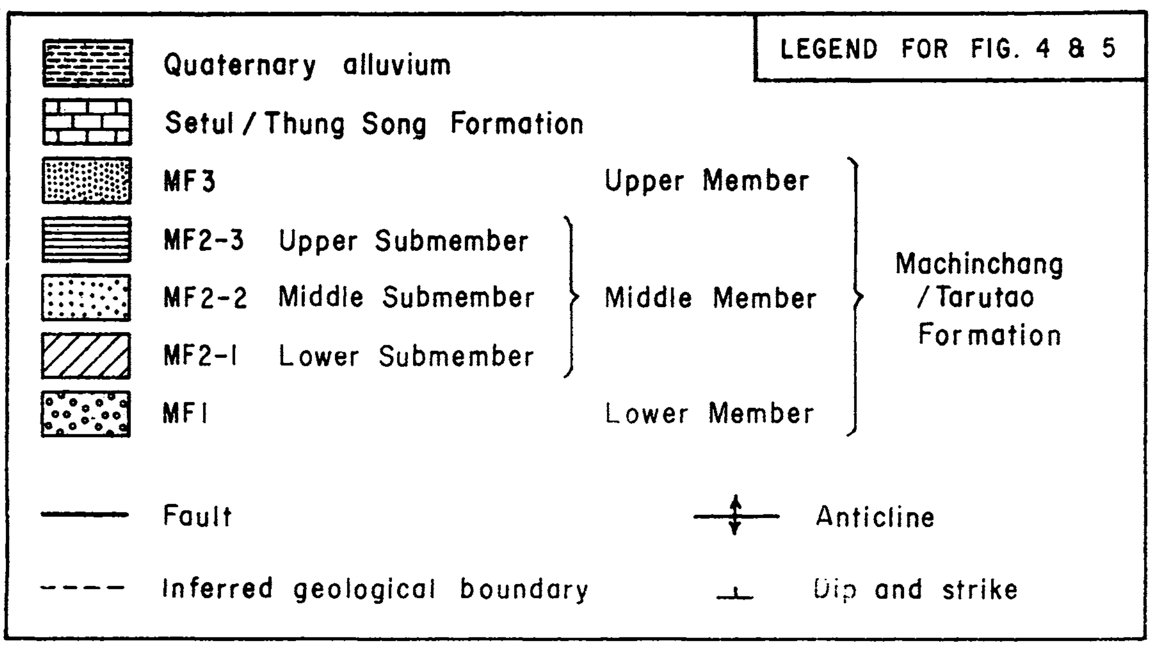


Fig. 6. Very thinly bedded MF 1 rhythmite subfacies from Tg. Hulor, Machinchang.

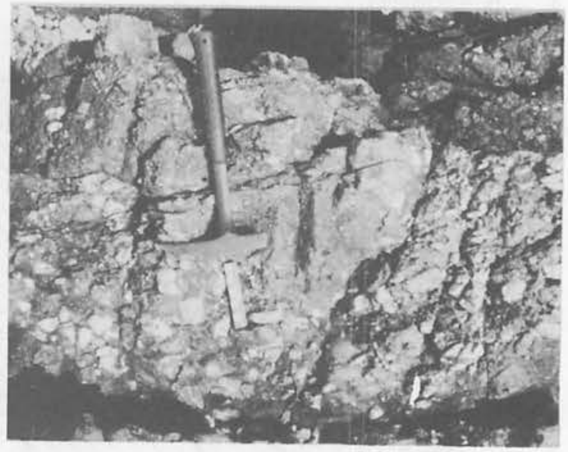


Fig. 7. Coarse angular quartz pebble conglomerate of MF 2-1 from Pulau Anak Datai, Machinchang.

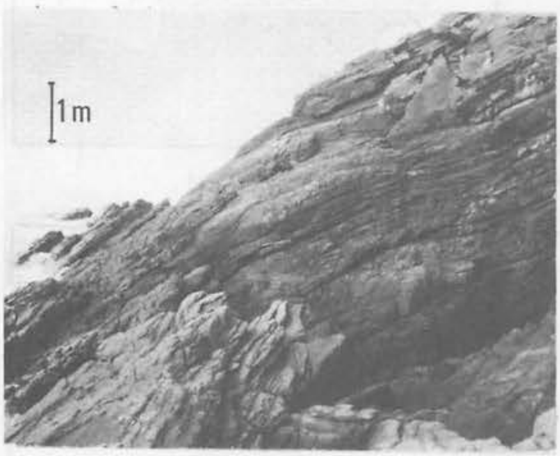


Fig. 8. Thinly wavy- bedded MF 2-2 member from east of Tg. Chinchin, Machinchang.

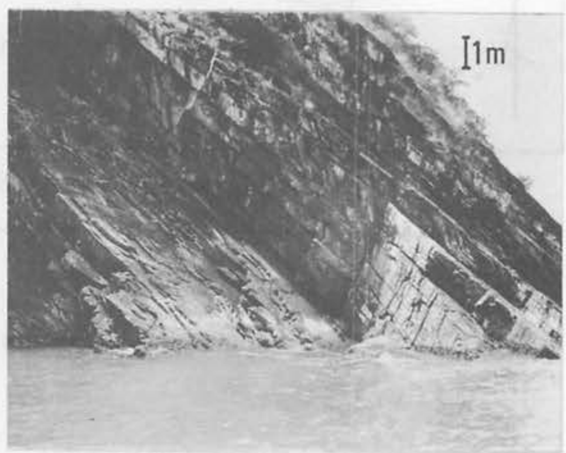


Fig. 9. Thick straight-bedded MF 2-3 member from west coast of Machinchang near Tg. Chinchin.

Fig. 10. Hand specimen of *Kinneyia* from top of MF 3 sandstone bed in west side of Pulau Jemurok, Machinchang.

Fig. 12. Lighter coloured irregular limestone bands interbedded with darker fine clastics from member MF 3 at southern cliff-face of outcrop in the middle of Ao Talo Phante Malaka, Ko Tarutao.

Since the Machinchang and Tarutao members and submembers are defined lithostratigraphically they are treated here as facies. These large facies are split into component subfacies which represent variations in the general environment of deposition to produce subenvironments. The subfacies are first identified, briefly described and interpreted before an overall interpretation is given to the environment of deposition of the member or submember as a whole. Finally, an overall interpretation of the facies sequence for the whole formation is attempted and the probable paleogeography is discussed.

Lower Member MF 1 (450 m+ in Tarutao; 1620 m+ in Langkawi)

This is essentially an areno-argillaceous unit exposed in the core of the Machinchang Anticline at Telok Datai (Figure 5). Four subfacies are distinguished in this member.

The first subfacies is of very thinly (mm to cm) interlayered rhythmite deposits of light brown siltstone grading into dark grey mudstones (Figure 6). Fine parallel laminae predominate and only a few beds are rippled or show small scale load structures. This subfacies probably represents deposition of silt and clay from suspension clouds in a quiet environment such as on an offshore shelf to give the generally undisturbed very thin graded laminae of silt and clay. Occasional weak currents caused small scale rippling and the contrasting lithologies of silt on clay facilitates the development of small load structures.

The second subfacies is made up of cm to dm bedded fine argillaceous sandstones which cut erosively into the rhythmites of the first subfacies These beds are graded and the tops are of dark mudstones similar to those of the first subfacies. Cross-bedding is rare and most of the beds appear to be massive internally. Occasional clay chips and rare sand-filled burrows are present in a few beds. Thin section studies showed that the sandstones are texturally and mineralogically immature with small amounts of fresh angular feldspars and abundant clay matrix indicative of rapid erosion, transport and deposition. This subfacies probably represents storm deposits whereby large amounts of sandy sediments were occasionally brought in and deposited very rapidly during short-lived storm events which sometimes ripped up some of the underlying thin clay beds to give intra-formational chips. After each storm quiet conditions returned and rhythmite deposition was resumed.

The third subfacies is of slumped, very thick, poorly bedded to massive argillaceous fine sandstone found at Tg. Hulor. This subfacies was probably created by the slumping of sand deposits perhaps from a prodelta into the deeper shelf environment. It is interbedded with the fourth subfacies which is a 5 m thick interval of black carbonaceous and pyritiferous silty shale indicative of reducing conditions. Rapid burial by overlying slump deposits might have "sealed" the underlying shale and shielded it from oxidation on the sea bed.

There is a gradual increase in the thickness and abundance of sandy beds as member MF 1 is traced upsection. It is hence a coarsening upwards sequence. An overall sequence such as this is normally found in prograding shorelines or deltaic deposits where the sands build outwards over the finer shelf sediments.

Middle Member MF 2 (1950 m in Tarutao; 1575 m in Langkawi)

The middle member is a fining upwards sequence with the coarse sand-stone and conglomeratic facies of submember MF 2-1 at the bottom, the thin wavy bedded sandstone facies with occasional pebbly intervals of submember MF 2-2 in the middle and the medium to thick straight bedded fine sand-stone and siltstone facies of submember MF 2-3 at the top.

Submember MF 2-1 (500 m+ in Tarutao; 575 m in Langkawi) has a coarse subfacies interbedded with a finer subfacies. The coarse subfacies is made up of graded bedded, wedging beds of abundantly cross-bedded pebbly sand-stones and conglomerates (Figure 7). Some slumped beds and herringbone cross-bedding are also present. Downcurrent directions from cross-bedding are variable but are generally westwards. The petrography is mainly sub-litharenites containing metamorphic and volcanic rock fragments and some quartzarenites. The conglomerates are poorly sorted and have angular clasts in the lower part of the submember but are better rounded higher up. This coarse subfacies is probably of estuarine channel fills or upper shoreface deposits in a prograding conglomeratic shoreline.

The finer subfacies consists of thin to thick beds of low angle, polymodal or westwards directed planar cross-bedded fine sandstones with occasional heavy mineral concentrations of ilmenite, tourmaline and zircon in their upper parts. Rare ripple marks are present. These sandstones are texturally and mineralogically mature quartzarenites or sublitharenites and most of them are probably upper shoreface to beach deposits. No body-fossils were found but the trace-fossil, *Phycodes pedum*, a type of feeding burrow of the neritic zone was encountered in this submember on Ko Tarutao. Parts of the sand could thus be lower to middle shoreface deposits. Angular volcanic fragments in the conglomerates and also a coarse acid tuff interval discovered on Pulau Anak Datai show that there was volcanic activity in the vicinity of the depositional basin.

Submember MF 2-2 (700 m+ in Tarutao, 340 m in Langkawi), is characterized by a thin to medium wavy-bedded (Figure 8) fine sandstone subfacies with occasional graded pebbly sandstone and also fine tuffaceous and thin argillaceous intercalations. Cross-strata are common in some localities and few in others. Both large planar low angle as well as trough high angle types are present. Tidal influence is demonstrated by the presence of herringbone cross-bedding in the Machinchang outcrops. Other sedimentary structures include rare ripple marks, slump and load structures. Channelling is seen in some beds with clay chips at the bottom. Paleocurrent patterns for individual localities are variable but the overall pattern is a north-west directed fan. Petrographic studies show that quartzarenites perdominate in the Machinchang and sublitharenites in Tarutao. The sorting is good but rounding is poor showing constant currents acting for short durations or high rates of sediment supply. Rare heavy mineral concentrations are found in some beds. This submember was probably deposited in the upper or inner parts of an estuarine facies which overlies the coarse estuarine channel fill facies of MF 2-1. Such a variable fining-upwards sequence can belong to the tidally-dominated channel to tidal flat facies which overlies the lag deposit comparable to that of the estuarine-facies of the Ogeechee River by Greer (1975 in Elliot, 1978 p. 171). The wavy bedding was probably caused by gentle sedimentary deformation or differential warping which has been known to occur when more than one kind of material is present in variable thicknesses under compaction or consolidation (Dunbar and Rogers 1951 p. 104).

Submember MF 2-2 (750 m in Tarutao; 700 m+ in Langkawi) is of very fine to fine, thick straight-bedded sandstones (Figure 9) with thin to thick intervals of fine acid tuffs, and it is increasingly argillaceous up-section. The sandstones are usually parallel-laminated or cross-bedded with grouped low-angle planar sets and some herringbone sets. Occasional heavy mineral and fossil fragment bands are present in the upper parts of the beds in Tarutao. Paleocurrent patterns are bimodal or polymodal and the sandstones are texturally and mineralogically very mature. This dominant subfacies within MF 2-3 are probably beach deposits. Associated with this subfacies are some sandstone beds with exceptionally high angle, thick trough cross-strata which may be beach dunes or more likely, over-steepened point bar deposits of tidal channels, as some deformed laminations are also occasionally associated with them. A significant portion of this submember is also made up of sandstone beds with a complex sequence of multidirectional trough cross-beds indicative of multidirectional flow in the surf zone (Clifton et al., 1971; Carter; 1978 in Reinson, 1979 p. 61). This is probably an upper shoreface subfacies. Taken together, the combination of beach and upper shoreface subfacies within MF 2-3 probably represent a series of barrier beach complexes. Rare ripple marked beds, some thin argillaceous and fine acid tuff horizons found in this submember were probably laid down in the quiet lower shoreface zone or in the back-barrier troughs or lagoons commonly associated with the barrier beach complexes.

Upper Member MF 3 (575 m in Tarutao; 420 m in Langkawi)

Although this unit is again an areno-argillaceous facies like unit MF 1, they are from dissimilar environments of deposition. Whereas MF 1 was laid down in the quiet deeper waters of the offshore shelf, MF 3 is from a protected very shallow marine shoreline environment which had been intermittently exposed as shown by the exposure structures called *Kinneyia* (Figure 10). The abundance of fossils and trace-fossils in MF 3 shows that it is more completely a life or vital facies than MF 1. MF 3 is a fining upwards sequence with decreasing bed thicknesses upsection in contrast to MF 1 which shows the reverse. A fourth point of difference is the presence of abundant large scale load structures in MF 3 which are absent in MF 1. This may be because the MF 1 muddy sediments had a longer period to consolidate before the deposition of overlying sands whereas in MF 3 the sands were deposited over the muds even before they had a chance to be properly consolidated hence producing large load structures. This would be so if MF 1 was laid down in the quiet offshore shelf with occasional storms bringing in sands while for the shallower MF 3 the effects of storms were more frequently felt.

Three subfacies can be distinguished in this member which is better represented in Tarutao than in Langkawi.

The first subfacies is made up of cm to dm bedded mudstones which are in parts accompanied by thin lenses and streaks of rippled siltstones or very fine sandstones. The finely micaceous mudstones have variable silt and sand content and are coloured dark brownish red, purplish, pale green or dark grey. They can be massive, finely laminated or fissile. This subfacies is most abundant in the upper parts of the unit in Tarutao. Whitish green or purplish beds of very fine acid tuff are associated with this subfacies which are probably suspension deposits in quiet water conditions. This subfacies is not well exposed on Langkawi.

The second subfacies is of thin to thick bedded very fine sandstones and siltstones which are parallel laminated or low angle planar cross-bedded to hummocky bedded. The thicker beds such as those found on Pulau Jemurok show features of storm deposits (Figure 11). Some of these beds

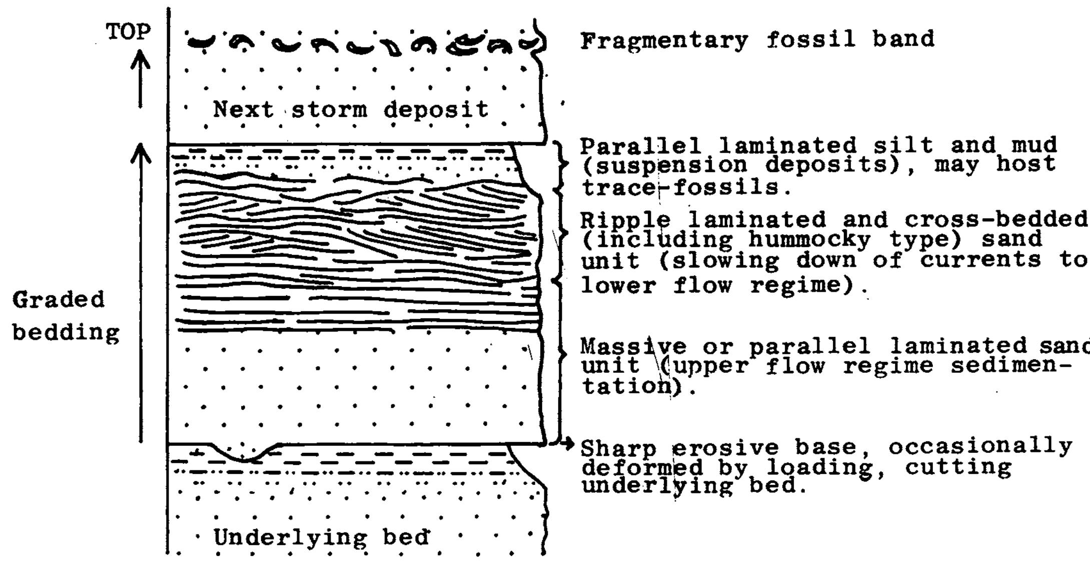


Fig. 11 Sketch of storm deposit in MF 3 member from Pulau Jemurok.

have thin fossiliferous bands of fragmentary trilobites and brachiopods. Such shell-rich layers alternating with barren or sparsely fossiliferous intervals are common in many strata associated with storm deposits (Kreisa, 1981; Dott, 1983). Trace-fossils such as *Dictyodora, Chondrites, Gordia, Neonereites* and the trilobite tracks, *Diplichnites, Monomorphichnus* and *Dimorphichnus* have been found in this subfacies. Common intertidal structures such as various types of low amplitude wave ripples are found together with *Kinneyia* on the top surface of some sand beds. Paleocurrent patterns for individual beds are usually unimodal or bimodal but the overall pattern of MF 3 is polymodal. Petrographically, these fine well sorted but poorly rounded sublitharenites with abundant mica and secondary hematite flakes and minor amounts of fresh feldspar are indicative of rapid deposition in a sheltered environment such as a back-barrier lagoon or restricted bay.

The third subfacies consists of thin wedging beds and lenses of impure limestones (Figure 2) found in the uppermost parts of MF 3 in the transitional zone from clastics to the overlying Ordovician-Silurian carbonates. These limestone bands show fine wavy laminations with small scale cross-bedding. Fossil fragments, pellets, oolites and intraclasts are present in some bands. Angular silty chips form edge-wise conglomerate in one band and may indicate strong intermittent currents ripping up an underlying semiconsolidated layer or perhaps the removal of dessication chips by currents. This subfacies is interbedded with mudstones and fine sandstones which demonstrates the fluctuating nature of the depositional conditions in the environment. The fossil-rich bands were either shell-beds and skeletal lime sands deposited within the low energy subtidal lagoonal environment similar to that described by James (1979) or could be shell-rich layers associated with storms (Kreisa, 1981; Dott, 1983).

The most likely environment of deposition for the various MF 3 subfacies is a back-barrier lagoon connected to the open sea by tidal channels like that of the *Lingula* facies of the Devonian Baggy Beds described by Goldring (1971) where shallow marine quiet water conditions normally prevailed for the settling out of the fine silts and clays of the first subfacies but were occassionally interrupted by rapid fine sand sedimentation brought about by storms to produce the thick sand beds of the second subfacies and perhaps the shell-rich bands of the third subfacies. Parts of the lagoon were mud and sandflats which were intermittently exposed to the air. Carbonate deposition was not widespread at first but gradually increased in the later stages of MF 3 deposition as shown by the increasing occurance of the third subfacies upsection. Clastic sedimentation was replaced by large scale carbonate deposition of the overlying Thung Song and Setul Formations due probably to a reduction and eventual termination of the influx of clastic detritus as the hinterland was progressively peneplaned. This was not unlikely considering that there was a steady decrease in grainsizes with increasing maturity of the sands from MF 2-1 to MF 3.

OVERALL INTERPRETATION OF THE TARUTAO AND MACHINCHANG FORMATIONS.

The overall depositional environment for the Tarutao and Machinchang sediments was probably deltaic. Miall (1979 p. 47) proposed seven characteristics for recognising ancient deltas. Five of these applies to the present case. The remainder two which refers to coal beds and mixed faunas are inapplicable because of the absence of land plants and fauna during Cambro-Ordovician times.

The five characteristics are:-

1) The great thickness of over 3000 m of the Tarutao and Machinchang Formations.

2) The presence of considerable volumes of sand and/or silt.

3) Sedimentary structures indicate shallow water deposition by traction rather than turbidity currents.

4) Gradation into finer grained clastic deposits of offshore origin is traceable in MF 1.

5) Coarsening upward cycle from MF 1 to MF 2-1.

In addition the abundance of gravity-induced slumps as present in MF 1 is also a common feature of deltas. (Coleman and Gagliano, 1965).

The sequence that is present appears to represent:- (i) offshore shelf silts and clays (MF 1) coarsening upwards to (ii) coarse estuarine channel lag deposits (MF 2-1) which fine upwards to (iii) a shallow upper estuarine channel fill (MF 2-2) which is succeeded by (iv) a barrier beach complex (MF 2-3), behind and overlying which is (v) a back-barrier open lagoonal deposit (MF 3). Such a sequence is most likely to belong to a high destructive (ie. not fluvial dominated), wave - influenced delta, which tends to produce a series of beach-ridge complexes because of the dominance of beach-barrier shoreline processes (Fisher et al., 1969 in Miall, 1979). This may also explain why the dominant cross-bedding direction is westwards or shorewards. Distributary channels and associated interdistributary tidal flats are not as abundant as in high-constructive, fluvial - influenced deltas. Interbedded with the clastic sediments are also acid tuffs indicating intermittent volcanism in the viscinity of the depositional basin.

PALEOGEOGRAPHY

The general trend of the Yunnan-Malayan Geosyncline is north-south, hence variations between the rocks of the Machinchang and Tarutao Formations would represent longitudinal facies variations parallel to the ancient coastline more than lateral facies variation.

Some of the more noticeable variations are:-

i) An apparently larger proportion or greater thickness of the coarse MF 2-1 facies in the Machinchang than in Tarutao.

ii) Beds within comparable members and submembers are thicker in Machinchang than in Tarutao.

iii) Subfacies are more variable within the Machinchang than Tarutao members and submembers.

iv) The conglomerate clasts and volcanic fragments found within the Machinchang MF 2-1 are coarser and more angular than those in Tarutao.

v) The redness of the Tarutao beds compared to the lack of reddish colour in the Machinchang beds.

Variations (i) to (iv) are good indicators that the main channel of the delta was located in or closer to the Machinchang area than to Tarutao as decreases in coarse channel lag facies, bed-thicknesses, grainsizes and angularities accompanied by a decrease in variability of facies would be expected the further the depositional environment is from the active channel. There is still no adequate explaination for variation (v).

The local paleogeography then, is the channel of the delta entering into the basin in the vicinity of the Machinchang region and the Tarutao region was located somewhat away from this main channel and was at the flank of the delta.

CONCLUSIONS

The Cambro-Ordovician Tarutao and Machinchang Formations are each divisible into three members with the middle member further divisible into three submembers. The sequence represented by these members and submembers has been interpreted to be of offshore shelf silts and clays coarsening upwards to coarse estuarine channel lag deposits which fine upwards to a shallow upper estuarine channel fill which is succeeded by a barrier beach complex behind and overlying which is a back-barrier open lagoonal deposit. This sequence is most likely to belong to a high destructive, wave influenced delta which had built over an offshore shelf deposit to produce a series of barrier-beach sands aligned parallel to the shoreline with subdued channel sands cutting across them.

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