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The Holocene transgression in Peninsular Thailand

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Abstract: A series of sites along the eastern coast of Peninsular Thailand was investigated using palynology, geomorphology, and C^{14} dating. A fairly clear record of the Holocene transgression has emerged.

The sea-level curve presented here is of the Fairbridge type, that is it includes periods of trangression and regression. It is postulated that the transgression began around 8,500 yrs BP and progressed more or less steadily to a highstand of about 5 m above local mean sea-level at 5,700 yrs BP. A regressive phase occurred then until 4,700 yrs BP when sea-level was at or near its present position. The next 1,000 yrs are unclear because of the possible errors invovled, but it would seem that sea-level fluctuated until 3,700 yrs BP when a stillstand occurred. The sea regressed for the final time at 2,700 yrs BP, the present level being reached at 1,500 yrs BP. The maximum height of the sea is thought to be not more than + 5 m above local mean sea-level. A chronology based upon sea-level changes is presented here.

INTRODUCTION

In the eastern coastal areas of Thailand the most profound event during the Quaternary has been the eustatic sea-level changes. Although these cyclic raising and lowering of sea-levels are glacially or more precisely cosmically controlled (Covey, 1984; Goudie, 1977) they have had tangible effects on more down-to-earth aspects of Thailand. These changes in sea-level heralded modifications in climate, weathering regimes, and landform development. In turn, some economic mineral deposits and more importantly for Thailand, soils and hence agriculture were affected. It may be thought of as a mega- to macro- scale event having effects felt at levels of finer and finer resolution until the lives of ordinary coastal rice farmers are affected. Additionally, the development of some cultural aspects of Thailand was also influenced. Many of Thailand's ancient population centres, Ayuthaya for example, were founded at or near former Holocene shorelines. Knowledge of the timing of events of the Holocene transgression should therefore have some applications towards understanding Thailand's historical and social development.

The most recent of these happenings, the Holocene or Flanderian transgression, occurred here about 11,000 yrs BP as first reported by Biswas (1973). It is the most readily studied and as such should provide some information concerning similar Pleistocene eustatic sea-level changes (Biswas, 1973). In the past few years several studies have at a local level examined various aspects of this event (Dheeradilok *et al.*, 1984; Hastings, 1983; Kaewyana and Kruse, 1981; Nutalaya and Rau, 1981; Pramojanee and Hastings, 1983; Sawata *et al.*, 1983; Sinsakul and Jongkongyanasoontorn, 1984; Sinsakul *et al.*, 1983). This paper is a first attempt in Thailand to address this event on a broad scale. The authors hope that in doing this we may contribute information towards a truly regional, that is SE Asian wide, correlation of this important event.

In order to undertake this study an integration of various disciplines, within and without the Earth Sciences, was needed. In addition to the more traditional methods of geomorphology, stratigraphy, and palynology, radiometric dating and computer-based data management were also used. Geomorphology provided a framework of landforms that aided in selecting sites for investigation. Stratigraphy provided the methods to describe and correlate the sediments encountered. Palynology's role was in delineating some of the depositional environments and especially in locating the carbon-14 samples in relation to past sea-levels. Radiometric dating and computer matching of each site's stratigraphy allowed us to correlate all of the above more rapidly and, we fell, more accurately. Although this type of integrated work has been previously attempted (Pramojanee and Hastings, 1983) it is the first time this has been done on such a scale. The authors hope that this kind of integrated study will become standard practice in future Quaternary research projects.

FIELD WORK

The field work for this study took place along the eastern coast of Peninsular Thailand from the province of Chumporn south until Pattani (Fig 1). This amounts to about 600 km of coastline investigated. The work involved drilling transects totalling 55 sites, in various landforms perpendicular to the present coastline. Descriptions were made of the sediments encountered using standard soil survey techniques (texture, pH, colour, mottles, macro-fossils, etc.) and samples collected for later C^{14} dating and pollen analysis. Drilling was usually terminated upon reaching a stiff, mottled sediment characteristic of subaerial weathering. It is widely held that this type sediment represents the weathered Pleistocene land surface which was uncovered during the last full glacial period. Carbon-14 dating (19,000–43,000 yrs BP) of samples recovered from this type of sediment supports this contention (Pramojanee *et al.*, 1984). The thickness of the Holocene sediments has considerable variation (> 11 m to < 2 m) even though they average around six metres. The stratigraphy of these sediments will be described below.

PALYNOLOGY

Selected samples, collected by means of a piston corer or gouge, were analysed for pollen content and type. The samples were processed at the Botany Department of Chulalongkorn University, Bangkok, using standard maceration procedures. Pollen diagrams were constructed for each sample in order to facilitate interpretation. The major categories for each diagram was based on present day coastal vegetation catena as shown in Figure 2. This catena is founded primarily upon work done by Santisuk (1983), the Royal Forestry Department, Bangkok, and Watson's (1928) inundation classes for coastal vegetation.

In general each sample analysed for pollen content could be classed into one or more of the categories of the vegetation catena as mentioned above. The samples collected from basal peats above the Pleistocene land surface and below the marine sediment consistently reflected increasing salinity conditions by an increase in the amounts of pollen types associated with the Swampy Mangrove vegetation. This is obviously due to a rising sea-level. These basal peats are thought to have primarily

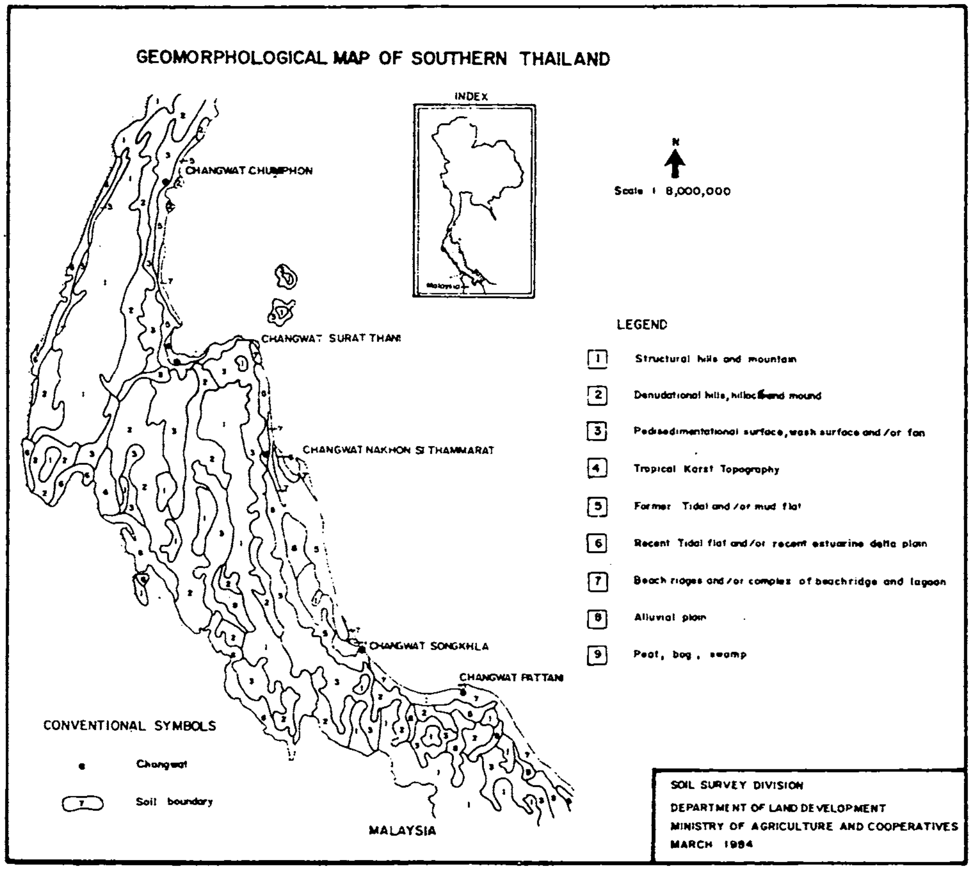

Fig. 1. Geomorphology and location of study area.

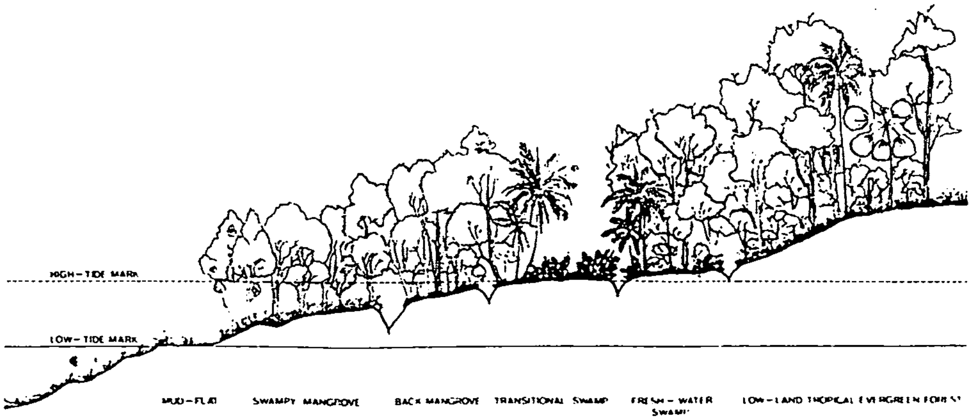

Fig. 2. Coastal vegetation catena.

been deposited under a tidal flat/swamp environment. Samples from above the marine clay usually showed a decline in salinity conditions with a vegetation (as reflected by the pollen content) similar to Back Mangrove to Transitional. These samples probably reflect a stable or falling sea-level. As with the basal peats above, these samples are thought to have been deposited under a tidally influenced environment. Additionally some samples, for example site 15, contained high amounts of pollen types associated with riverine plant types (*Barringtonia, Ilex,* etc.) which are interpreted to be alluvial deposits. These samples have possibly been reworked making the information concerning past sea levels derived from these suspect.

In the interests of brevity and considering the scope of this paper no pollen diagrams will be presented here. Rather an assessment of each C^{14} dated sample's environment will be presented in Table 2. The position of each dated site relative to past sea-level was determined by the type of vegetation as indicated by pollen analysis, that existed at the site.

GEOMORPHOLOGY

In general, the landforms of Peninsular Thailand can be divided into five geomorphological units (Fig 1):

1) structural origin
2) denudational origin
3) marine origin
4) fluvial origin
5) Tropical karst topography

The structural origin landform is the more or less continuous mountain range forming the backbone of the Peninsula from north to south. It is composed of many rock types but mainly Cretaceous granite. Comparatively lower in elevation, one finds the other main rock type, Mesozoic sedimentary rocks. This bedrock is found mainly in the middle portion of the Peninsula. Locally, due to tectonic movement, distinct structural landforms, e.g. fault line scarps, various kinds and degrees of folding, tilting beds, can be observed. The elevation of this landform type ranges from 400–1600 m asl.

At a generally lower elevation on either side (west and east) of the structurally derived landforms one finds the denudational origin type. This unit is characterized by hilly to rolling and undulating topography with elevations of 50–300 m asl. This landform can be subdivided into two major types, denudational hills, hillocks, and mounds, and pedisedimentational surface and/or fan. The denudational hills, etc. is the landform formed by the residual weathering of bedrock or the local alteration of residually weathered bedrock. The pedisedimentational surface/fan was formed by the deposition of transported material brought down from the higher adjacent landforms by means of various processes other than fluvial.

The next major group of landforms is marine in origin. Due to tectonic movement, the marine landforms of the west and east coasts are clearly different. Often referred to as an emergent shoreline, the east coast is characterized by a distinct sequence of beach ridge and lagoonal and/or former or recent tidal deposits. The marine terraces, generally clearly distinguished, are in some places obscured by younger sediments or otherwise destroyed by subsequent erosional processes. Geomorphologically, the sequences of beach ridge and lagoonal deposit landforms are thought to have developed when sea-level was stable and/or regressing. From evidence from this study and others in coastal Thailand (Sinsakul *et al.*, 1983), this landform is believed to have developed since the stillstand at 3,700–2,700 yrs BP.

The submergent west coast is generally characterized by steep cliffs, abundant offshore islands and estuarine delta plains. A sharp boundary exists between the lowland young marine sediments, mostly estuarine, and the older upland types. All of the estuarine delta plains are still tidally influenced. C-14 dating of sediment from the estuarine plain at local mean sea level yielded an age of about 1,500 yrs BP. It can be concluded from this that the formation of the delta plain in this region was relatively young.

On the west coast, dependending upon the coastal environment, there exists a few narrow sets of beach ridge and lagoonal deposits similar to the east coast system landforms. There is no marine terrace present on the west coast of Thailand.

The alluvial plain landform is present as a long narrow strip bordering the major rivers in the region. The topography is flat to nearly flat and has an elevation ranging from 2–10 m asl. This landform is generally the most productive agriculturally.

Tectonic activity, local fault displacement, or differential resistance may be responsible for the outcrop of Permian limestone on which the karst topography is developed. This landform is clearly distinguished in the middle portion of the west coast. It is characterized by undulating to rolling topography, deep red clayey soils, and abundant limestone haystack or pepino hills. This landform is especially suitable for agriculture.

STRATIGRAPHY

In general, the stratigraphy of the Holocene sediments in Peninsular Thailand can be divided into three broad categories which are termed marine, transitional and brackish.

The marine type is the lowermost of the three and is usually greenish, glauconitic clayey sediment having a high pH (8.0 or higher). Within this sediment is generally layers of shells or shell hash. This type directly overlies the eustatic peat layer which is bottommost of the Holocene sediments. Pollen analysis as stated above indicates that this peat was formed as a tidal swamp which was rapidly submerged as the Holocene transgression progressed. It is included in the marine type category mainly for convience though it probably was more like the brackish type when it was originally deposited. The marine type sediment is thought to have been deposited under nearshore, shallow, quiet water conditions.

The transitional sediment class is usually composed of three types of sediment;

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¦========¦
¦^^^^^^^^¦ )SILTY/PEATY   pH < 5.0
¦========¦
¦========¦<---------BRACKISH SEDIMENTS
¦::::::::¦
¦^^^^^^^^¦ )SANDY/SILTY/PEATY  pH = 6.0-7.0
¦========¦
¦::::::::¦<---------TRANSITIONAL SEDIMENTS
¦ C      ¦
¦   C    ¦                              ------
¦        ¦                              ¦ c c¦ SHELLS
¦  C     ¦ )CLAYEY   pH = 8.0           ¦__c_¦
¦        ¦
¦    C   ¦                              ------
¦ C      ¦                              ¦^^^^¦ PEAT
¦        ¦                              ¦____¦
¦   C    ¦<---------MARINE SEDIMENTS
¦^^^^^^^^¦
¦^^^^^^^^¦<---------BASAL PEAT
¦^^^^^^^^¦                              HOLOCENE
~~~~~~~~~~<-------- EROSION SURFACE=====================
¦*   *   ¦                              PLEISTOCENE
¦ *   *  ¦                              ------
¦  *  *  ¦ )CLAYEY  pH = 7.0-8.0        ¦* * ¦ PLINTHITE/
¦ *     *¦                              ¦____¦ RED,BROWN MOTTLING
¦________¦
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Fig. 3. Generalized stratigraphy of Holocene sediments in Peninsular Thailand

sandy, clayey or peaty. Its colour and moderate pH (6.5–7.0) indicate deposition under reducing conditions, probably alluvial. Sandy textures probably being tidal inlets and clayey-peaty textures of back swamps or alluvial plains. Its stratigraphic position is somewhat variable but is usually between the marine and the brackish types.

Brackish sediments is the uppermost type. It's texture is usually peaty or silty and has a low pH (< 5.0). It is postulated that this class was deposited during or just after the stillstand or regression in mid to late Holocene time. These sediments were probably deposited as tidal flats or tidal swamps similar to the eustatic peats found below the marine type as described above.

Figure 3 shows a very generalized stratigraphy for the above types of Holocene sediments found along the eastern coast of Peninsular Thailand.

DISCUSSION

There is by now sufficient evidence to safely conclude that the Gulf of Thailand was dry land prior to the beginning of the Holocene, 11,000 yrs BP (Aleva *et al.*, 1973; Biswas, 1973; Geyh *et al.*, 1979). It was uncovered by an eustatic drop in sea-level on the order of 100–200 m. This lowering of sea-level was caused by the last full glacial event at the polar caps and in much of the Northern Hemisphere (Flenley, 1982; Goudie, 1977). A sketch map of what the Gulf area may have looked like considering a

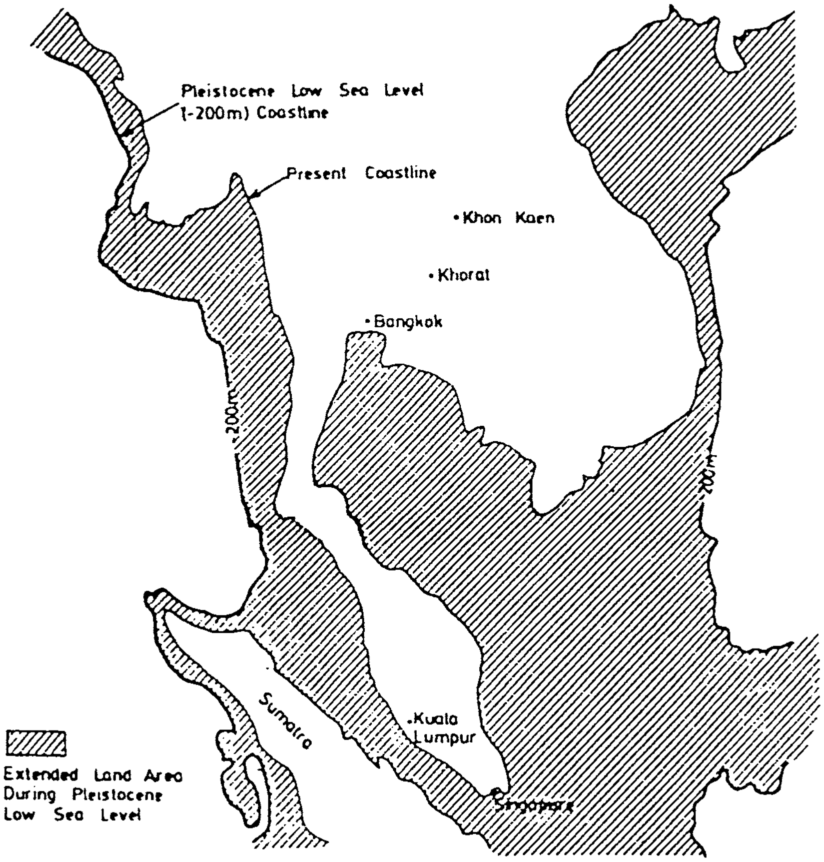

Fig. 4. Sundaland assuming sea-level at − 200 metres.

200 metre drop in the level of the sea is shown in Fig. 4. This vast exposed area was subjected to continental subaerial weathering processes probably operating under a much drier climate than at the present (Flenley; 1981; Hastings and Leingsakul, 1983 & 1984; Loffler *et al.*, 1983; Verstappen, 1980). These weathering processes resulted in the widespread formation of deposits containing plinthite and brown/red mottling and having a firm consistency. Characteristics of this sort are easily recognizable in the field and hence are invaluable as stratigraphic markers for recognizing the former Pleistocene land surface (Dheeradilok and Kaewyana, 1983).

Evidence for former sea-levels is presented in Table 1. These are plotted as a sea-level curve in Figure 5. The data presented in Figure 5 was plotted relative to local 'mean' sea-level. Each vertical error box was constructed using local tidal ranges, leveling/compaction (1–5 %) errors and where available, pollen analysis. Tidal range, any post-depositional compaction and the leveling method used caused the vertical error box to expand while pollen analysis would help to compress it. The horizontal

TABLE 1

SEA-LEVEL INDICATORS IN THAILAND.

SITE	MAP	GRID	SAMPLE TYPE	ELEVATION*	AGE**	NOTES	VEGETATION TYPE	REFERENCE
1	5025 III	386946	1	-8.20 - -7.80	8600±300	-	BM	1
2	5334 IV	901172	2	-1.90 - -0.90	8400±1300	-	LTF	2
3	5136 IV	748308	3	-6.50 - -4.50	8140±180	-	BM	1
4	5136 IV	748308	3	-6.40 - -4.40	7330±90	-	BM	1
5	5023 I	570875	1	-0.90 - -0.60	7540±80	-	T(R)	1
6	4625 I	431198	2	-4.50 - -1.50	7340±80	1		3
7	5222 IV	427327	1	+3.80 - +4.20	6520±80	-	FS-T	1
8	5023 I	589106	1	-0.90 - +0.90	6600±150	-		10
9	5023 I	569176	1	-3.40 - -1.20	6380±140	-		10
10	5222 IV	341555	1	+2.30 - +2.70	6170±100	-	T	1
11	5025 III	283937	1	-5.50 - -5.70	6100±100	-	T	1
12	5025 III	152075	1	-4.40 - -4 80	6100±190	-	BM	1
13	5024 IV	231799	1	-1.30 - -0.40	6080±100	-	BM	1
14	5023 I	548027	1	+2.30 - +0.40	5880±90	-		10
15	5025 III	178931	1	+0.80 - +1.60	5800±110	-	T(R)	1
16	5222 I	729538	1	-3.70 - -2.90	5850±270	-	??	1
17	4625 I	422216	5	+4.70 - +1.70	5730±80	2		3
18	5025 III	160915	1	+0.40 - -0.40	5530±180	-	S-BM	1
19	5037 II	538524	2	+1.60 - -1.60	5500±50	3		5
20	4829 III	144180	1	+4.40 - +2.60	5430±130	-	BM	1
21	5025 III	289937	1	-6.00 - -5.50	5400±100	-	SM-ShMa	1
22	5023 I	582026	1	+1.60 - +0.60	5400±90	-		10
23	5023 II	634882	1	+1.50 - +0.50	5320±180	-	T-BM	1
24	4725 IV	461213	2	-7.10 - -1.10	5140±220	1		3
25	5024 IV	231799	4	+1.90 - +1.40	5120±90	4	FS	1
26	5023 I	180610	2	-2.50 - -0.90	4840±260	-		6
27	4827 IV	267336	1	+0.55 - +1.45	4840±390	-	BM	1
28	5023 I	683044	1	+3.10 - +1.90	4370±90	-		10
29	5234 II	526024	2	+3.30 - +0.70	4250±80	1		7
30	5025 II	386946	2	-3.00 - -1.40	4100±260	1		1
31	4725 III	597243	2	-3.00 - 0.00	4000±80	1		3
32	5321 II	240838	1	+1.60 - +1.30	3780±250	-		8
33	5024 II	205775	1	+1.80 - +1.20	3630±80	-	T	1
34	5235 IV	325984	2	+2.00 - +1.50	3530±280	4		9
35	5321 II	240838	1	+2.20 - +1.85	3200±300	5	BM-T	8
36	4827 IV	247372	1	+2.40 - +0.60	2710±130	-	T	1
37	4828 IV	165020	2	+1.90 - +0.10	2350±70	2		4
38	4625 I	?	1	+1.50 - -1.50	1440±90	-	??	1

* = In meters relative to local 'mean' sea level
** = Radiocarbon years Before Present (yrs BP)
? = Exact grid location not available.

SAMPLE TYPE:
1 = Peat
2 = Shell
3 = Mangrove wood
4 = Freshwater peat
5 = Shell deposit in cave

NOTES:
1 = In open marine sediment, below sea level
2 = Possibly deposited by surge
3 = Intertidal zone
4 = From archaeological site probably above sea level

VEGETATION TYPE:
SM = Swampy mangrove
BM = Back mangrove
T = Transitional swamp
(R) = Riverine influences
ShMa = Shallow marine
LTF = Lower tidal flat
FS = Freshwater swamp
?? = No pollen analysis done

REFERENCES:
1 = This study
2 = Pramojanee and Hastings,1983
3 = Sinsakul and Jongkanjanasoontorn,1984
4 = Personal communication: Kanchit Siribakdi,DMR,1984
5 = Chonglakmani and others,1983
6 = Sawata and others,1983
7 = Sinsakul and others,1983
8 = Hastings,1983
9 = Suchitta,1980
10 = Personal communication: Niran Chaimanee,DMR,1984

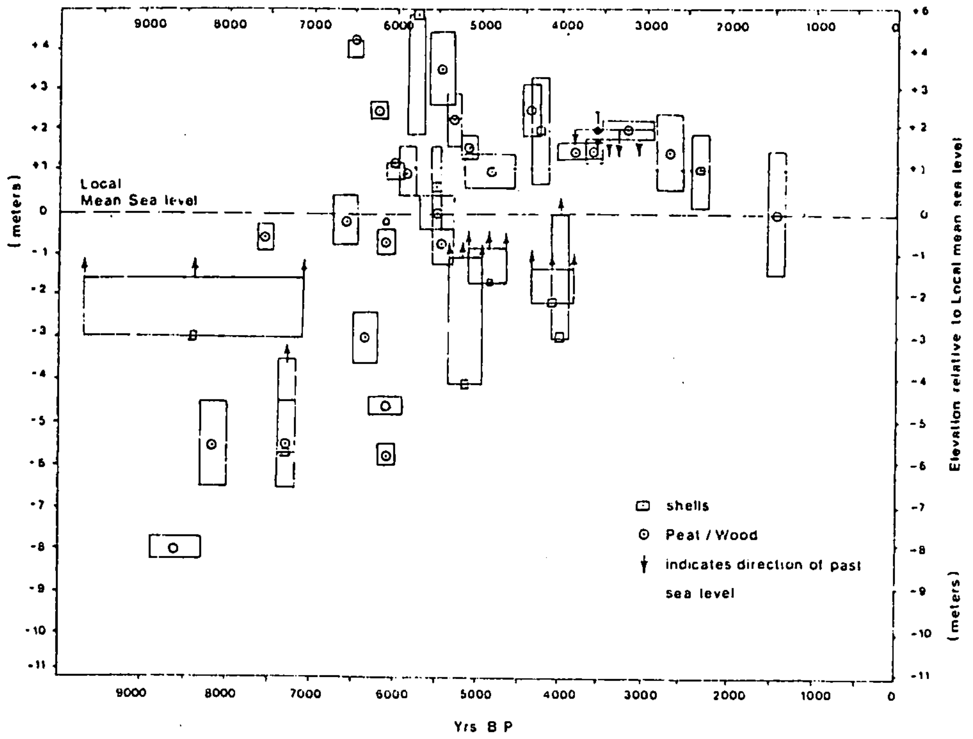

Fig. 5. Tentative Holocene sea-level curve for Thailand (including new data).

error box was based solely on C-14 dating errors of one standard deviation. The C-14 and half-life used was 5568. All samples original to this study were processed at the Office of Atomic Energy for Peace, Bangkok Thailand by Manit Sonsuk.

In the short time since the authors' original presentation at GEOSEA V a veritable explosion of new evidences concerning Holocene sea-levels have occurred, much of it being previously unavailable C-14 dates from sites investigated by the authors. This has forced us to re-think our previous conclusions. The authors' prior contention that the Holocene transgression in Thailand was essentially like that described by Shepard (1963), in that the curve was smooth, is now thought to be erroneous. The new evidence leads the authors to now conclude that the Holocene transgression in Thailand followed a curve similar to that as proposed by Fairbridge (1961) that included regressive phases.

Refering to Figure 5 one can see that the sea-level history in Thailand is rather complex for much of the Holocene. This more-or-less conforms to Fairbridge's ideas about the nature of the Holocene transgression. The transgression began about 8,500 yrs BP and progressed more or less steadily from then until a highstand of around + 4.7 m above local 'mean' sea-level was reached at 5,700 yrs BP. The first's regressive phase began then with sea-level falling until it was at or near it's present position. Sea-level then rose until it reached a height of +2.0 m above local 'mean' sea-level. A stillstand occurred from 3,700 yrs BP until 2,700 yrs BP. The final regressive phase occurred from then until present sea-level was reached around 1,500 yrs BP.

A critical examination of the early part of the curve reveals the erratic nature of the evidence for this time. This is probably due to the bias introduced by the nature of the early Holocene sea-level rise. Much of the evidence is necessarily well below the present sea-level and hence difficult to find. Reference to other studies in Sundaland indicates a steady rise in sea-level (Geyh *et al.*, 1979; Tjia *et al.*, 1977) though its exact nature is still in need of further investigation.

The evidence for the +4.7 m highstand is somewhat questionable. The evidence, a shell deposit inside a cave (Sinsakul and Jongkanyanasoontorn, 1984), might have been deposited by man or perphas by a tidal surge event. Argument for its validity is a wave cut notch at Khao Dang, Lake Songkhla in Songkhla province which was measured at +4.80 m above local mean sea level (Hastings and Liengsakul, pers. comm.). Again reference to another investigation in Sundaland agrees well with a maximum height of around +5 m (Geyh *et al.*, 1979).

The evidence for the first regressive phase after 5,700 yrs BP comes from 10 widely spaced sites, from Chumporn to Nakorn Srithammarat province. Additional evidence can be found in Chanthaburi and Narathiwat provinces. In Chanthaburi, pollen analysis of an undated peat deposit there revealed an anomalous influx of freshwater pollen types in a generally transgressive trending pollen diagram (Pramojanee and Hastings, 1983). The start of the transgression there was dated to 8,400 yrs BP and therefore this regression must have been younger. An oxidized, well-mottled clay was found below a 3,780 year old peat in Narathiwat (Hastings, 1983). The clay was found to contain no pollen or framinifera. It was then theorized to have been a palaeosol in which development was arrested by the Holocene transgression. It now seems more probable that this clay represents a brackish water deposit that was oxidized during a more recent drop in sea-level.

Since the indicators for this regressive phase came from such a large geographic area the authors rule out any local event, such as abnormally high sedimentation rates or tectonics, that would have caused an apparent regression. Though this may be true it must also be stated that this regressive phase may only be a slowing of the rate in sea-level rise. Any reduction of the rate of transgression below coastal sedimentation rates would lead to shoreline out-building and therefore to the formation of progradational or 'regressive' landforms. Whether this portion of the curve represents a true regression or only an apparent one is still open to debate.

It appears that sea-level flucuated from 5,000 yrs BP until 3,700 yrs BP when a stillstand was reached. Owing to the nature of the possible errors involved it is not possible to be more precise about the sea-level then. The curve as a whole appears to be spasmodic, so it is probably not unrealistic to expect to be sapsmodic, so it is probably not unrealistic to expect this trend to continue on a smaller scale. Sea-level fell slowly after 2,700 yrs BP until present sea-level was reached about 1,500 yrs BP.

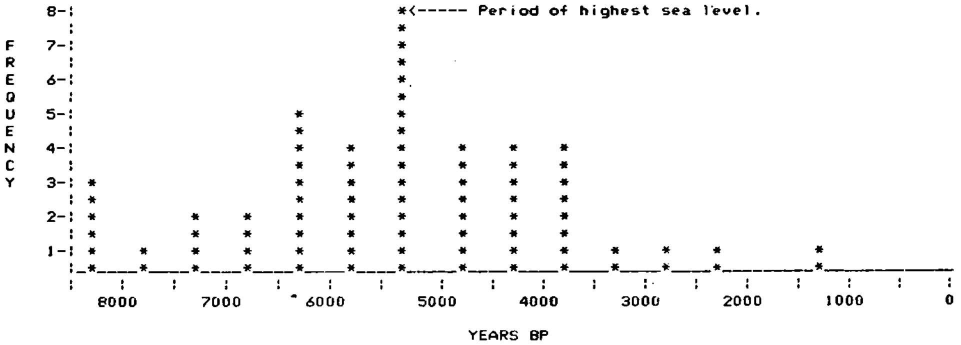

Fig. 6. Frequency of Carbon-14 dates

Figure 6 shows the frequency distribution of the C-14 dates for sea-level indicators from this paper. The high frequency of dates from 5,000–5,500 yrs BP also supports the contention that the highest sea-levels occurred around this time. Since sea-levels would never have been higher, samples from this period stand the greatest chance of being preserved and subsequently recovered.

The overall trend of the rate of sea-level change is one of decline with time. The initial rise in sea-level was 0.44 cm/yr while the first regressive phase had a rate of 0.41 cm/yr. After 4,500 yrs BP the sea rose at a rate of 0.17 cm/yr and the final regression took place at only 0.06 cm/yr. The decline in the rate of sea-level change might be due to a corresponding decline in the rate of glacial melting. Glacial melting like any process that requires energy is subject to the effects of entropy and will slow down with time.

The various sea-level changes discussed above can serve as convenient demarcation lines for sub-dividing the Holocene in Thailand. Figure 7 is a tentative Holocene chronology based on sea-level changes in Thailand. It is hoped that this chronology will be tested against other evidence for Holocene sea-levels as well as evidence for palaeoclimatic and archaeological changes in order to evaluate their possible interdependence.

SUMMARY

An investigation into Holocene sea-levels in Thailand has revealed that the transgression probably followed a pattern similar to one described by Fairbridge (1961). It is theorized that the transgression began about 8,500 yrs BP and progressed more-or-less steadily until a highstand of around + 5 m was reached at 5,700 yrs BP. A regressive phase occurred then until sea-level was at or near its present level. Sea-level probably fluctuated until 3,700 yrs BP when a stillstand occurred. Sea-level fell for the final time after 2,700 yrs BP. The present sea-level was reached at 1,500 yrs BP.

ACKNOWLEDGEMENTS

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TIME*	SUB-DIVISION	EVENT
8500-		Beginning of Holocene transgression.
8000-		
7500-		Steady rise in sea-level
	I	
7000-		
6500-		
6000-		
5500-		Beginning of first regressive phase
5000-	IIa	Steady fall in sea-level
4500-		Rise in sea-level
	IIb	Drop in sea-level **
4000-		
3500-	III	Stillstand
3000-		
2500-		Beginning of last
	IV	regressive phase
2000-		
		Present sea-level
1500-		
1000-		
	V	Present sea-level
500-		conditions
0-		

* In Radiocarbon years Before Present (yrs BP).
**Possible time of sea-level fluctuation.

Fig. 7. Tentative Holocene chronology in Thailand

Bangkok, for his usual excellent job with the C-14 dating. Thanks are due to the Botany Department at Chulongkorn University Bangkok, especially Dr. Obchan Thaithong, for providing the laboratory facilities for processing the pollen samples. We would like to thank Phisit Dheeradilok, Sin Sinsakul, and Woorakon Kaewyana, of DMR Bangkok, for providing information and useful comments. Our thanks are also due to Jos Okkerman and Roeland Hillen, of CCOP Bangkok, for their comments especially concerning the 'proper' way to present sea-level data. Taweesak Verarasilp, our colleague at DLD, provided tremendous support during the beginning stages of the development of our computer data base for the stratigraphy and dating results.

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