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THE RELATIONSHIP BETWEEN THE OFFSHORE TOPOGRAPHY AND THE PORT DICKSON — CAPE RACHADO COAST

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Sinopsis

Pinggir pantai Port Dickson — Cape Rachado menunjukkan dua jenis pantai, iaitu pantai yang berpermatang dan alur, dan pantai yang tidak mempunyai permatang dan alur. Beberapa penerangan mengenai perbezaan keuda-dua jenis pantai ini dikemukakan. Walau bagaimanapun, penerangan yang paling penting yang dibicarakan panjang lebar ialah peranan yang dimainkan oleh topografi luar pantai dalam mempengaruhi pantai-pantai Port Dickson — Cape Rachado.

Synopsis

Port Dickson — Cape Rachado coast exhibits two types of beaches, that is the ridge and runnel beaches, and the non ridge and runnel beaches. Various explanations of the differentiation of these two types of beaches are put forward. However, the most important explanation discussed at length is the role of the offshore topography in influencing the Port Dickson — Cape Rachado beaches.

Introduction

The coast of Port Dickson is delimited by two major headlands — the Port Dickson beadland in the north and Cape Rachado in the south. Port Dickson headland, being the most prominent, juts out into the sea in a south-west to north-east direction for about 1.7 km. The north-south width of the headland is also about 1.7 km at its broadest point. It is at this headland that the Port Dickson town centre is situated. Cape Rachado at the extreme southern limit of the study area also extends out to sea for nearly 1.6 km in a north-east to south-west direction. Its north-south width is nearly 1.1 km at its broadest point, but only 0.4 km at its narrowest. Cape Rachado is a very hilly and forested headland with its highest peak 74 m above sea-level. The two headlands have a significant influence on wave refraction and inshore currents.

Between these two major headlands, there are other minor headlands which produce a sequence of small bays. Magnolia Bay in the central part of the study area is only 0.8 km long and is formed by the two minor headlands of Bukit Tuanku Haji in the north and Tanjong Lembah in the south. Labuan Bilek Bay, slightly longer than

0.4 km just south of Magnolia Bay, is formed by Tanjong Lembah and Bukit Tanjong Perdi headlands. Telok Kemang about 1.6 km south is formed by the Bukit Tanjong Kemang headland in the north and Tanjong Tanah Merah headland in the south. In the extreme southern part of the study area there is Cermin Bay (also known as Blue Lagoon) which is formed by the headlands Bukit Tanjong Peria in the north and Cape Rachado to the south.

Contemporary sandy beaches occupy a large part of the Port Dickson coast even though they are not in a continous form. The most popular tourist beaches here are the Telok Kemang beach followed by the ninth milestone beach, the Blue Lagoon beach, the Si Rusa beach, the Bagan Pinang beach, and the Magnolia Bay beach.

These contemporary beaches can be divided into two categories. The first comprises those beaches with ridge and runnel present at low tide. The second includes those beaches without ridge and runnel morphology. The Bagan Pinang beach has the biggest and most prominent ridge and runnel system in the area. This is followed by the Si Rusa and the Blue Lagoon beaches. There is no prominent ridge ad runnel developed at other areas. However, at the Magnolia Bay beach there is a ridge and runnel system developing at the northern part of the Bay. There is also slight evidence of ridge and runnel developing at the northern part of the ninth mile beach. Ridge and runnel morphology is completely absent at the Telok Kemang beach. A local topography map is given in Fig. 1.

Field Measurement

6 profiles measurement were chosen in Port Dickson. The location of these profiles is seen in figure 1. These profiles are referred to in the text as F1 to F6 for reference purposes. In between these profiles, profile midpoint samples at midtide level were also noted. but only littoral environment observations and sediment samples were taken at these intermideate points. The midpoint samples in between profile carry a prefix 'a' for location north of the main profile and 'b' south of the main profile.

All profiles were surveyed normal to the shore using standard procedures of quick-set levelling method. Each profile runs across the natural zones of the beaches, the backshore and the foreshore.

Profile surveys were carried out by levelling along a strategic line at right-angles to the coast from some fixed datum. The fixed datum in this study refers to a midtide position which is taken to be 0'. Studies by Bascom (1951) have shown that the part of the beach face subject to wave action at midtide elevation gives the best reference point so

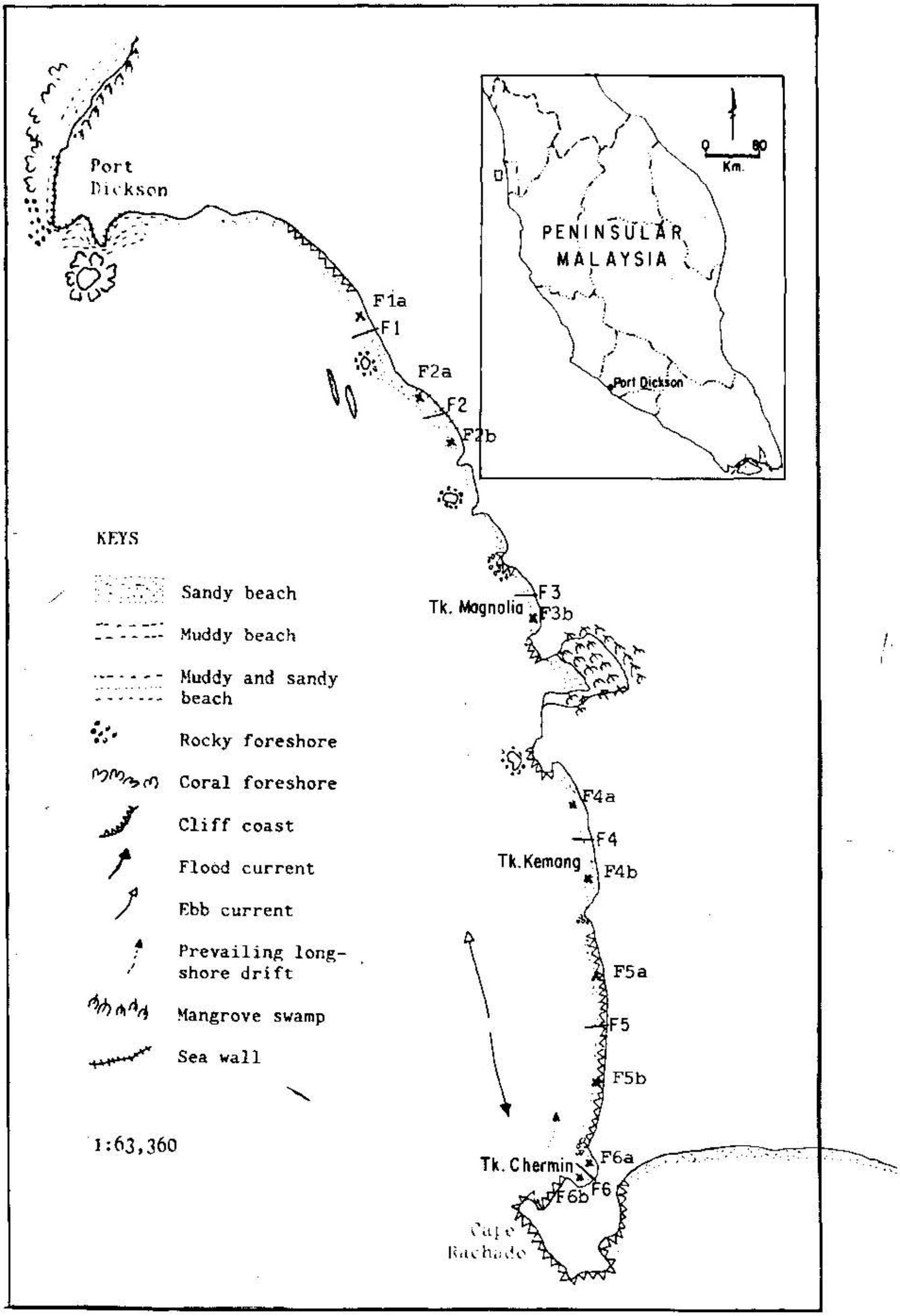

Figure 1

Local Topography of Port Dickson Locations of Sampled Areas research, therefore, a similar midpoint datum is adopted as the reference point. The midtide is taken as a datum (0') for individual profile survey.

General Description of Profiles

Profile F1 (Fig. 2) is about 260 m long. It is a straight profile up to the midtide point. In the lower midtide zone it has the characteristics of a ridge and runnel profile with two low but prominent ridge and one runnel. The first ridge in the lower midtide zone is 0.1 m and the second is 0.45 m high (height above midtide point or level). The runnel has a depth of 0.1 m below midtide level. The orientation of the ridge and runnel is generally ESE-WNW, while the orientation of the profile normal to the beach is 245°C (WSW). The ridge and runnel is thus nearly parallel to the crest of the oncoming prevailing waves during the South-West Monsoon. Profile F1 has a mean midtide slope angle of 1.4°.

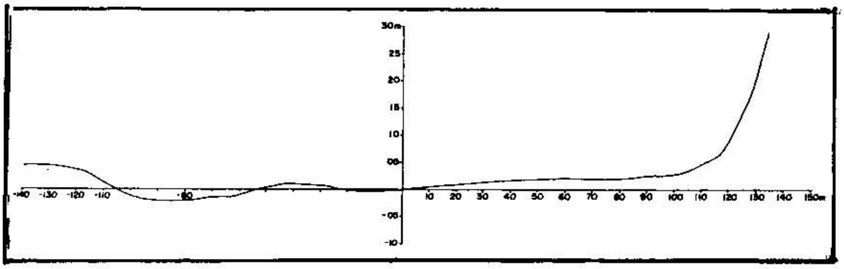

Figure 2
Profile F1

Profile F2 (Fig. 3) is 270 m long. It is a ridge and runnel profile with two prominent ridge and two runnels. The first ridge has a height of 0.6 m, and the second ridge is about 0.1 m above midtide level,

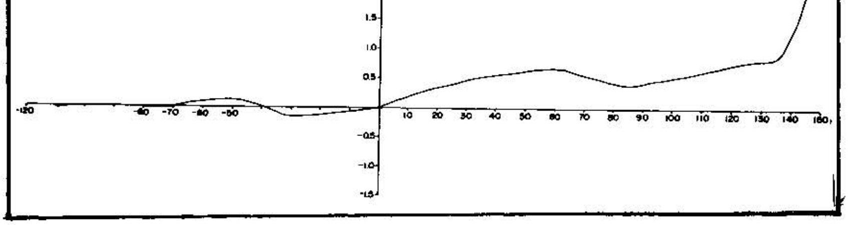

Figure 3.
Profile F2

while the runnels are 0.3 m above midtide level and 0.2 m below midtide level. The orientation of the ridge and runnel is in an ESE-WNW direction, while the orientation of the profile is 230° (nearly southwest in direction). The ridge and runnel is thus again almost parallel to the crest of the oncoming prevailing waves. Profile F2 has a mean midtide slope angle of 2°.

Profile F3 (Fig. 4) is 165 m long. It is concave above the midtide point, and displays ridge and runnel form below midtide level. The ridge is about 0.1 m above midtide height and the runnel is 0.2 m below midtide height. The orientation of the profile ESE-WNW, parallel to the crest of the incoming waves. The profile orientation is 241° (WSW) and has a mean midtide slope angle of 1.7°.

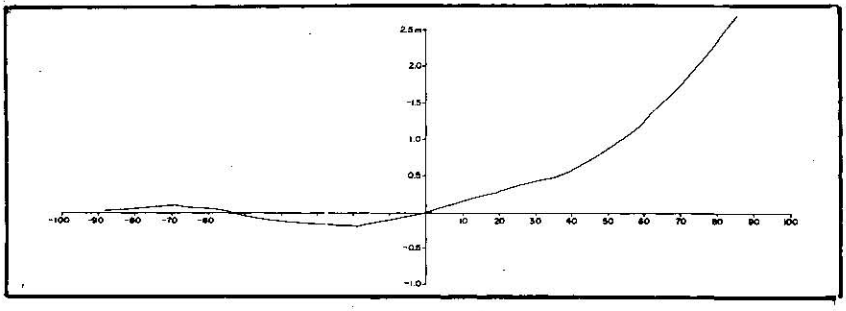

Figure 4.
Profile F3

Profile F4 (Fig. 5) is 65 m long. It is generally concave and has a mean midtide slope angle of 2.3°. Ridge and runnel forms are absent. The profile is oriented 263°.

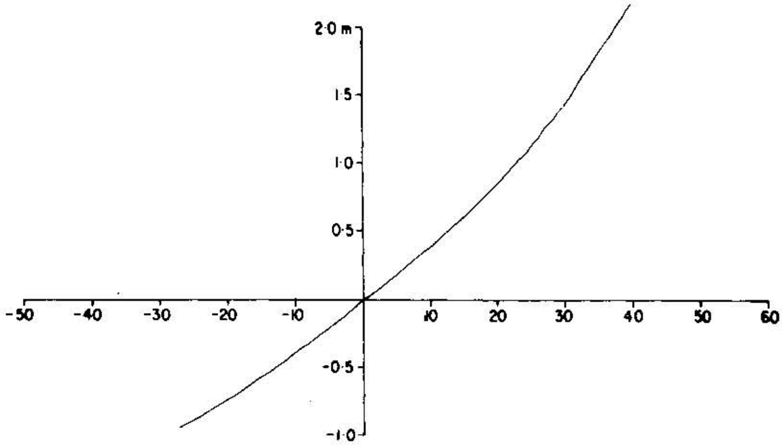

Figure 5
Profile F4

Profile F5 (Fig. 6) is 50 m long. It is rectilinear with a mean midtide slope angle of 2.7°. The profile is oriented 270°. Again, there are no ridge and runnel forms on this profile.

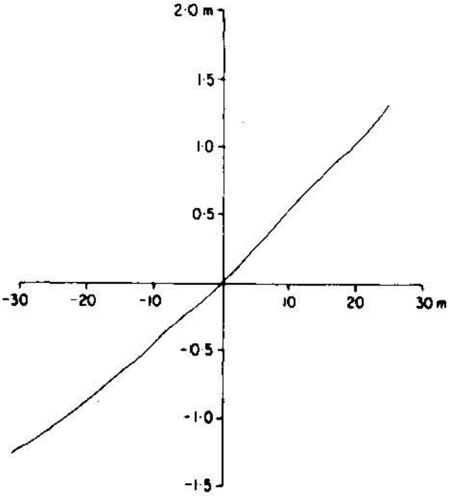

Figure 6
Profile F5

Profile F6 (Fig. 7) is 250 m long. It is a ridge and runnel profile with three ridge. The first ridge above the midtide level has a height of 0.75 m, the second and third ridge below midtide position are about 0.2 m high. The runnels are nearly equivalent to the midtide level. The orientation of the ridge and runnel system is SSW-NNE, parallel to the crest of the prevaling waves. The orientation of the ridge and runnel system showing that the overall morphology is well adjusted to the wave pattern. The profile has a mean midtide slope angle of 1.4°. As described above one can classify the profiles of Port Dickson

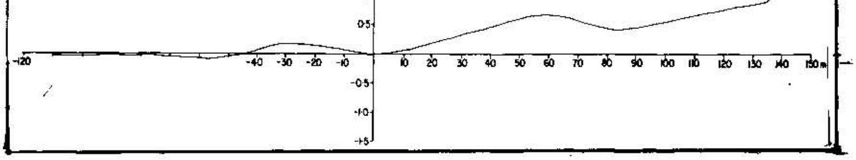

Figure 7
Profile F6

into two groups: those with ridge and runnel features (F1, F2, F3, F6), and those without ridge and runnel features. These two groups can usefully be discussed separately.

The Ridge and Runnel Characteristic Profiles

The ridge and runnel forms shown by profiles F1. F2, F3 and F6 are generally oriented parallel to the shore and also to the approaching wave crests during the South-West Monsoon. The number of ridges in each profile varies from one in F3, two in F1 and F2, and three in F6. There are two prominent ridges in profiles F1, F2, and F6. This ridges have height of 0.4 m – 0.75 m. Other ridges are within 0.1 m – 0.2 m above midtide height. The width of these ridges also varies. The three prominent ridges of F1, and F2 and F6 are from 60 m – 70 m, while others are about 30 m in width.

King and William (1949) identify the term 'ridge and runnel' for the morphological highs and intervening lows found trending parallel or subparallel to the coastline on certain beaches. They have a distinct genetic connotation, in that the ridges and swash bars originating and developing only in the intertidal zones.

Orford and Wright (1978) stress the need for formal distinction between the North American term of ridge and runnel as advocated by Hayes (1967), Hayes and Boothroyd (1969), Galvin and Hayes (1969), Owen (1977), Davies, et al. (1972), Fox and Davis (1974), Owen and Frobel (1977), and those of the British term advocated by King and William (1949), King (1972), and Wrigt (1976). The North American ridge and runnel appears to be firstly related to macro-profile adjustments of excess sediment to distinctive wave climate differences. A fundamental and integral part of this process is the formation and migration of a prominent three dimensional sand body. The British connotation of ridge and runnel is related by concept to a subtler in situ process of beach slope adjustment. The interaction of beach slope sediment size and wave steepness conditions the form of the beach response. Secondly, the North American ridge and runnel appears to originate as a mixture of breaker-point bar and swash bar development, while the British type of ridge and runnel is seen as a function of swash bar development only. Thirdly, North American ridge and runnel depends on a wide wave spectrum for beach stripping and beach replenishment 'cycles' (storm/fair weather sequence). British ridge and runnel is a function of tidal range, a wide foreshore of low gradient and definite limit to the wave period and breaker height (controlled by restricted fetch). Thus a comparison of litoral ridge growth on the east coast of the United States of American with the ridge and runnel topography of King and William (1949) solely on the basis of ridge form masks the fact that there are disticnt differences in genesis between the two types (Orford and Wright, 1978), and the Malaysian evidence must be reviewed in this light.

It has been observed that ridge and runnel beaches are often found on coasts which are not exposed to the open ocean. In the intertidal zone two types of profile could possibly be developed — one is a smooth profile, and the other is the ridge and runnel profile. The smooth profile is formed on beaches which have a gradient approximating to the equilibrium value. But if the gradient is lower than this equilibrium, then ridges and runnels are formed (King and William, 1949). Therefore, the formation of ridge and runnel is believed to represent a tendency for the waves to adjust the slope to an equilibrium gradient on a beach which is initially much flatter.

It seems that the formation of the Malaysian ridge and runnel begins at low tide, when the waves will try to build up a gradient appropriate to their size by the formation of a swash bar. Such a bar will obstruct the drainage of a beach, and the runnels will be deepened by the waer draining from the beach as the tide falls. As the ridge grows, it partially protects the beach from landward movement of sand by the direct action of waves. The runnel fills quietly with water, thus leaving undisturbed the ripples formed by wave action at high tide. As the tide rises the sea passes over the lower ridge, and thus ultimately the swashbar effect is then repeated further up the beach, leading to the construction of a second ridge landward of the first. This process continues up to the level of high tide where another bar may tend to form. Ridge and runnel profile characterises beach developed on coasts with limited fetch and short predominant waves.

The Port Dickson beaches at F1, F2, F3 and F6 have all the characteristics that are required for ridge and runnel formation. First, they have a very wide intertidal zone (165 m at F3, 260 m at F1, 250 m at F6 and 270 m at F2). Secondly, they are not exposed to the open ocean (being protected by Sumatra island) and are thus subject to a limited fetch and short predominat waves (ranging from 6 to 26 m or 2 to 4 sec. wave period). All the ridges and runnel profiles have very gently mean midtide slope angles of 1.4° - 2°. If King's argument is applied here, then the beaches at F1, F2, F3 and F6 all have gradients lower than equilibrium; and thus the formation of a ridge and runnel system is an attempt by the waves to form the equilibrium gradient on the beach which is too flat. From this discussion it can be seen that the Malaysian ridge and runnel is much closer in origin to the British connotation of the term than to its North American counterpart.

The Non Ridge and Runnel Profiles

The non ridge and runnel profiles occur at F4 anf F5. Even though F4 and F5 profiles are exposed to limited fetch and short predominant waves, as is the case with the ridge and runnel profiles, they differ in that they have steeper mean midtide slope angel (F4 has 2.3° and F5 has 2.7° mean midtide slope angle). The intertidal zone for these profiles are also much shorter ranging from 50 – 65 m. This results from greaer local exposure to wave energy.

Conslusion on Ridge and Runnel Characteristics Profile

From the above discussion it is clear that the beaches are divided into those with ridge and runnel (F1, F2, F3 and F6) and those without (F4 and F5). Sediment size analysis did not reveal much answer as to the existence of the two groups of beaches. Fig. 8 shows the spatial distribution of the mean sediment sizes for midtide samples along the Port Dickson coast. As seen from the figure there is not much variation in the overall sedimnet size. there is no pattern that seem to distinguish between the ridge and runnel beaches from that of non ridge and runnel beaches.

There are three explanations of the differentiation of the two types of beach that can be put forward. The first is that the steeper gradient and shorter intertidal zone, must have contributed to the non-development for ridge and runnel at F4 and F5. By contrast, development of ridge and runnel are favoured at F1, F2, F3 and F6 where thre are wider tidal range and much flatter profile. However, a second possible explanation for the development of the two types of beach is the role of offshore topography (Sharifah Mastura, S.A. 1983). A third possible explanation for the presence or absence of the ridge and runnel system might be explained as being due to the influence on wave refraction by the offshore banks in front of those beaches. Figure 9 show wave refraction result for period = 4 seconds, Deep-water wavelength = 81.9 and approaching angle of waves is southwest (for wave refraction procedures and Refraction Index R.I., refer to Sharifah Masture, 1983). The result shows that F6, F6a, F6b, that is the Blue Lagoon beach, have wide orthogonal spacing R.I. of 0.7. The distribution of wave energy at the nineth mile beach show that high energy is focusses near the central part (just north of F5). The southern and northern parts of the F5a an F5b profiles show wide orthogonal spacing and low energy focus. Teluk Kemang beach also shows similar trend with the nineth mile beach, that is, there is a concentration of high energy near the central bay where F4 is. The northern and southern parts of the bay have wide orthogonal spacing indicating low wave energy input. The highest concentration of wave

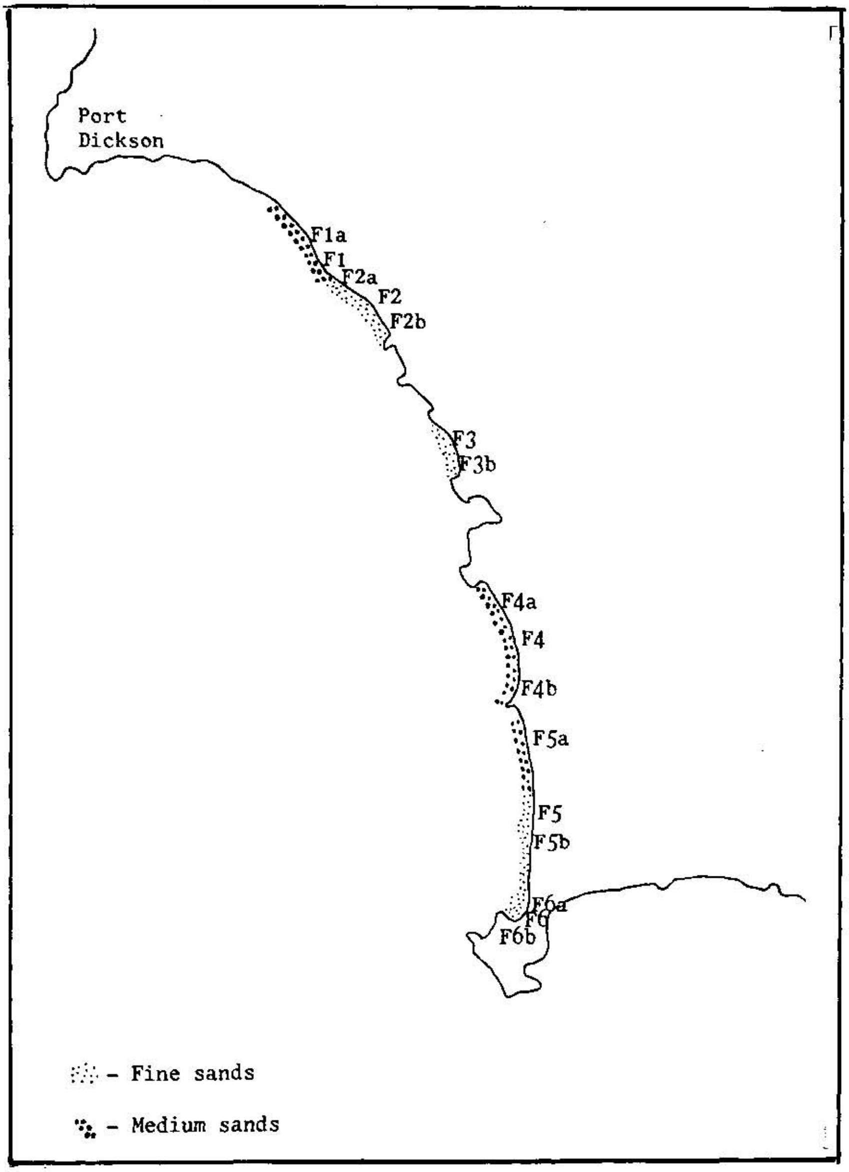

Figure 8
Mean Sediment Size Along Port Dickson Coast

energy along Port Dickson is located at the headlands of Bukit Tanjong Perdi and Tanjong Lembah which are outside the sampling area. The two headlands are located in between profiles F3 and F4. Bukit

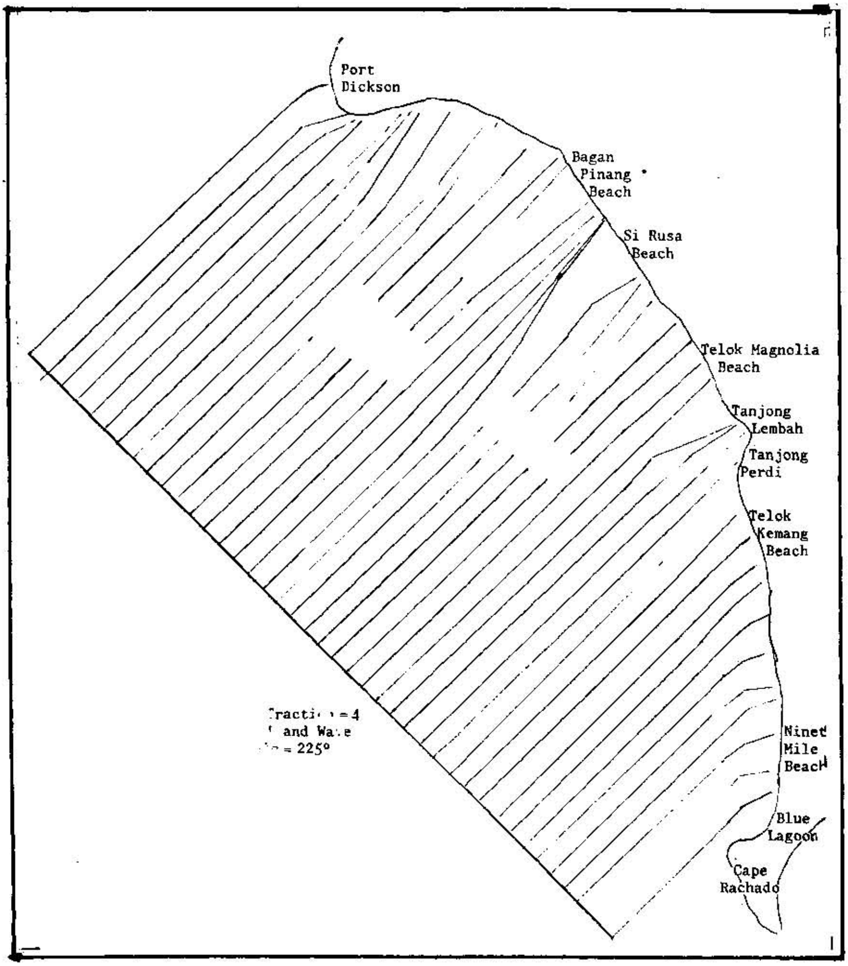

Figure 9
Wave Refraction = 4 seconds, Lo = 81.9′ and Wave Approaching Angle = 225°

Tanjong Perdi headland has R.I. of 1.1, while Tanjong Lembah headland has R.I. of 1.6 an 5.0. Magnolia Bay beach shows equal energy distribution at the central bay (R.I. = 1.0), that is, where F3 is located, while the northern and southern parts have wide orthogonal spacing with R.I. of 0.33. This is because there is a slight deep water area just offshore. Just north of F2a near the third mile beach there is an area of high energy concentration with R.I. of 5.0 and 3.3. This is again outside the sampling area. South of F2b, near the fourth mile and Kampong Si Rusa, is also a high energy area.

The Bagan Pinang beach shows equal energy distribution. At F1a, that is just north of Bagan Pinang island, there is a high R.I. of 1.66, while at F1 the orthogonal spacing is wide with R.I. of 0.55. Another area of concentration of wave energy is at the Port Dickson headland itself. Here the R.I. is 1.6..

Detailed analysis of wave refraction along Port Dickson show a few interesting points.

i. The ridge and runnel beaches at F3, F2 and F1 are all located (with the exception of F1a) at the low energy area. F1a, however, has R.I. of 1.6. This probably explains why the medium size sediment is found in this area.

ii. The wave refraction diagram of Port Dickson is complex. This is because the sea bed contours at Port Dickson are complex due to the presence of the offshore sand banks. The source of the wave energy is dissipated along these banks.

iii. Sampling of Port Dickson coast is not continous. Thus most of the high energy points are not studied. Future work shoud consider the importance of continuity.

The present complex pattern of process-form-sediment pattern at the coast of Port Dickson are all interrelated with wave refraction and offshore topography of this area. The historical development of offshore topography and its relationship with the coast is a very important factor and will be discuss further below. The linking of historical development of offshore topography to the Port Dickson coast would assist coastal managers in predicting future change.

The Relationship Between the Sea-Bed Topography and the Port Dickson — Cape Rachado Coast

As stated earlier the prominent ridges on the Strait floor off Port Dickson — Cape Rachado coast are the product of tidal stream that flow parallel in direction plus a large quantity of available fine sediment. These ridges are either mud ridges or fine sand ridges (Keller and Richards, 1967).

King (1964) shows that sand ridges of a similar kind just offshore from Gibraltar Point, Lincolnshire, have a direct geomorphological relationship to the foreshore zone. According to King, in the area north of Skegness where the foreshore is not sheltered by offshore banks the waves have unrestricted access to the foreshore, and in this area their role is dominant in shaping the steeper foreshore as well as creating ephemeral beach ridges. However, to the south of Skegness major offshore banks shelter the foreshore, and as a result this area has a prominent ridge and runnel system and a gentler foreshore gradient. According to King, these offshore banks thus play an important role in providing shelter from the impact of the oncoming wave and also in directing the transport of sediments to certain areas of foreshore.

Along the Port Dickson — Cape Rachado beaches there are well-developed ridge and runnel systems occurring at F1, F2 an F6 (Figs. 2, 3 and 7). At F3 (Fig. 4) ridge and runnel is developed well in the northern part of the Magnolia bay facing the direction of the dominant southwest wave. At F5 there is evidence of some beach accumulation in the northern part of the bay which should be an initial stage in the development of ridge and runnel. It is only at F4 (Fig. 5) that a ridge and runnel system is not being developed yet.

The presence of the ridge and runnel system at F1, F2, F3 and F6 could be explained as being due to the influence of the offshore bank. Careful analysis of the isometric projection using Ginosurf program[1] from 1980 hydrographic chart data (Fig. 10) shows very clearly that there is a new offshore ridge (ridge 'C', Fig. 11) developed near Cape Rachado which is in front of F6 (the Blue Laggon). This ridge extends toward the ninth mile beach (F5). Personal observation on this beach at low tide clearly shows the presence of such a bank (this is seen by the waves which break along this bank far offshore). The presence of this offshore bank might reduce the energy of the waves reaching the foreshore of F6. This, together with the role of tidal stream and the availability of loose material would therefore explain the presence of a well-developed ridge and runnel system on the foreshore of F6. (This offshore ridge may also contribute to the development of the accumulation areas in the northern part of the ninth mile beach F5).

Observation of the isometric projection of the 1980 data shows another offshore bank (ridge 'b', Fig. 11). This offshore ridge is op-

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[1] GINOSURF package program produced by the computer Aided Design Centre in Cambridge is selected here to display the isometeric projection of the sea-bed changes for the years 1903, 1954, and 1980. GINOSURF is a library of subroutines for displaying three dimensional surfaces in a variety of ways. It is written in standard ANSI FORTRAN and is machine and device independent. The machine/device interface is provided by the basic graphics packages of Gino-F an Ginozones, which are available on the Honeywell 6080 computer at Southampton University. GINOSURF uses one or other of the basic GINO packages to initialise and release devices, and the entire range of facilities of the GINO package may be used in conjuction with the GINOSURF routines (1980). Graphical output produced by the program using the GINOSURF library was directed to a Tektronix 4010 video terminal for test runs and for the final plot to the Department of Geography CIL Drum Plotter Series 5000. (For detail description see Sharifah Mastura, S.A. 1983).

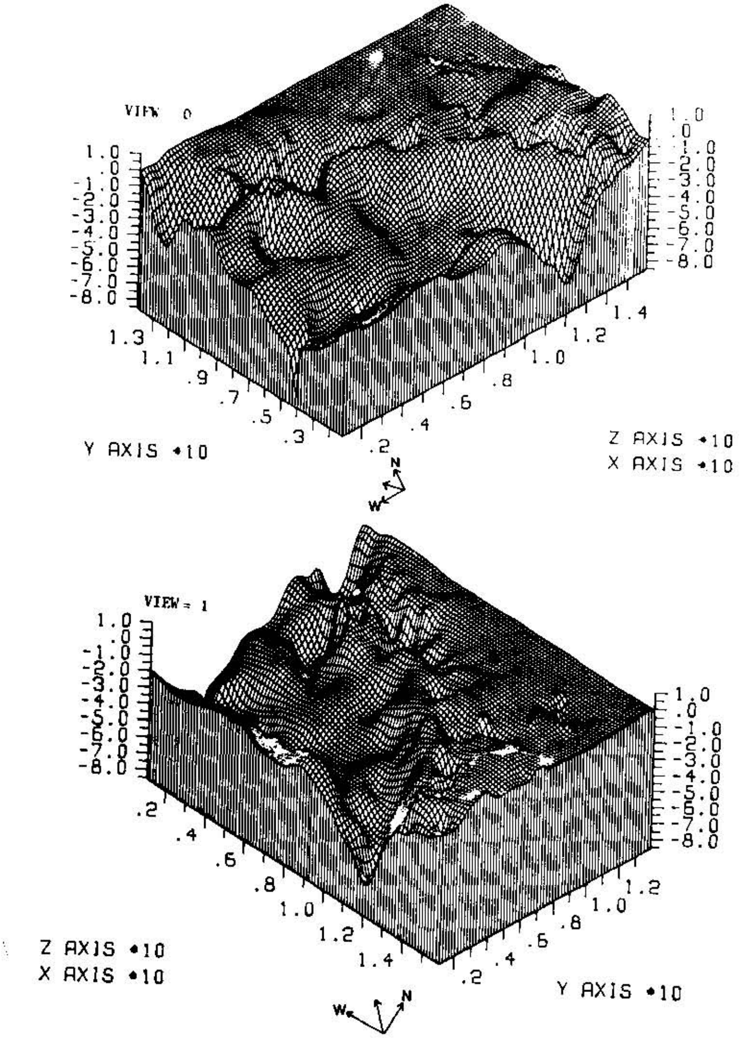

Figure 10
The Port Dickson 1980 Isometric Projection

posite the coast of F1 and F2 and extends just north of F3 (waves breaking along this bank are very obvious from the beaches at F1, F2 and F3). This also explains why the breakers that reach the shore of F1 and F2 are very low and weak, as most of their energy has been

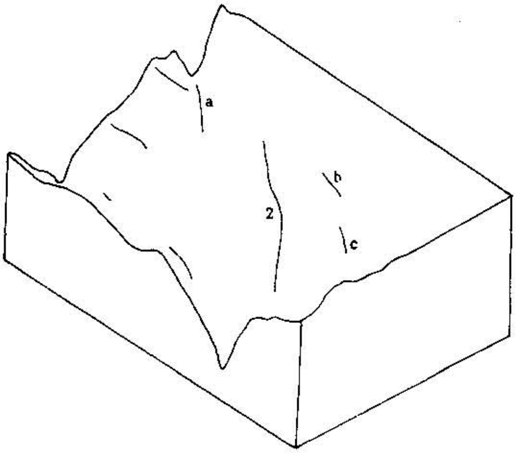

Figure 11
Trend of Ridges Depicted on View = 1 for 1980

dissipated at the offshore bank. This offshore bank again would explain the development of the ridge and runnel system on the foreshore zone in the F1, and F2 and the northern part of F3.

In between these offshore ridges there is a gap which on the isometric projection shows as a deep through. This gap is in front of F4 and F5. The deep water here may have contributed to the absence of the ridge and runnel system at F4 and F5. In addition, F4 is only a short distance from deep water areas and faces the steep side (on the east) of the sand ridge (number 2 in Fig. 11 see also arrow mark in Fig. 12). This is probably the result of the concentration of the tidal stream into a narrow channel in this direction.

Researchers have shown that such offshore sand banks may be mobile and growing features (King, 1964; King and Barnes, 1964; Cloet, 1954; Stride and Centwright, 1958; Robinson, 1956, 1960, 1964). The position and movement of these offshore banks therefore play an important part in providing shelter and also in directing the transport of sediment to certain areas of the foreshore. The movement of the banks may well be responsible for varying the position of the areas of maximum accretion in the foreshore zone from one period to another. Understanding the present and future coastal geomorphology of Port Dickson, therefore, may well be dependent on understanding the history of its offshore zone. Systematic work on this aspect in the future is therefore crucial both to the local geomorphologist, and to the coastal manager or developer.

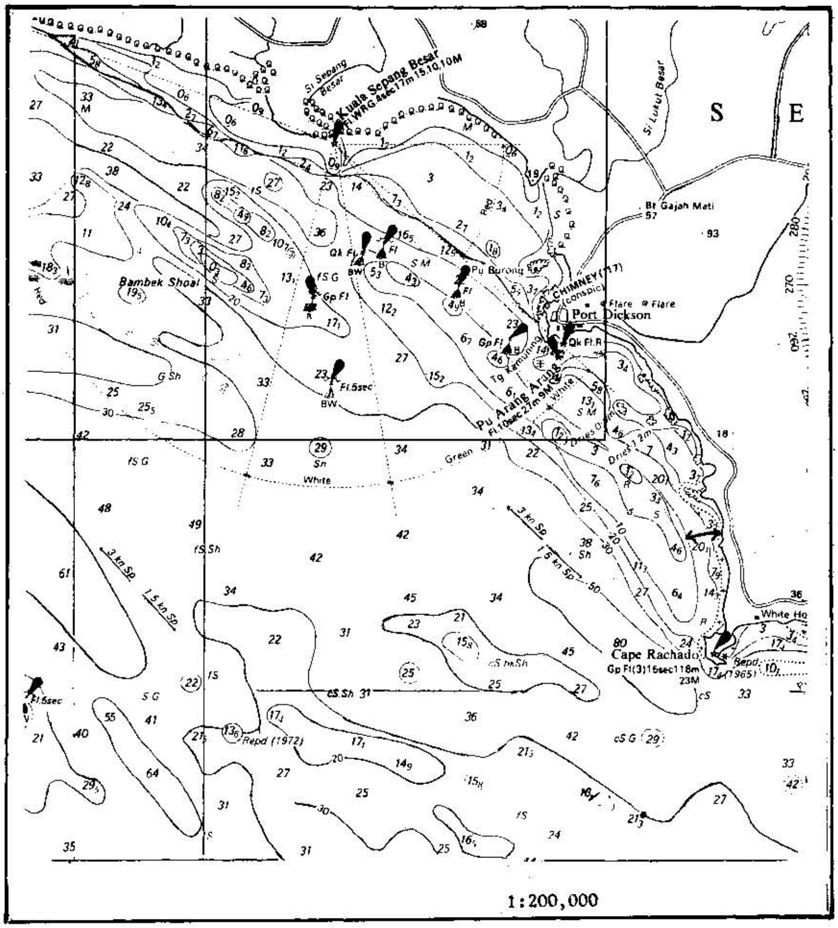

Figure 12
The Topography Off Port Dickson Coast

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