WORKSHOP ON STRATIGRAPHIC CORRELATION OF
THAILAND AND MALAYSIA

Haad Yai, Thailand
8-10 September, 1983

THE ORDOVICIAN SYSTEM IN SOUTHERN THAILAND AND NORTHERN MALAYSIA

Wongwanich,T.,
Geological Survey Division,
Department of Mineral Resources,
Bangkok 10400, Thailand

Wyatt, D.,
Geology Department,
University of Tasmania, Box 252C,
Hobart, Tasmania, Australia, 7001

Stait, B.,
Geology Department,
University of Tasmania, Box 252C,
Hobart, Tasmania, Australia, 7001

Burrett, C.,
Geology Department,
University of Tasmania, Box 252C,
Hobart, Tasmania, Australia, 7001

ABSTRACT

A Middle-Upper Tremadocian trilobite fauna is found in the upper two members (T3-T4) of the siliciclastic Tarutao Formation of Tarutao Island (Thailand) and the T3 member may young towards the south of the island. Six carbonate units can be recognised in the conformably overlying Thung Song Formation. These units display a gradual deepening of the environment of deposition from peritidal in the Upper Tremadocian (Middle Ibexian) and Lower Areningian (Upper Ibexian) to open subtidal in the Middle Areningian (Lower Whiterockian) At least two of the lithological units can be recognised in Satun Province (Thailand) and all of them occur to the west of the Gunong Raya Granite, Langkawi Islands (Malaysia) where they are metamorphosed to marble.

To the east of the Gunong Raya Granite the remaining 1100m of the Lower Setul Limestone can be divided into 9 lithological units ranging in age from Tremadocian-Llanvirnian (Ibexian-Lower Whiterockian). The Lower 8 units represent peritidal conditions and only in the ninth is there evidence of basinal deepening. This last (105m thick) unit may be of Llandilian (Upper Whiterockian) age or even younger and is overlain by the Silurian Lower Detrital Member. Biostratigraphic equivalents of the Lower Setul Limestone occur in peritidal dolomicrites in central and southern Thailand but no definite Llandeilian-Caradocian (Mohawkian) or Upper Ordovician fossils have yet been found in carbonates in central or southern Thailand or in Malaysia.

Mapping of individual carbonate units is recommended in order to delineate formations that are suitable and unsuitable for commercial exploitation especially those of potential significance to the cement manufacturing industry.

INTRODUCTION

The Ordovician System in the border area of Thailand and Malaysia consists of the upper part of the siliciclastic Tarutao Formation and the carbonate Thung Song Formation (Thailand) and the carbonate Lower Setul Formation and possibly the upper part of the siliciclastic Machinchang Formation (in Malaysia). Our work, of which this is a preliminary report, is an extension of the stratigraphic and structural work of Bunopas *et al.* (in press), Bunopas (1982), Burton (1974), Teraoka *et al.*(1982) in Thailand and of Jones (1981) in Malaysia and of the palaeontological work of Kobayashi (1957,1958,1959), Kobayashi & Hamada (1964, 1970,1978), Yochelson & Jones (1968) and Igo & Koike (1967,1968).

Our studies have concentrated on the Langkawi Islands (Malaysia) and Turatao Island (Thailand)(Fig. 1). On these islands the exposure is relatively good and the deformation and metamorphism is relatively low - though contact metamorphism against granites on Langkawi has obliterated much sedimentological and palaeontological information. The conodont colour alteration index (C.A.I.) of Epstein *et al.* (1977) indicates metamorphic temperatures of between 200°-300°C with some in excess of 350°C in Kanchanaburi Province (Thailand) suggesting that palaeomagnetic results from Ordovician carbonate in these areas (Haile, 1980) should be interpreted with care.

Deformation is intense on mainland peninsular Thailand and Malaysia but some of the lithological units mapped on Tarutao can be recognised in Satun Province. Strike faulting is common leading to a repetition of units and to differences of opinion concerning stratigraphic continuity across failures in outcrop.

LITHOSTRATIGRAPHY

We have concentrated on subdividing and mapping lithological units within the carbonates using relatively subtle (and to many geologists, invisible!) sedimentological criteria. Bedding thickness and the abundance and distribution of dolomite and chert are obvious to all but 'birds-eyes', 'flat-pebbles', algal laminations and stromatolites are less obvious yet allow lithological subdivision as well as palaeoenvironmental interpretation. Using these simple criteria we have recognised six major subdivisions on Tarutao Island and 15 in the Langkawi Islands. Details of these units and their sedimentological and palaeontological constitution will be published elsewhere.

The carbonate sequence on Tarutao can be divided into at least 6 conformable lithological units which overlie the siliciclastic Tarutao Formation. The lowest unit is well exposed at Malacca Creek and is conformable with the underlying Tarutao Formation. It consists of about 30m of thinly bedded argillaceous and dolomitic limestone which is intensively horizontally bioturbated, mud cracked, contains abundant algal laminations and is rich in the valves of the polyplacophoran *Chelodes whitehousei* Runnegar *et al.* (Stait and Burrett, *in press*,a). An intertidal, perhaps lagoonal, environment is envisaged for this unit.

Above this unit is 75m of massively bedded cross-bedded and channelled dolosiltites and calcarenites. Bioturbation is intense, 'U'-shaped burrows are common and mud cracks are present. A shallow tidal channel complex is envisaged as the environment of deposition of this unit. This unit appears to be thinner (35m) in the south of the island. It is overlain by 40m of massively bedded (15-30cm thick) dolomitic calcisiltite/micrite consisting of digitate stromatolites often aligned in predominantly an east-west direction with minor alignment NE-SW. By comparison with modern stromatolites alignment at Shark Bay in Western Australia (Logan *et al.*, 1974) a north-south directed shoreline is indicated. Small (3cm diameter) sponges are found between the stromatolites. The stromatolites give a characteristic wavy appearance to the bedding that can be observed at a considerable distance. This stromatolitic unit is well exposed along much of the east cost of Tarutao (e.g., opposite (west of) Ko Sing Ha, Ko To Sen and on the west coast of Ko Pa Nan). Above this unit is 105m of a more argillaceous and thinly bedded (1-3cm) unit becoming more nodular in the upper part with green, grey and red shales surrounding calcareous nodules. This unit

is overlain by 45m of white crinoidal calcarenite and biosparites thinly bedded (2-4cm) at the base becoming thicker upwards containing abundant sponges, receptaculitids, and calcified brachiopods. Above this and, like the two preceding units, well exposed on Ko Lae Tong, is a grey and pink well bedded limestone 70m thick. Much of this sequence consists of coarse-grained calcarenites. Another unit outcrops on Ko Sing Ha and consists of nodular dark grey limestones with an abundant receptaculitid fauna. We assume this to be the youngest lithological unit exposed on Ko Tarutao.

Langkawi Islands

A very similar sequence is exposed on Pulau Langkawi to the west of the Gunong Raya Granite and, although metamorphosed, the major lithic units found on Tarutao, can be recognised. The only fossil found is one valve of the polyplacophoran *Chelodes* (Fig. 2). Ong (1980) has estimated the thickness of this sequence as 900m and we have measured 570m of this section (Fig. 5).

To the east of the granite the remaining 1100m of the Lower Setul Limestone has been subdivided into nine conformable and mappable units - designated E-M (Figs. 3,6). All of these units are found on Pulau Langgun but many can also be mapped on the main island (Fig.4). Member E consists of 128m of very dark grey, thinly bedded nodular dolomicrites interbedded with rare algal laminated dolomicrites. Member F is 85m of massively bedded, pink, mottled dolomite. Member G consists of 305m of thinly bedded very dark grey, nodular dolomitic micrite interbedded with lensing biosparite with prominent vertical worm tubes. Also present are cryptalgal dololaminates and very thick argillaceous beds. Silicified gastropod beds

are common and nautiloids, brachiopods and crinoids are also present. Unit H consists of 68m of cryptalgal dolomicrites and flat pebble conglomerates interbedded with channel biosparites and rippled, dolomitic micrite. Chert lenses and nodules are abundant especially in the lower part. Bioturbation is abundant and isolated, domal stromatolites and soft sediment slumping are present. The unit is capped by 12m of massive dolomite. The fauna consists of gastropods, brachiopods and nautiloids.

Unit I consists of 126m of dark grey, thickly bedded nodular biomicrite interbedded with biosparite and red argillaceous lenses. Fauna consists of nautiloids, receptaculitids, stromatoporoids and gastropods.

Unit J consists of dark grey to black thickly bedded nodular stylolitic dolomitic micrite interbedded with channel biosparites which are cross bedded and often vertically bioturbated. There are several beds of cryptalgally laminated dolomicrites; and flat pebble conglomerates near the top of the unit. Shale bands and chert horizons are common. This unit is richly fossiliferous with silicified nautiloids, stromatoporoids, gastropods and brachiopods. Above this is a stratigraphic gap of unknown thickness.

Unit K consists of 102m of buff, massively bedded dolomite with the mid 33m consisting of festoon cross-bedded and laminated dolosparites with minor dolomicrites. Chert nodules are rarely present as are brachiopods, nautiloids and receptaculitids.

Unit L consists of 52m of thinly laminated nodular stylolitic dolomitic micrite interbedded with thin dolosparite and rare beds of massive dolomite.

Unit M consists of a lower 70m of red and pink thinly bedded argillaceous micrite with prominent syneresis cracking. There are more ferruginous horizons with brachiopods, gastropods, nautiloids and sponge spicules. The upper 35m consists of very light grey thickly bedded calcilutite and laminated argillaceous limestone with large pyrite nodules being common. Above this unit is the 17m of the Lower Detrital Member of Jones (1981).

All units may be interpreted as having been deposited in peritidal environments. The upper part of unit M may have been deposited in deeper subtidal conditions but detailed petrographic investigation is necessary for definite palaeoenvironmental interpretation.

BIOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

The oldest fauna on the Shan-Thai block, consisting of *Pagodia (Oreadella) thaiensis*, *Thailandium solum*, *Mictosaukia buravasi*, *Saukiella tarutaoensis* and *Coreanocephalus planulatus* is found in the T3 member of the Tarutao Sandstone and possibly in the Machinchang Formation of Langkawi (Kobayashi, 1957; Teraoka *et al.*, 1982). This fauna is of Upper Cambrian age and is succeeded by the Lower Ordovician fauna described by Stait *et al.*, 1983, from the T4 member of Malacca Creek, consisting of *Pseudokainella malakaensis*, *Rossaspis? bunopasi*, *Asaphellus* sp. *Geragnostus* sp. and a harpid. It is also found at two localities in the T3 member of the Ao Talo Dang in southern Tarutao apparently (Teraoka *et al.*, 1982, fig.2) along strike from the Upper Cambrian faunas of Ao Talo Topo 11km to the northwest. This suggests that either the T3 member is incorrectly mapped at Ao Talo Topo or that the T3 member is strongly diachronous and youngs towards the south.

Rossaspis occurs within the Tarutao Island carbonate sequence (Stait and Burrett, 1983). Kobayashi and Hamada (1978) have described a trilobite fauna from the upper part (Unit M) of the Lower Setul Limestone consisting of *Geragnostella. Trinodus, Geratrinodus purconvexus, Geratrinodus levigatus, Eccoptochile?, Nileus malayensis, Remopleurides* cf. *emerginatus, Microparia, Raphiophorus, Lonchodomas rhombeus* and *Decoroproetus.* Kobayashi and Hamada (1978) ascribed an Upper Ordovician age to this fauna but all are long-ranging genera and a Middle Ordovician age is just as likely.

The nautiloids are the only group of macrofossils that have yet been adequately described from the Ordovician carbonate of southern Thailand and Malaysia (Stait and Burrett, 1982; Stait and Burrett, *in press*; Stait *et al., in press*). The oldest nautiloids are unassignable endocerids from the lower two units on Ko Tarutao. Above this is *Anthoceras?* which occurs in the Lower-Middle Arenigian of Australia, N. China and Siberia. Above this is *Hardmanoceras chrysanthimum,* associated with conodonts of the *P. evae* zone and the youngest nautiloid on Ko Tarutao is a new genus of discosorid known also from the Middle Arenigian of Central Australia.

The ranges of nautiloids on Langkawi are shown on Fig. 6. Partial biostratigraphic correlation between the Tarutao sequence and the Langkawi sequence is suggested by the occurrence of *Hardmanoceras* in Unit H. This occurs with *Manchuroceras* sp.nov. which is also found at Ron Phibun (Stait and Burrett, *in press,* b). The youngest Ordovician nautiloids on Langkawi constitute an assemblage which includes *Chaohuceras, Georgina, Armenoceras chediforme* and *Wutinoceras* elements of which are known also from Satun and Kanchanaburi provinces (Fig. 7). This assemblage is typical of Lower

Whiterockian age faunas in North China, Tibet and Australia (Stait and Burrett, 1982,1983).

The polyplacophoran *Chelodes whitehousei* occurs in the lower part of the Thung Song Limestone on Ko Tarutao (Stait and Burrett,*in press*, b) and the stratigraphically long ranging gastropod *Peelerophon oehlerti* is known from the east coast of Tarutao (Jell *et al.*, *in press*).

Work on the conodont faunas is progressing and the few faunules as yet recovered (Stait and Burrett, *in press*, a & b) confirm the correlations derived from the nautiloids (Fig. 7).

A major result of our biostratigraphic work is that no Ordovician fossils younger than Whiterockian have been found on Langkawi or on peninsular Thailand. The Middle-Upper Ordovician trilobite fauna of Kobayashi and Hamada (1978) from Pulau Langgun comes from the upper part of unit M. Unfortunately, no diagnostic conodonts are known from this unit except for the Middle-Upper Ordovician *Protopanderodus liripipus*. On present evidence, a considerable stratigraphic gap is indicated above Unit M of the Lower Setul Limestone and below the Lower Detrital Member (Fig. 7).

Hopefully, our lithostratigraphic and biostratigraphic work will now be extended to peninsular Thailand and Malaysia.

ECONOMIC SIGNIFICANCE

The lithological units recognised and mapped on Tarutao and Langkawi vary considerably in their economic potential. For the purposes of cement manufacture some units are highly suitable whereas others are totally unsuitable due to a very high Mg content (e.g. Units F & K on Langkawi).

Treating the limestone as homogeneous, then, would seriously degrade the economic potential of this extensive deposit whereas a careful selection of limestone from only the highest grade units could be used as the basis of a high quality cement.

ACKNOWLEDGEMENTS

We thank S. Bunopas, C.P. Lee, S. Muenlek, W. Tansathein and M. Wade for their help and the A.R.G.S. and the University of Tasmania for financial support.

REFERENCES

Bunopas, S., 1982, Palaeogeographic history of western Thailand and adjacent parts of South East Asia - a plate tectonics interpretation: *Geological Survey Thailand Special Paper*, 5; 1-810.

Bunopas, S., Muenlek, S. and Tansuwan, V., Geology of Tarutao Island: *Journ.Geol.Soc.Thailand* (in press).

Burton, C.K., 1974,The Satun Group (Nai Tak Formation and Thung Song Limestone) of Peninsular Thailand: *Sains Malaysiana*, 3, 15-34.

Epstein, A.G., Epstein, J.B. & Harris, L.D., 1977, Conodont color alteration - an index to organic metamorphism: *United States Geological Survey Professional Paper*, 995, 1-27.

Igo, H. & Koike, T., 1967, Ordovician and Silurian conodonts from the Langkawi Islands, Malaya: *Geology Palaeontology of South East Asia* ,3, 1-29.

Igo, H. & Koike, T. 1968, Ordovician and Silurian conodonts from the Langkawi Islands, Malaya Part II: *Geology Palaeontology of South East Asia*, 4, 1-21.

Haile, N., 1980, Palaeomagnetic evidence from the Ordovician and Silurian of N.W. Peninsular Malaysia: *Earth Planetary Science Letters*, 48, 233-236.

Jell, P., Burrett, C., Stait, B. & Yochelson, E. (in press) The Early Ordovician bellerophontid *Peelerophon oehlerti* (Bergeron, 1889) from Argentina, Australia and Thailand: *Alcheringa*.

Jones, C.R. 1981, Geology and mineral resources of Perlis, North Kedah and the Langkawi Islands: *Geological Survey Malaysia Memoir*, 17, 1-257.

Kobayashi, T., 1957, Upper Cambrian fossils from peninsular Thailand: *Journal Faculty Science Univ.Tokyo*, 10, 367-382.

Kobayashi, T., 1958, Some Ordovician fossils from the Thailand-Malayan borderland: *Japanese Journal Geol.Geography*, 29, 223-231.

Kobayashi, T., 1959, On some Ordovician fossils from northern Malaya and her adjacence: *Journal Faculty Science, Univ. Tokyo*, 11, 387-407.

Kobayashi, T. & Hamada, T., 1964, On the Middle Ordovician fossils from Satun, the Malaysian Frontier of Thailand: *Geology & Palaeontology of South East Asia*, 1, 269-278.

Kobayashi, T. & Hamada, T., 1970, A cyclopygid-bearing Ordovician faunule discovered in Malaya with a note on the Cyclopygidae: *Geology and Palaeontology of South East Asia*, 8, 1-18

Kobayashi, T. & Hamada, T., 1978, Upper Ordovician trilobites from the Langkawi Islands, Malaysia: *Geology and Palaeontology of South East Asia*, 19, 1-28.

Logan, B.W., Read, J.F., Hagen, G.M., Hoffman, P., 1974, Evolution and diagenesis of Quaternary carbonate sequences, Shark Bay, Western Australia: *American Assoc. Petroleum Geol.Memoir*, 22, 1-358.

Ong, Y.H., 1980, Investigation of limestone raw material for the Pulau Langkawi cement project: *Geological Survey Malaysia, Industrial Mineral Assessment Report*, 6/1980, 1-28.

Stait, B. & Burrett, C., 1982,
Wutinoceras (Nautiloidea) from the Setul Limestone (Ordovician) of Malaysia: *Alcheringa*, 6, 193-196.

Stait, B. & Burrett, C.F., 1983,
Biogeography of Ordovician nautiloids and trilobites from Australia, Malaysia and Thailand and their tectonic implications: *Geological Society Australia Abstracts*, 9, 221-222.

Stait, B. & Burrett, C.F. in press a.,
Lower Ordovician polyplacophoran *Chelodes whitehousei* from Tarutao Island, southern Thailand: *Alcheringa.*, 8.

Stait, B. & Burrett, C.F. in press b.,
Ordovician nautiloid faunas of Central and Southern Thailand: *Geol.Mag.*

Stait, B., Burrett, C. & Wongwanich, T., 1983,
Ordovician trilobites from the Tarutao Formation southern Thailand: *N.Jb.Geol.Paläont.Mh., 1983.*

Stait, B., Wyatt, D. & Burrett, C., 1984,
Ordovician nautiloids faunas of Langkawi Islands, Malaysia and Tarutao Island, Thailand: *Alcheringa.*

Teraoka, Y., Sawata, H., Yoshida, T. & Pungrassami, T., 1982,
Lower Paleozoic formations of the Tarutao Islands, Southern Thailand: *Prince of Songkhla University-Geological Research Project Publication*, 6, 1-54.

Yochelson, E.L. & Jones, C.R., 1968,
Teiichispira, a new early Ordovician gastropod genus: *United States Geological Survey Professional Paper*, 613-B, 1-15.

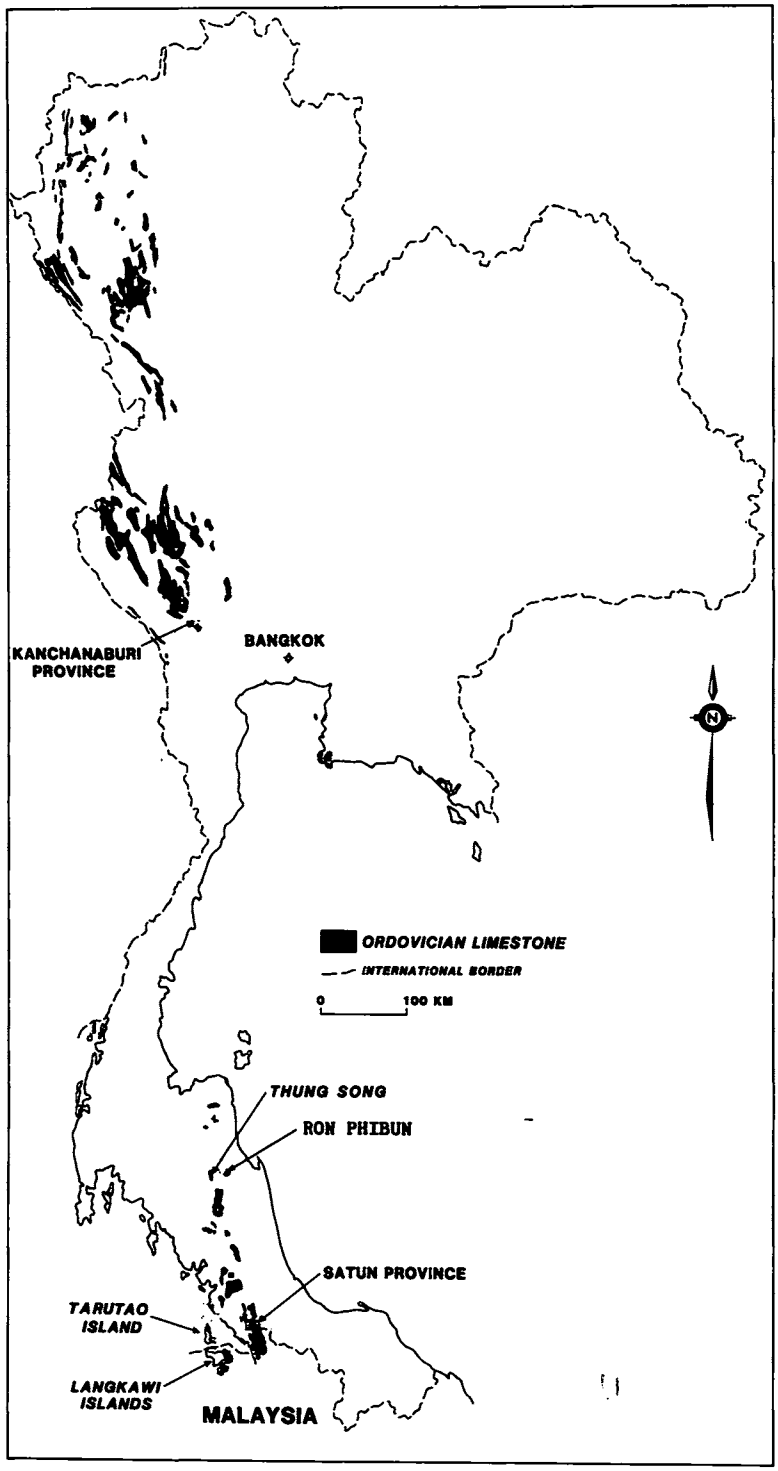

Figure 1. Map showing the location of areas mentioned in the text and the distribution of Ordovician strata in Thailand and Malaysia.

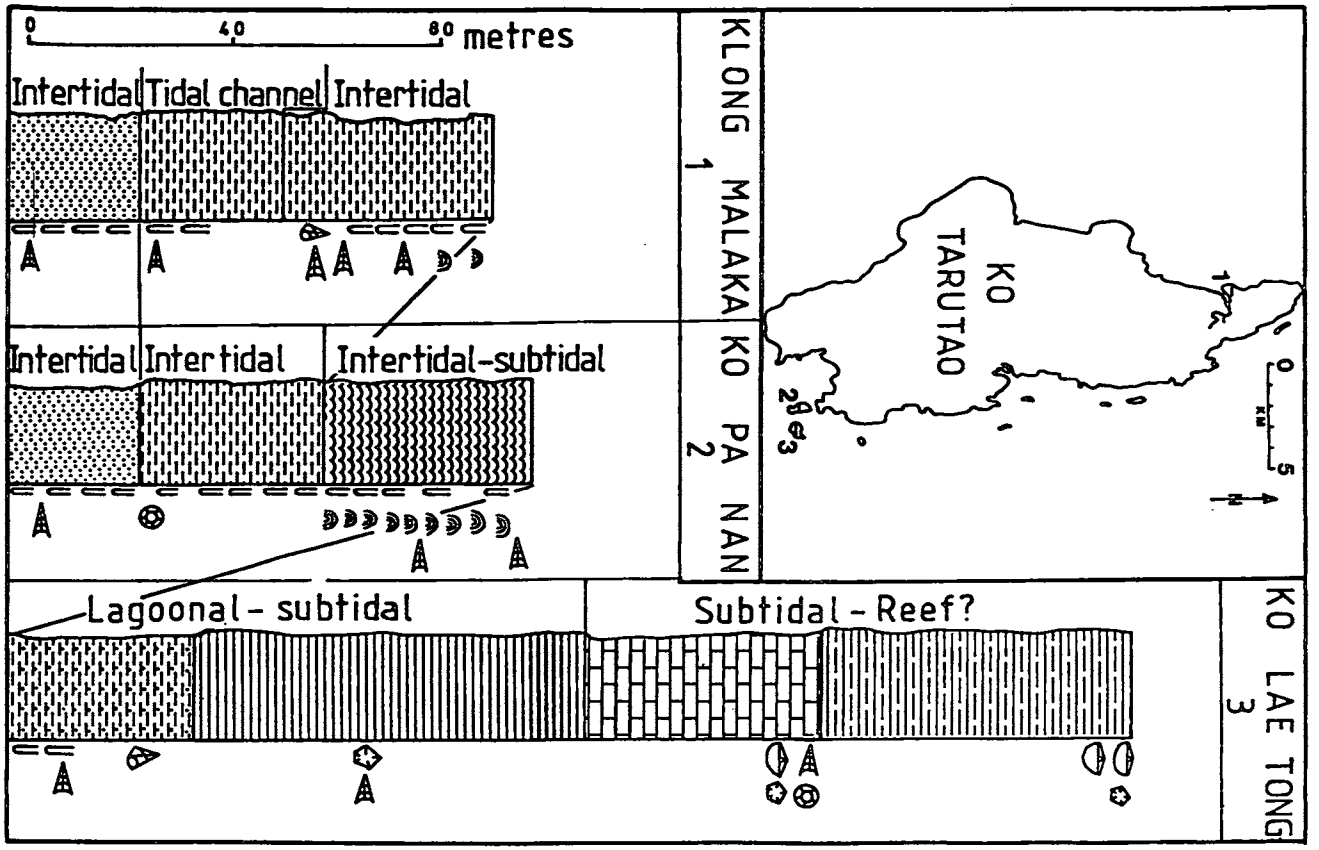

Figure 2. Stratigraphic sections of the Thung Song Formation on Ko Tarutao. The postulated depositional environment, faunal content and lithologic subdivisions are indicated.

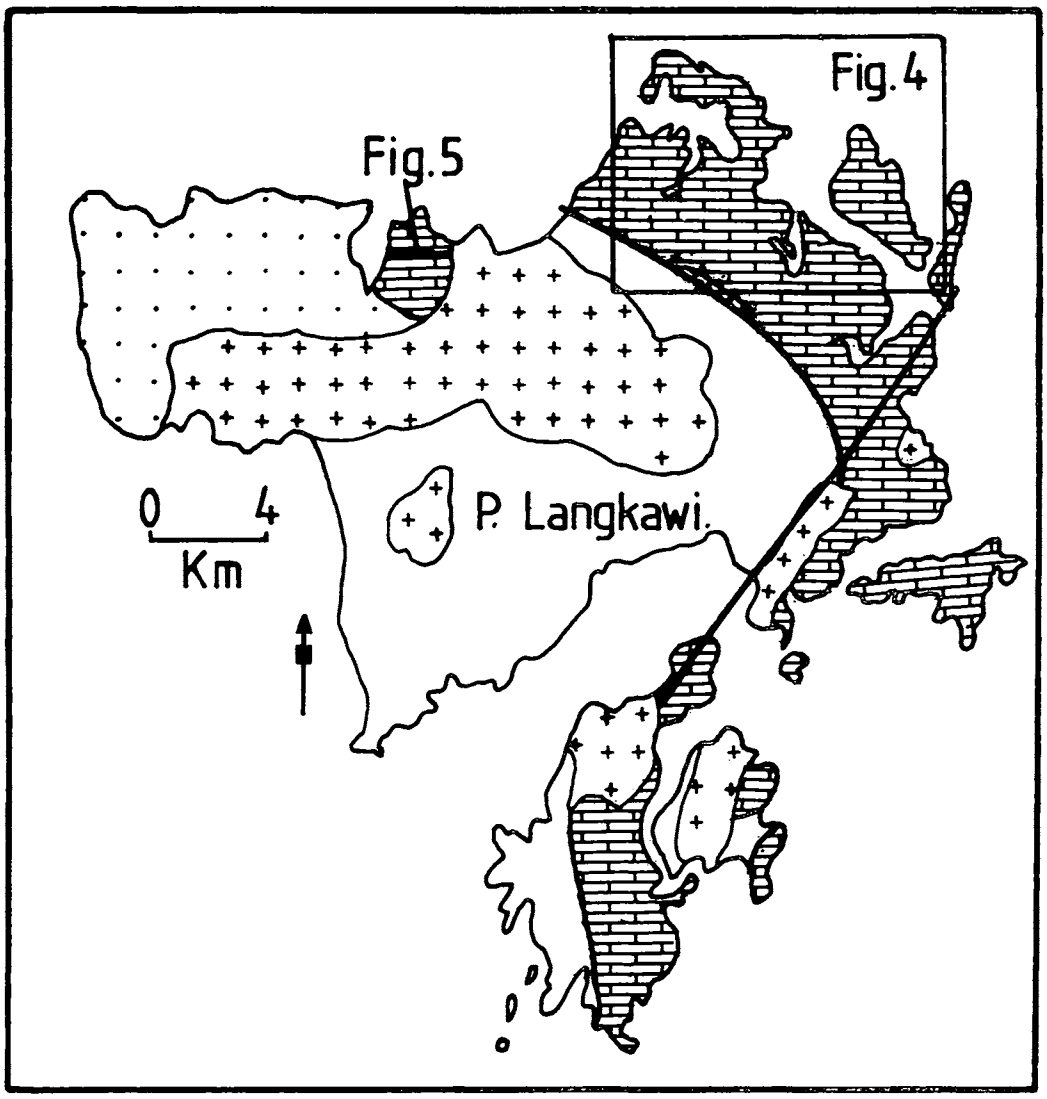

Figure 3. Locality map of Pulau Langkawi with the areas studied indicated.

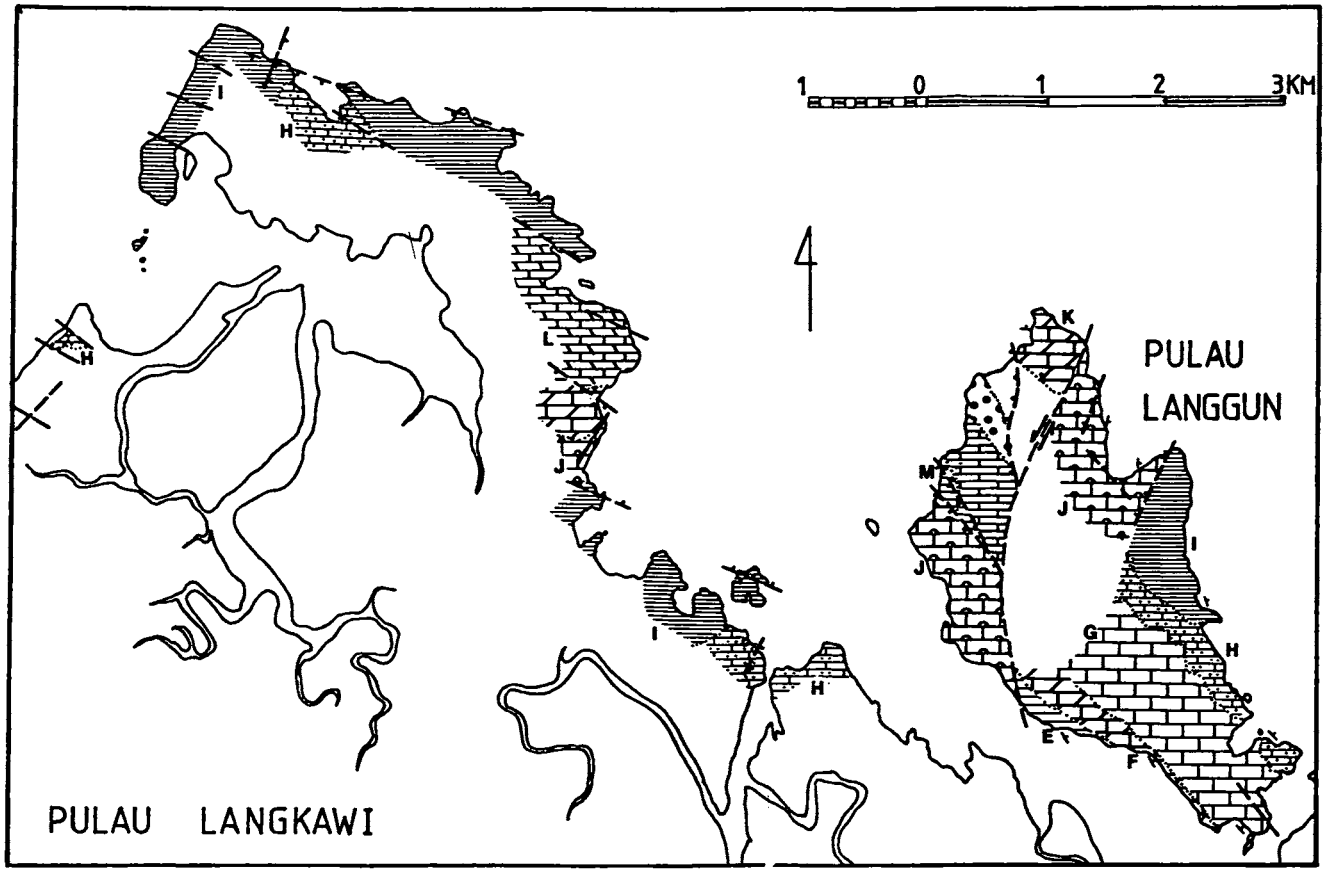

Figure 4. Geological map of North-east P. Langkawi and P. Langgun. The letters refer to the units mentioned in the text.

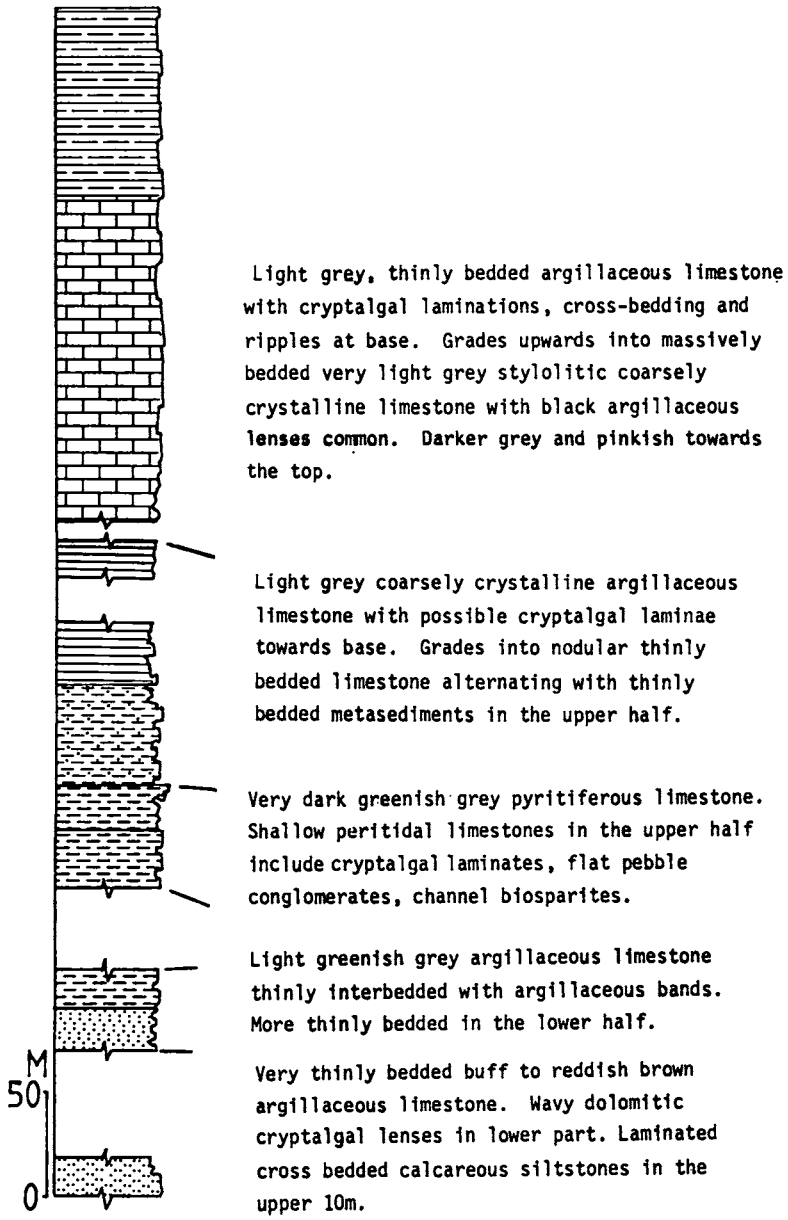

Figure 5. Section through the limestone at north-central P. Langkawi (see Fig. 3). A generallised description of the lithologies present is given.

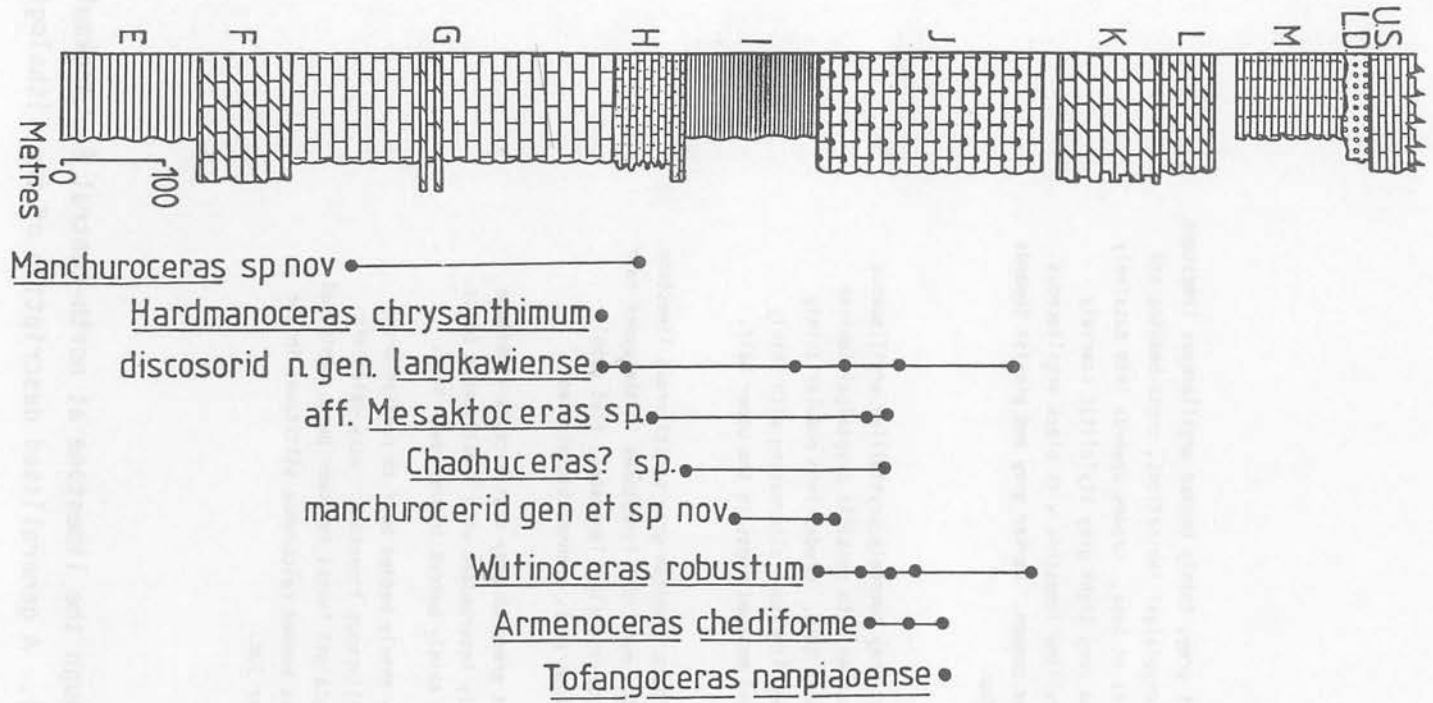

Figure 6. Composite stratigraphic column of the Lower Setul Limestone at north-east P. Langkawi and P. Langgun. The letters refer to the units mentioned in the text, L.D.- Lower Detrital Member, U.S. - Upper Setul Limestone. The ranges of the nautiloids is also indicated.

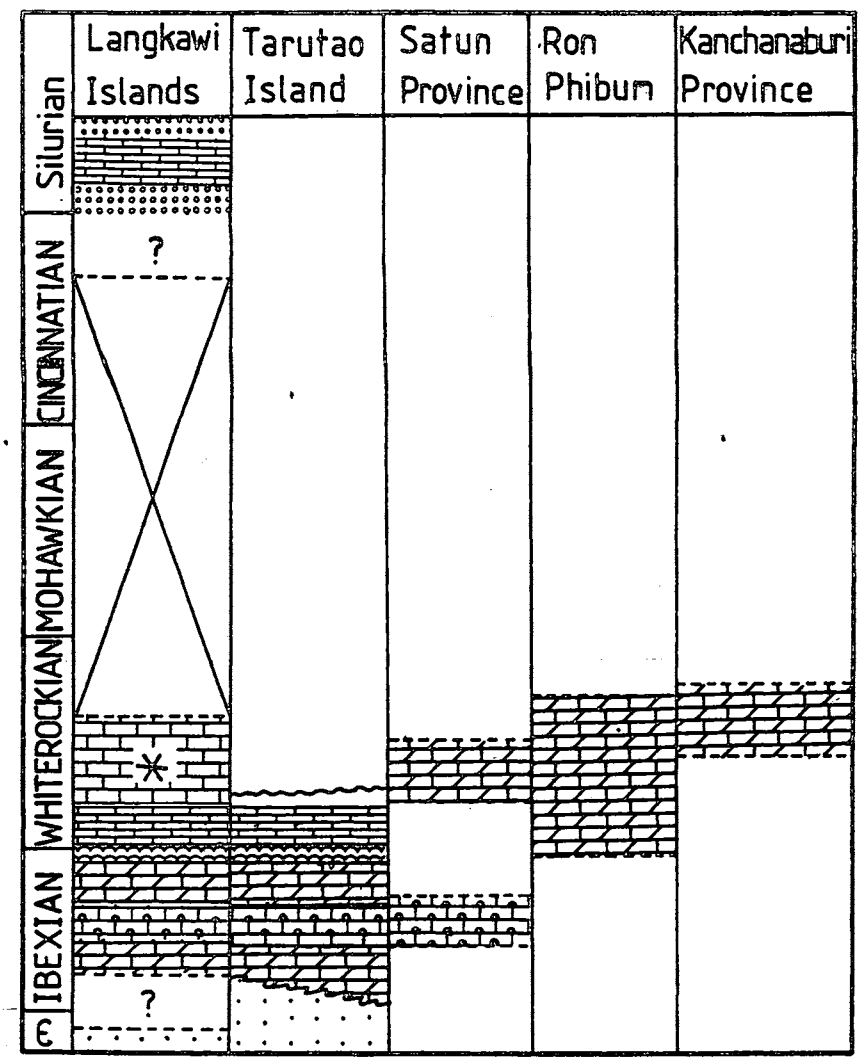

Figure 7. Diagram indicating the biostratigraphic correlations for Malaysia and Thailand. (✳) for details of the subdivision of this part of the column see figure 6.