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A new evidence of a higher Quaternary sea-level in Langkawi Islands

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Abstract: Shell deposits were observed at a wave-cut notch on the Setul Limestone in Pulau Tanjung Dendang, Langkawi. The elevation of shell deposits is approximately 23 m above the present sea-level. The most reliable sea-level marker is *Saccostrea cuccullata* which is found encrusted on the Setul Limestone. Radiocarbon ages of the two samples *Saccostrea cuccullta* are 6,970 ± 120 and 7,090 ± 100 yr. B.P. This indicates that the maximum Holocene sea-level reached 23 m above the present sea-level during 7,000 yr. B.P. This is the highest sea-level indicator reported in this region. This discovery provides a new information about the sea-level curve prior to 6,000 yr. B.P.

INTRODUCTION

Peninsular Malaysia is part of Sundaland which is tectonically stable during Quaternary (Tjia, 1992). More than one hundred fifty shoreline indicators from Peninsular Malaysia were collected and radiometrically dated (Tjia, 1992). He proposed that prior to the mid-Holocene (5,000 yr. B.P.) sea-level rose from a low position until it reached 4 m elevation during 6,000 yr. B.P. and attained a maximum level at 5 m during 5,000 yr. B.P. After the maximum elevation in mid-Holocene, there was a decrease of sea-level before it reached the present level. However, he noted that there were some anomalous sea-level elevations during 9,510 and 6,550 B.P. which were observed in the Langkawi Islands. Jones (1981) has reported a higher level of undated shell deposits about 9.1 m (30 feet) above the present sea-level at Teluk Kubang Badak, Langkawi

Recently, we discovered a shell deposit at a sea notch about 23 m high above the present sea-level at Pulau Tanjung Dendang. The aim of this article is to report a new evidence of a higher sea-level indicator discovered at Pulau Tanjung Dendang, Langkawi and its significance in the study of the Quaternary sea-level.

GEOLOGICAL SETTING AND THE OUTCROP

The Langkawi Islands are situated at the northwest of Peninsular Malaysia. This area is tectonically stable during Quaternary. Many sea-level indicators have been studied by Tjia (1992). A new site of a higher sea-level was observed at Pulau Tanjung Dendang. Pulau Tanjung Dendang is located in northeast of Langkawi main island (Fig. 1). It is an elongated island with a north-south alignment. The island is composed of the Setul Formation. One third of the island (the northern part) consists of the Middle Ordovician limestone, and another two third (the southern part) comprises the Silurian limestone. These thickly bedded, dark grey limestones are separated by the Lower Silurian Detrital Member. The limestones, and the Detrital Member are well exposed at Teluk China Mati, a small bay facing east. The limestones exhibit typical karst topography, high terrain with vertical cliffs, high caverns with stalactites at the north end of the island. Several small narrow strip of beaches are only exposed during low tides.

There is a vertical limestone cliff strikes southwest-northeast crossing the island from Teluk China Mati rocky beach. A wave-cut notch was observed at the height of 23 m above the present sea-level. An approximately 15 m long and 6 m wide of marine shell bed exposed below the wave-cut notch at the south end of the cliff (Fig. 2).

There are three types of the sea shell occurrences observed at this locality *viz*.

i. a 30 cm high colony of *Saccostrea cucculata* (Born) which is encrusting to the wall of the wave-cut notch (Fig. 3; Pl. 1, figs. 1a, 1b).
ii. an assemblage of marine shells cemented to the wall and the roof of the wave-cut notch that consists of fragments of poorly preserved bivalves and gastropods,
iii. a bed of sea shells at the base of wave-cut notch which comprises *Anadara granosa* (Linnaeus), *Anadara* sp., *Barbatia bicolorata* (Dillwin), *Geloina ceylonica* (Lamarck), *Spondylus butleri* (Reeve), *Isognomon isognomon* (Linnaeus), *Ostrea* sp., *Nerita* sp., *Hyotissa hyotis forma sinensis* (Gmelin), *Telescopium telescopium* (Linnaeus), *Goniopora malaccensis* (Brueggermann), and *Balanus* sp. (Plates 1 and 2). The thickness of the bed is 70 cm. Most of the valves of the Bivalvia are arranged in such a way that the convex side is facing towards the top and forming imbrications (Fig. 4). This indicates that the deposition of the marine shells was subjected to the wave actions. This assemblage was later cemented and preserved under a 6 metres high limestone tower (Fig. 2).

SACCOSTREA CUCCULLATA AND SEA-LEVEL

Saccostrea lives in tropical and subtropical waters of normal marine salinities, 35.1–35.45‰ (Moore, 1971). *Saccostrea cuccullata* is a species known as rock oyster (tiram batu) which is found growing and encrusted on hard rocks in the intertidal zone. It is commonly found at the base of the sea notch that exposes to the heavy wave actions. It lives in an extremely severe environment. During

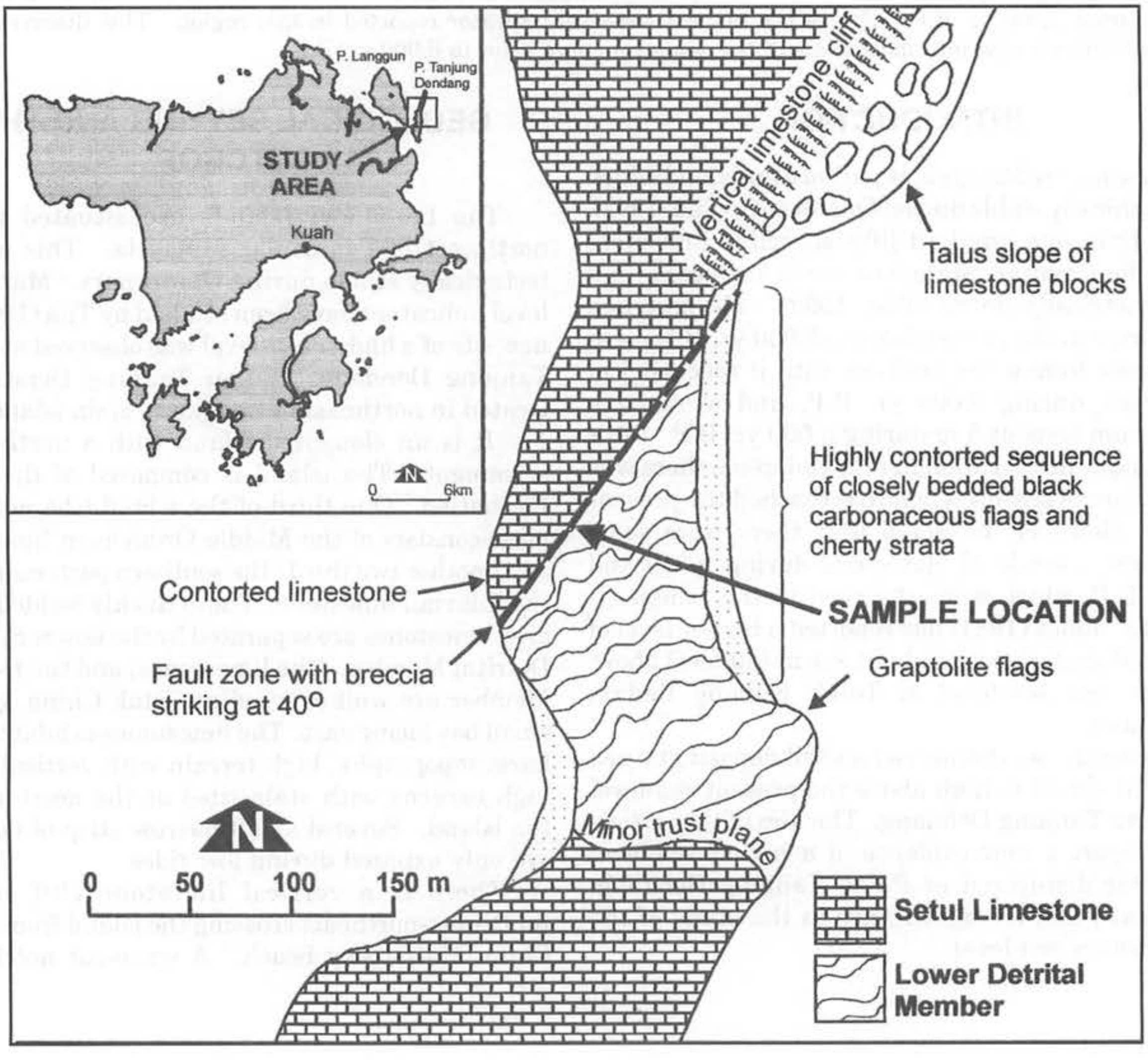


Figure 1. Geological map of the middle part of Pulau Tanjung Dendang showing sample location (after Jones, 1981).

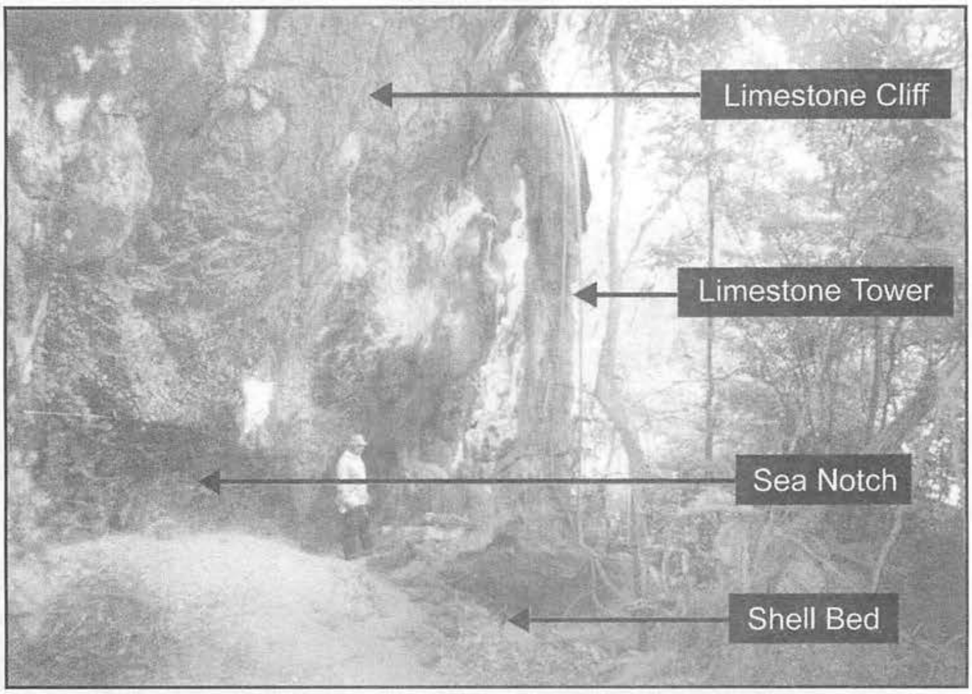


Figure 2. Photograph of the study site showing limestone cliff, tower, sea notch and shell bed.

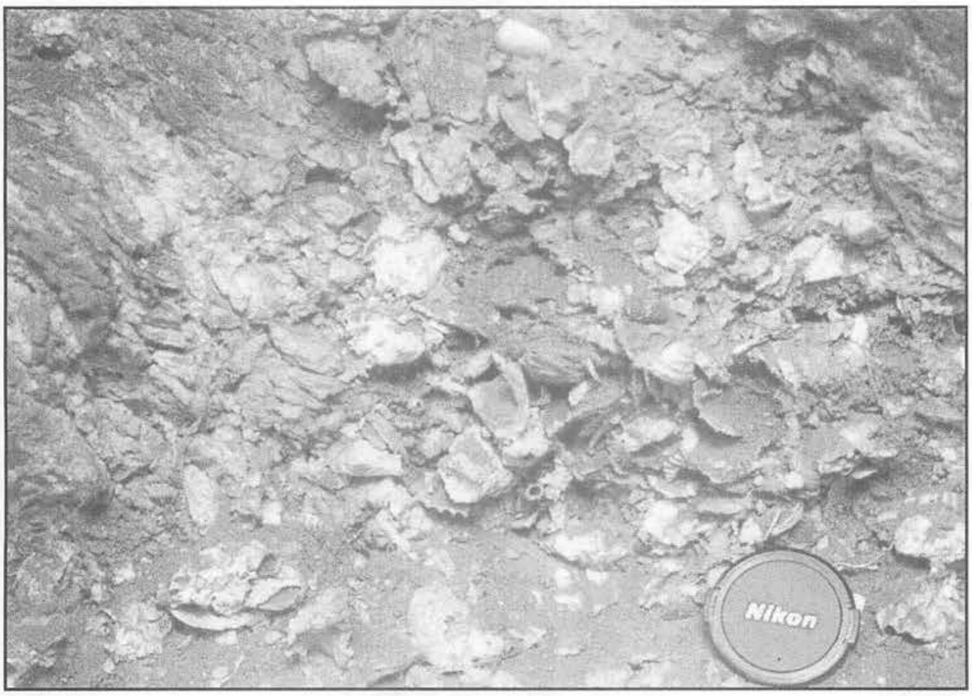
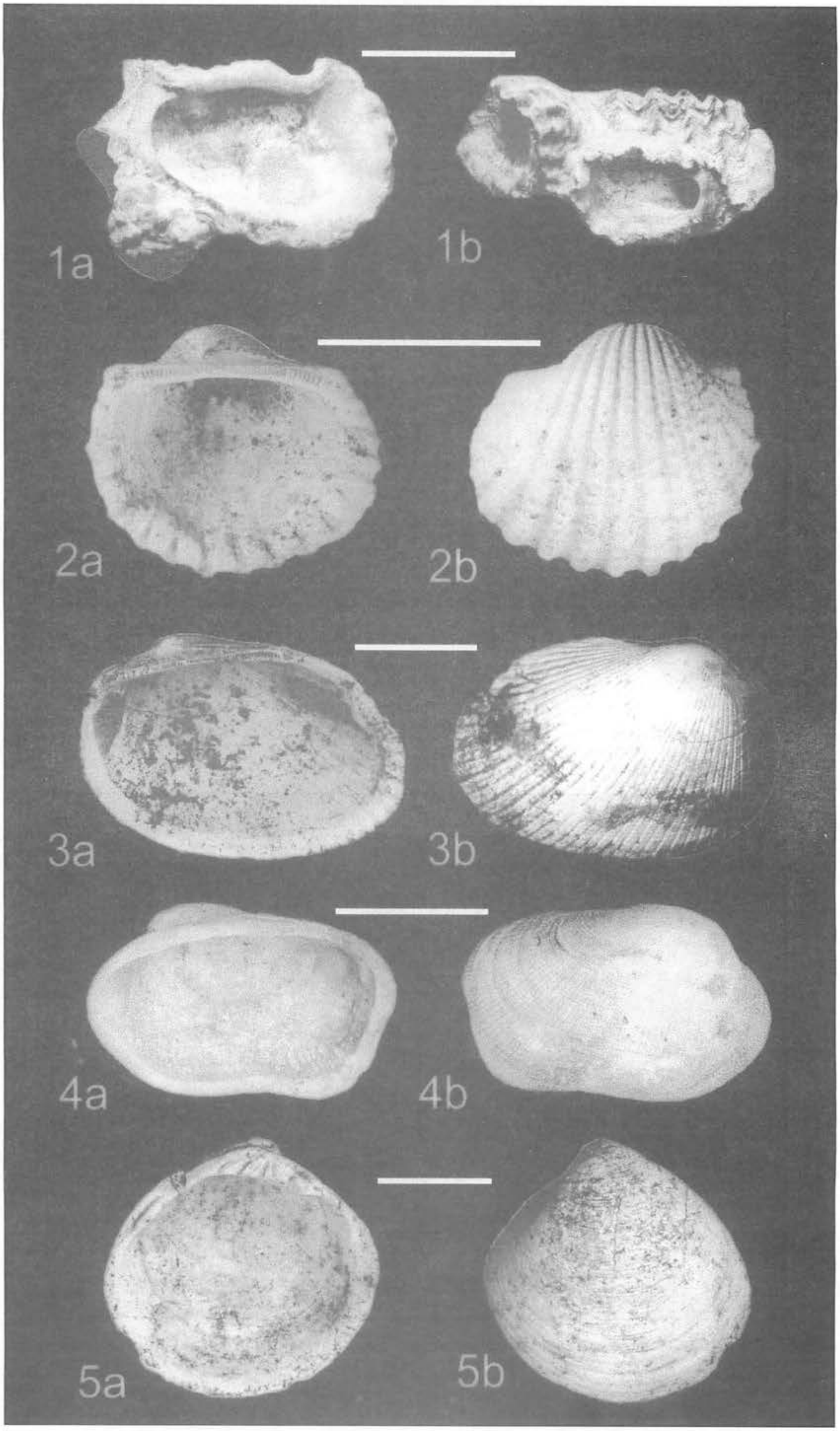


Figure 3. *Saccostrea cucullata* encrusted on the surface of Setul Limestone.


1a
1b
2a
2b
3a
3b
4a
4b
5a
5b

low tides it is exposed to air and direct sunlight, and the shells must remain closed. *Saccostrea cuccullata* is a most reliable ancient sea-level indicator.

THE AGE OF *SACCOSTREA CUCCULLATA*

Two samples of encrusted *saccostrae cuccullata* (L-940482-1 and l-940482-2) that each one consists of several shells weighing 100 g, were sent to Teledyne Brown Engineering, United States of America for radiocarbon age dating. Radiocarbon ages of the two samples are listed below:

Sample	Age in yr. B.P.
l-940482-1	6970 ± 120
l-940482-2	7090 ± 100

The ages of the two samples are not much different and therefore we conclude that *Saccostrea cuccullata* gives a reliable radiocarbon ages which can be utilised for the study of sea-level.

DISCUSSION AND CONCLUSION

The occurrence of *Saccostrea cuccullata* at a sea notch in the Teluk Cina Mati area is considered natural because the shells were found in growth position encrusted in the Setul Limestone. Colonies

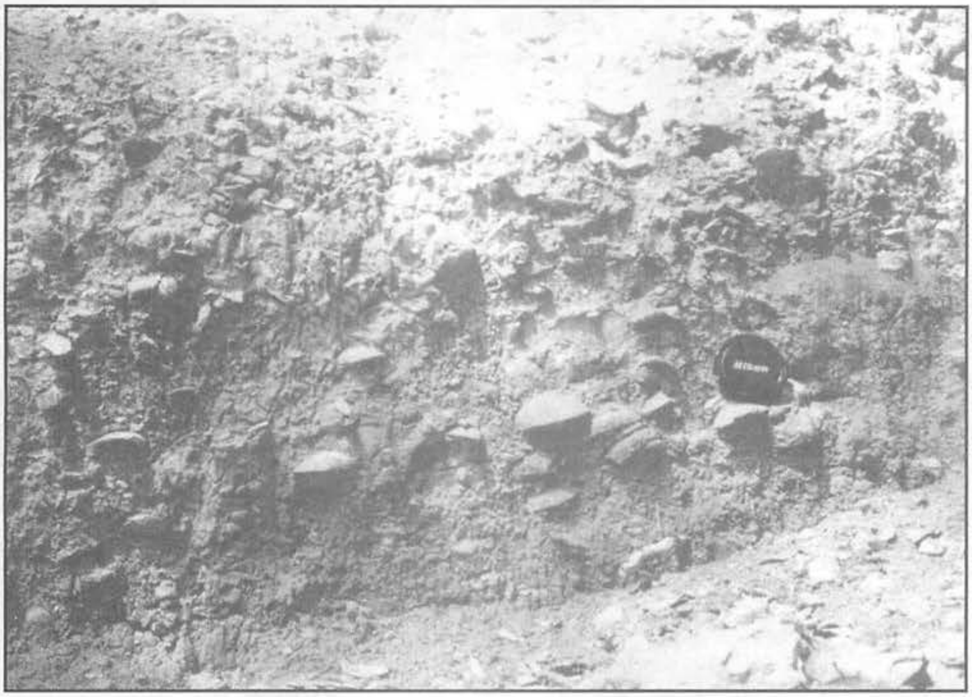


Figure 4. Shell bed showing some shell imbrications.

Plate 1. Scale bar = 3 cm for each specimen

1. *Saccostrea cuccullata* (Born),
   - 1a. interior view of the left valve
   - 1b. side view of the left valve
2. *Anadara granosa* (Linnaeus)
   - 2a. interior view the right valve
   - 2b. exterior view the right valve
3. *Anadara* sp.
   - 3a. interior view the right valve
   - 3b. exterior view the right valve
4. *Barbatia bicolorata* (Dillwin)
   - 4a. interior view of the right valve
   - 4b. exterior view of the right valve
5. *Geloina ceylonica* (Lamarck)
   - 5a. interior view of the left valve
   - 5b. exterior view of the left valve

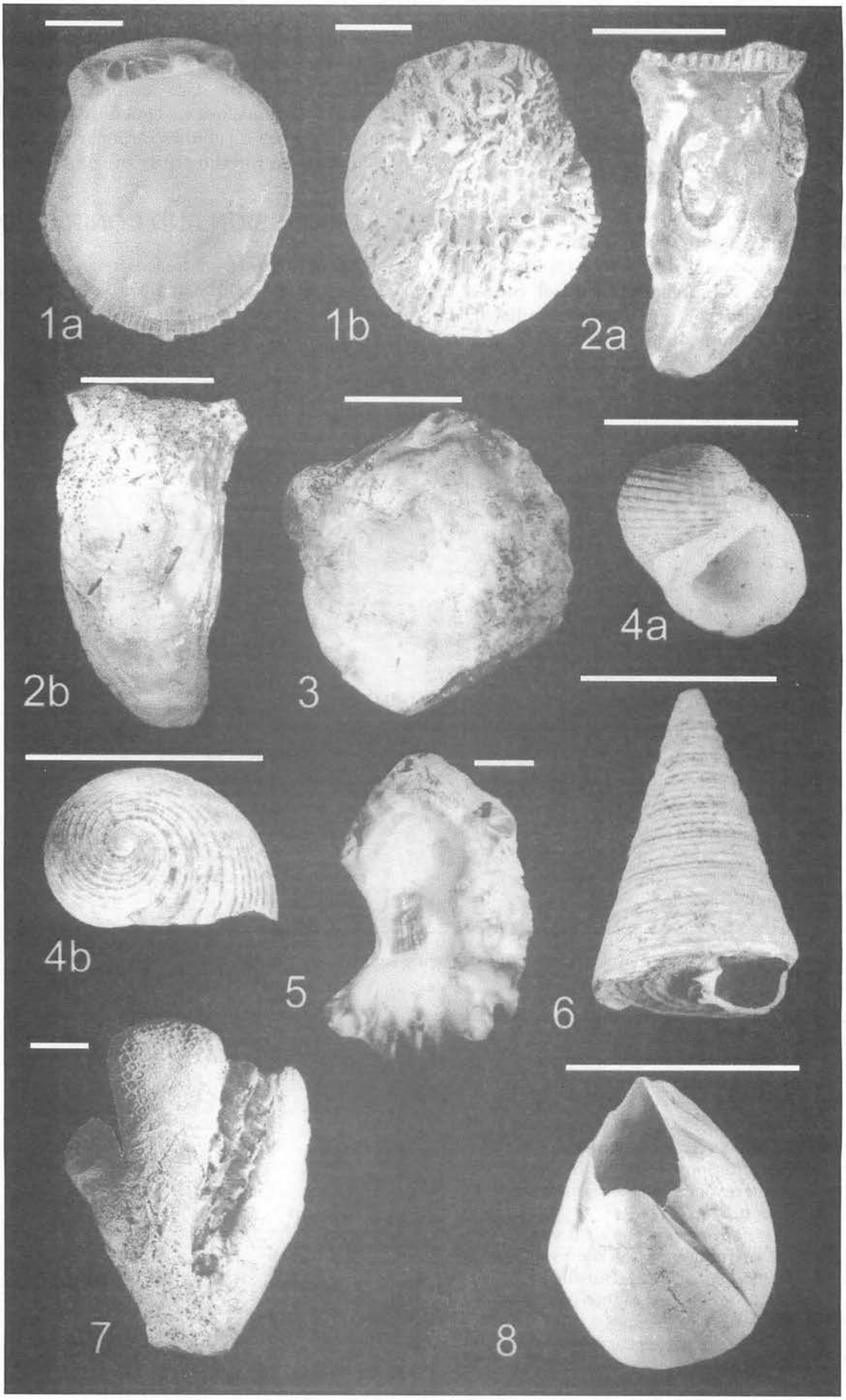

1a
1b
2a
2b
3
4a
4b
5
6
7
8

Figure 5. Paleogeography of the Langkawi Islands during 7,000 yr. B.P.

Plate 2. Scale bar = 3 cm for each specimen

1. *Spondylus butleri* (Reeve)
   - 1a. interior view of the left valve
   - 1b. exterior view of the left valve
2. *Isognomon isognomon* (Linnaeus)
   - 2a. interior view of the left valve
   - 2b. exterior view of the left valve.
3. *Ostrea* sp., interior view of the left valve
4. *Nerita* sp.
   - 4a. apertural view
   - 4b. dorsal view
5. *Hyotissa hyotis forma sinensis* (Gmelin), interior view of the left valve
6. *Telescopium telescopium* (Linnaeus), side view.
7. *Goniopora malaccensis* (Brueggermann), side view
8. *Balanus* sp., dorsal view.

of *Saccostrea cuccullata* together with imbricated marine shell deposits were observed at an elevation of 23 m above the present sea-level. If this is true, many coastal area of the Langkawi Islands was submerged during 7000 yr. B.P. (Fig. 5). This is the highest Holocene transgression level ever reported in Langkawi and also in Peninsular Malaysia.

The data are not compatible with the Quaternary sea-level curve of Peninsular Malaysia by Tjia (1992). The curve shows that highest transgression was about 5,000 yr. B.P. where the sea-level was at the elevation of 5 m above the present sea-level. After reaching the maximum, the sea-level started to regress step-wise before reaching the present level. Geyh *et al.* (1979) recorded the maximum transgression in the Strait of Malacca between 5,000 and 4,000 yr. B.P. reached 5.8 m above the present sea-level. Tjia (1992) compared his data from the Langkawi Islands to those of Geyh *et al.* (1979) from the southern Malacca Strait. He concluded there were differences in the elevations of sea-level prior to 5,000 yr. B.P. between the two areas. It is evident, that the elevation of the sea-level is not the same even in a small area such as the Strait of Malacca.

Sinsakul (1992) constructed a Holocene sea-level curve for coastal area of Thailand. There was a steady rise in sea-level from 8,000 yr. B.P. to 7,000 yr. B.P. and reached a maximum height during 6,000 yr. B.P. where the sea-level was 4 m above the present sea-level. Somboom and Thiramongkol (1992) have studied the evolution of shoreline of the Chao Phraya delta, Thailand. They concluded that the maximum Holocene transgression took place around 6,500–7,300 yr. B.P. where the sea covered most of the present Chao Phraya delta to as far as north of Ayuthaya (approximately 70 km north of Bangkok).

The data that we obtained from *Saccostrea cuccullata* in this study are not compatible with both Tjia and Sinsakul sea-level curves. Both sea-level curves also vary in the time of the maximum transgression and the elevation of sea-level. Based on our discovery, the Holocene maximum transgression was reached during the 7,000 yr. B.P. where the highest sea-level was at 23 m above the present sea-level. The ages of the maximum transgression in the Langkawi Islands are agreeable to that of Somboom and Thiramongkol (1992).

Tjia (1992) mentioned there were four data which were not compatible with his sea-level curve. Those data were obtained from several samples of corals and rock encrusted oysters from Langkawi Islands. The two samples of corals which attached to the Setul Formation at elevations 2.4 m and 3.4 m gave the radiocarbon ages of 8,320 ± 160 yr. B.P.

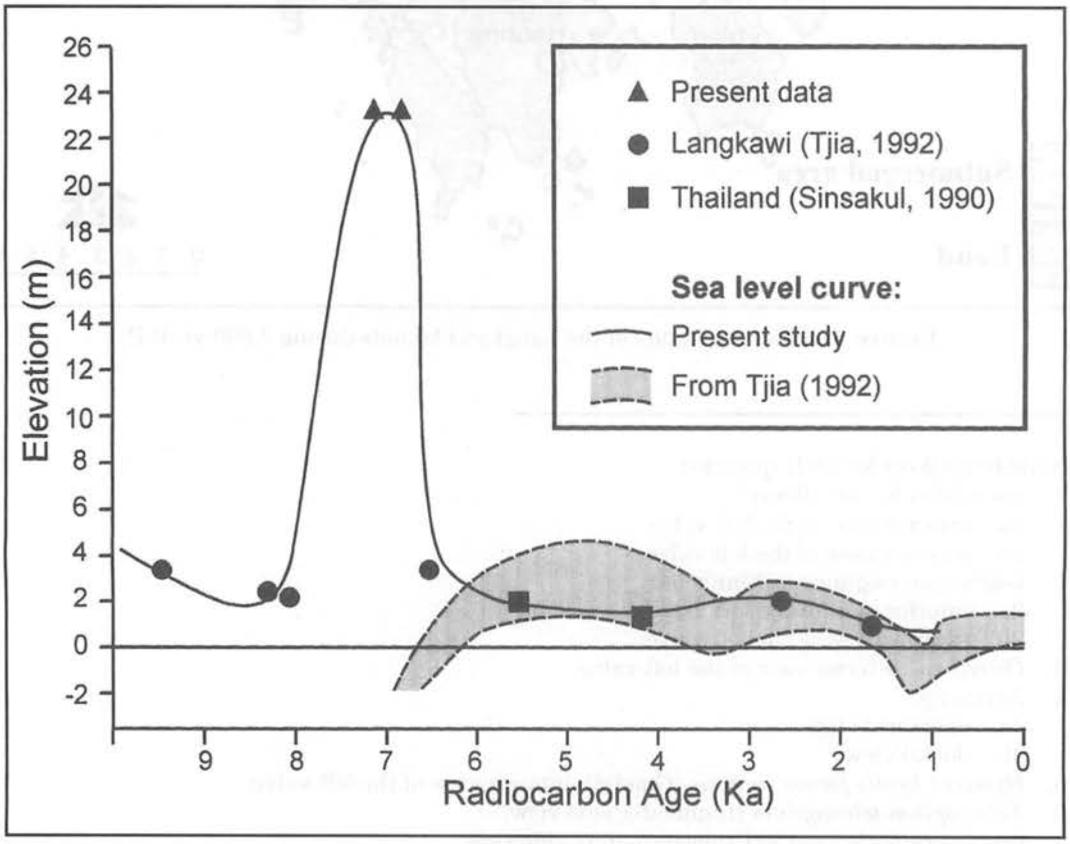


Figure 6. The middle and late Holocene sea-level curve of Langkawi Islands.

and 9,510 ± 185 yr. B.P., respectively. The other samples (oyster shells) were collected from elevations 3.5 m and 2.3 m above the present sea-level which gave radiocarbon ages of 6,550 ± 80 yr. B.P. and 8,129 ± 190 yr. B.P., respectively. It seems that it is not uncommon to find a higher Holocene sea-level elsewhere. There is no standard global sea-level curved for the late Quaternary (Stanley, 1995). Our new data are included in this group which indicate anomalously high sea-level. If we combine the data obtained from the oysters and corals of Tjia (1992), the oysters of Sinsakul (1990) and our data we could estimate the fluctuation of sea-level prior to 6,000 yr. B.P. (Fig. 6)

There are certain general late Quaternary sea-level patterns widely recognised. Compilations of world sea-level data based on radiocarbon dates show that the sea-level rose rapidly from 18,000 yr. B.P. until 8,000-6,500 yr. B.P. and approached its present stand by approximately 5,000 yr. B.P. (Stanley, 1995). Nearly all sea-level curved converge at 7,000 yr. B.P. (Stanley and Warne, 1994). The rise of sea-level pattern was not smooth but episodic, it fluctuated as the sea-level rose. There are many factors which influence the change in sea-level such as glacier, tectonic and geoid as discussed by Tjia (1992).

The differences are mainly on the elevations of the sea-level, some places are higher than the others. Since this area is tectonically stable, the difference in the Holocene sea-level curve in this area could be due to the shift of geoid configuration (Tjia, 1992). The present sea-level data seem to be extremely high compared to those of Tjia (1992) and Sinsakul, (1992). But the new data provide a new evidence about the sea-level history which was unknown before. There is no worldwide sea-level curve, each region has its own sea-level history. This is the history of sea-level changes in the Langkawi Islands.

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