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Monsoon-control of the Eastern Shoreline of Malaya

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Abstract: Monsoon-controlled currents along the eastern shoreline of Malaya are predominantly southward throughout the year for the tract between latitudes 3°N to 5°N, whereas the other coastal stretches are subjected to mainly north-northwestward currents. These dominant current senses affect the directional displacements of lower stream courses. Beach ridges tend to develop on the downcurrent sides of river outlets as the result of the longshore current directions during the wet monsoon when the streams are transporting the bulk of their annual load.

The step-like (in plan) protuberances of the eastern shoreline mainly reflect the *en echelon* arrangement of resistant rock bodies. These asymmetrical headlands may maintain their shapes if the shorter sides face into the current, but the "risers" (defined in the text) will gradually become smooth shorelines through sedimentation if they occur on the leeward sides of headlands.

SHORELINE FEATURES

The eastern shoreline of the Malay Peninsula, or West Malaysia, possesses two general trends in north-south and northwest-southeast directions. Beach ridges and deltas indicate the shoreline to be prograding. Geomorphological studies along parts of this coast have been conducted on beach ridges, especially by Nossin (1961, 1964, 1965), and on the transformations of sand bodies with time (Hill, 1966).

Asymmetrical headlands

Apart from the projections by deltas, the eastern shoreline also shows conspicuous headlands, most of which have asymmetrical shapes in plan. In the stretch north of the Trengganu estuary, conveniently designated as the northern coastal tract, the shorter sides of headlands, subsequently to be termed "risers" (see fig. 2), face north to northwest, while south of that river the "risers" are generally facing south. Some of the headlands project as much as 3 km from the general shoreline (fig. 1). Most of the asymmetrical headlands appear to have been formed by hills or ridges of resistant rock. Vertical aerial photographs at an approximate scale of 1:25,000 indicate that the "risers" are usually rocky coasts with islets nearshore, while the longer and smoother sides of the headlands are formed by sedimentation.

Smaller promontories along the coastal stretch south of the Trengganu River occasionally show "risers" facing in the opposite direction to those of the larger headlands. It is also not uncommon to find that the smaller headlands have more symmetrical shapes in plan. The orientations of coastal stretches south of the Trengganu River are plotted against the acute angle between the shoreline and the ridge causing the promontory (fig. 2 and fig. 3). A further distinction has been made be-

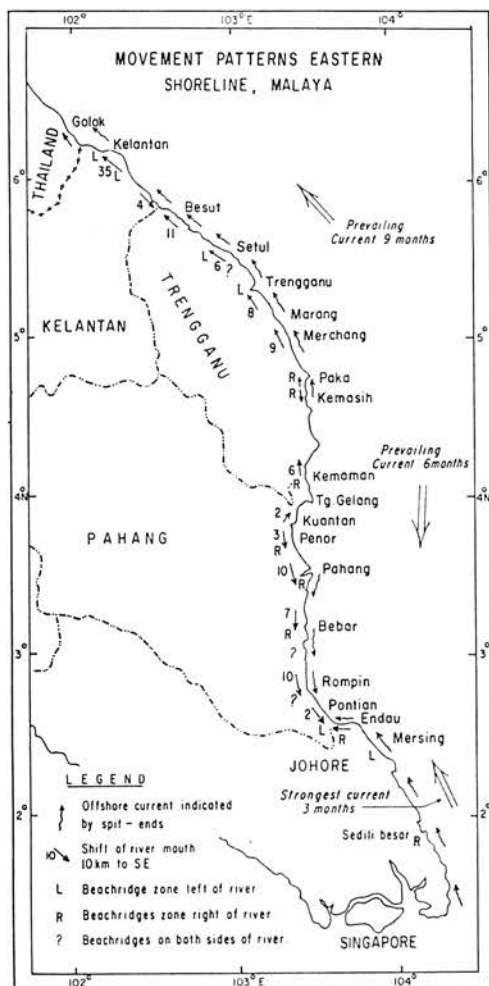


Fig. 1. Index and displacement pattern of coastal elements along the eastern shoreline of Malaya.

tween acute ridge-shoreline angles occupying the north-west sector and those which lie in the southeast-west sector. The diagram of fig. 3 implies that along the southern coastal tract, south facing "risers" of headlands are most likely to develop if the ridge trends parallel to the shoreline, or if the acute ridge-shoreline angle is in the northwest sector and is not more than 50° or exceptionally 70° . North facing "risers" are common if the acute ridge-shoreline angle is in the southeast-west sector and amounts to 35° or more. Sub-symmetrical headlands with two "risers" tend to develop if the ridge trends more or less normal to the shoreline or if this angle is between 40° and 60° and occupies the southeast-west sector.

A study of the aerial photographs further shows that an equally important factor for the orientation of headland "risers" concerns the *en echelon* arrangement of the ridges, for example near the Sungei Besar outlet in the Trengganu area, and north of the Sedili Besar mouth in Johore.

Accumulation of sediments is commonly shown on the photographs to be unequally distributed on the two sides of promontories. The evidence suggests the influence of offshore currents. This will be dealt with in the last part of the paper.

Beach ridges and spits

On aerial photographs beach ridges appear as zones which are straight to slightly concave with respect to the sea, and consist of alternating light and darker toned bands. The dark bands represent vegetation occupying beach swales, while the lighter coloured zones are underlain by bare to sparsely vegetated sand bodies which are the ridges. Fig. 1 indicates that there are stretches of coastline where beach ridges have their most prolific development either to the right or to the left of the respective

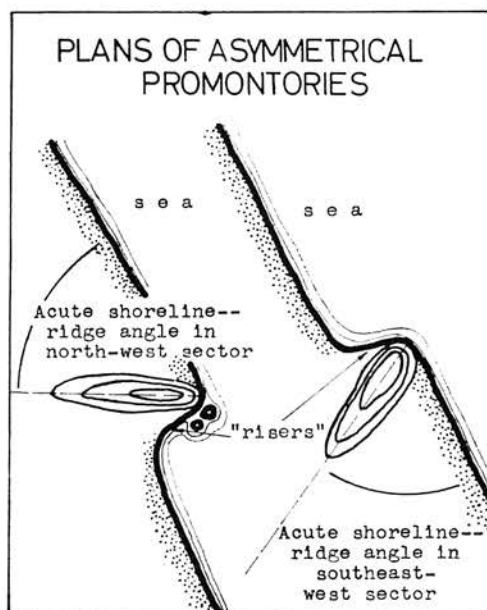


Fig. 2. Explanation of some parameters used in the text.

stream outlets. Right and left designations refer to directions looking downstream. From the Thai border southward as far as Kuala Trengganu, beach ridges mostly occur to the left of river mouths. In other localities beach ridge zones occur to the right of the rivers. In several parts of the coast beach ridges may occur with almost equal abundance left and right of the river courses, which may indicate either irregularly directed displacements of the river courses on the coastal plain, or the influence of adjacent rivers whence most of the sediment for the beach ridges has been derived—indicated on fig. 1 by question marks. In still other localities beach ridges have been forced to develop on one side of the rivers on account of the unavailability of suitable lowland on the other side, as for example near the Marang and Dungun rivers.

River-mouth bars and some offshore bars may have single unattached ends and thus fall into the category of spits. Along the eastern shoreline the general

trend of the free spit-ends is trailing north to northwestward. Recurved spits occur if the loose spit-ends point southward, except along the coastal tract between and including the Pahang River mouth to some distance south of the Bebar River outlet. Along this part of the shoreline the prevailing offshore currents are southward (see below).

Nossin (1965 and earlier papers) is convinced that the bulk of the material composing the beach ridges and bars has originated from the sea floor. He argues that the stream velocities of the coastal plain are too low to be able to transport much sand toward the sea. Even during the north-east monsoon rains, the increased stream velocities—through volume increase—are mostly checked by the bars and most of the river load still does not reach the sea.

However, the aerial photographs of March and early April 1966 clearly show how the river load—indicated by narrow, light-toned wedges off river mouths—enters the sea for distances of 500 m or more. It seems inconceivable that only fine-grained material reaches the sea, if one takes into account the substantial lengths of the sediment-laden tongues. The present author has seen similar "jets" of turbid water off river mouths along the north coast of Java, Indonesia, during the wet monsoons. Aerial photographs of the area also record the phenomenon. Moreover, secchi-disc measurements by Verstappen (1953) in Djakarta Bay have clearly proved that turbid conditions are restricted to the vicinity of river mouths. If marine currents have brought in the sediment for the coast from offshore areas, then one would expect the turbid conditions to be extensive.

Lower-course changes

The distribution pattern of beach ridges and abandoned stream channels on the coastal plain supplies information on the younger history of the plain and the rivers.

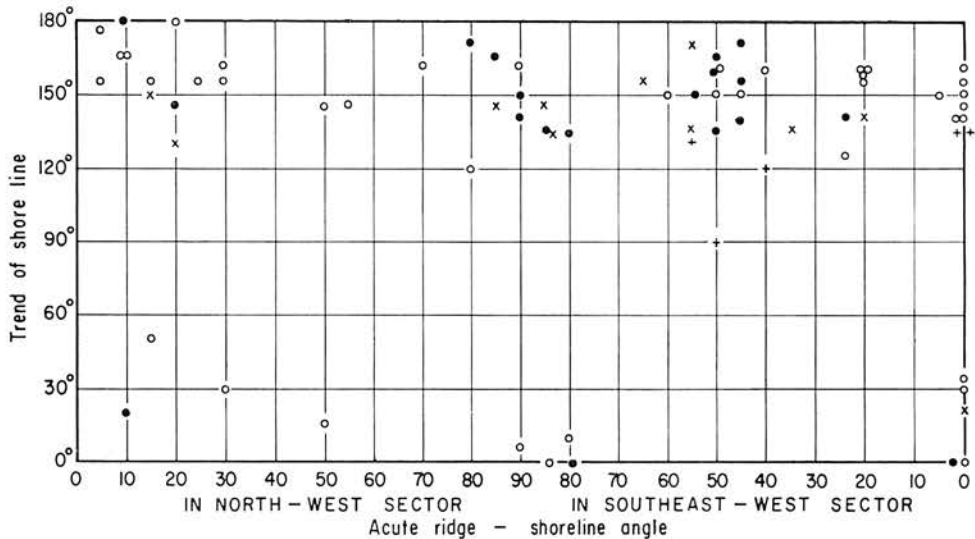


Fig. 3. The plot of shoreline trend against acute shoreline-ridge angle either occupying the north-west sector or southeast-west sector. Symmetrical "risers": solid dots. Shorter side of asymmetrical "riser" faces: south (circles); north (crosses) north along northern coastal tract (plus sign).

Fig. 4 shows an example of channel changes in the lower Bebar River and the adjacent shoreline. The general trends of the beach ridge series have been used to interpret shoreline A, and outlets A and B.

Along the eastern shoreline of Malaya four tracts may be distinguished according to the sense of displacement of the lower courses either to the left or to the right of preceding channels. In the first tract, from the Thai border up to Kuala Merchang, the general shift of river courses on the coastal plain is toward NW or WNW. For instance, the oldest recognizable Kelantan River channel lies 35 km toward the right of the present river. The second coastal tract is between Kuala Paka and Tanjong Gelang where rivers have been shifting both ways but with strong tendencies to move toward the left. In the third tract, from the Kuantan River mouth to Pontian, course shiftings are predominantly toward the right. The last tract consists of the remaining shoreline to the southern tip of the Peninsula, where lower-course changes are toward the left.

INTERPRETATION OF DISPLACEMENT PATTERNS ALONG THE SHORELINE

The plan-wise asymmetry of headlands, sand accumulation on one side of promontories, the directions of trailing spit-ends, the occurrences of beach ridges on certain sides of river mouths, and the directional shifts of river outlets imply different offshore and presumably different climatic conditions along the various coastal tracts.

Rainfall records published by the Drainage and Irrigation Department, Malaysia (Anonymous, 1961), indicate that the wet monsoon for the eastern part of Malaya is in the period October through February, and occasionally may extend as late as early April. During these months as much as 75 percent of the annual rainfall may be precipitated. The yearly rainfall averages 2000 mm to 2500 mm.

Table 1 compiles the directions of sea currents off the east coast and has been derived from information published by Van der Stok (1922). Along the eastern shore-

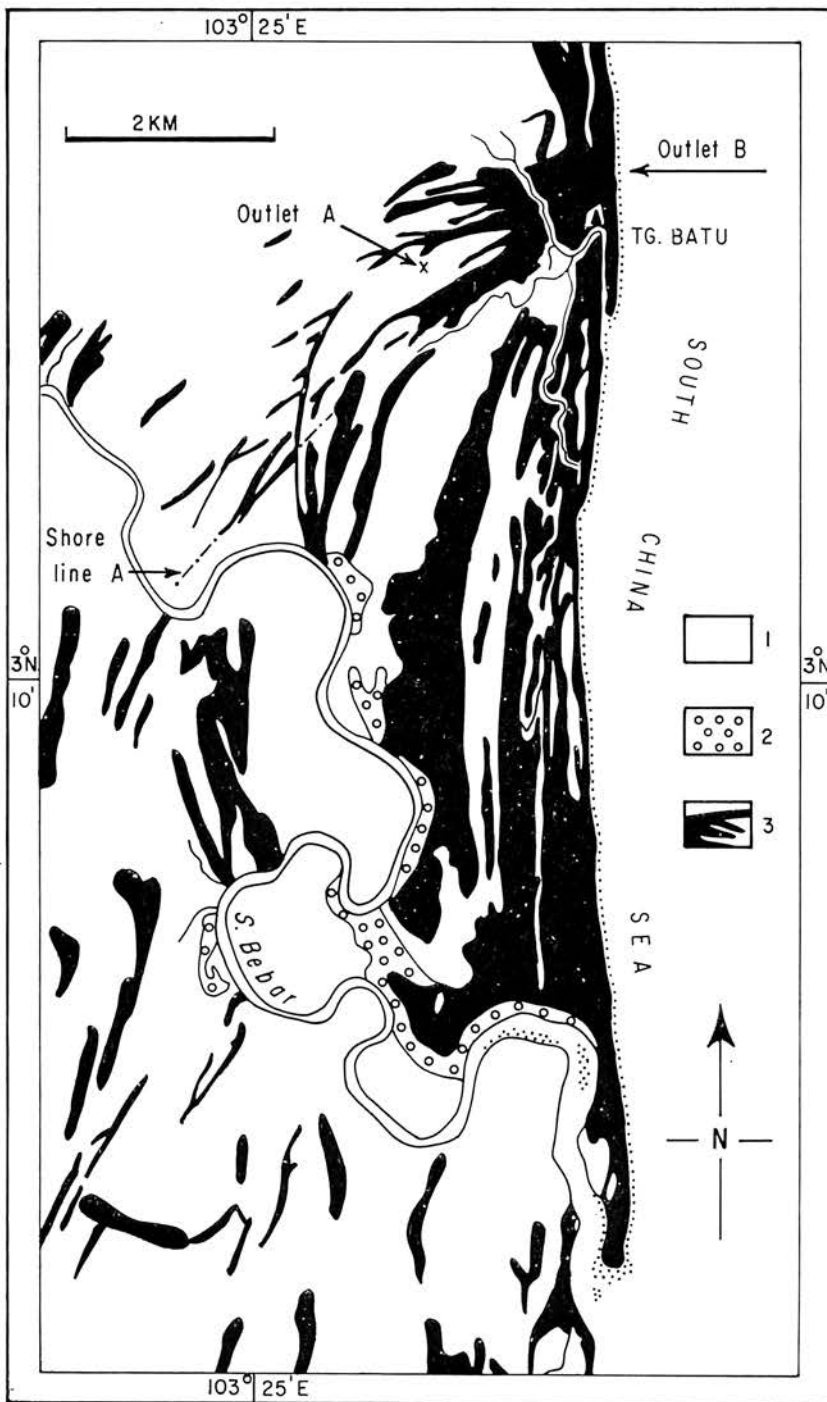


Fig. 4 Channel changes in the lower Bebar River as indicated by the shape and distribution of beach ridges and natural levees; 1)=coastal alluvium, 2)=natural levees, 3)=beach ridges.

Table 1. Surface currents off the east coast of Malaya; in nautical miles per day; from J. P. van der Stok (1922).

Latitude	Dec - Feb	Mar - May	Jun - Aug	Sep - Nov
6°-8°N	to SW 15-19.9	to SE 5-9.9	to NE 10-14.9	to N 10-14.9
4°-6°N	to SE 25	to S 10-14.9	to N 15-19.9	to N 10-14.9
2°-4°N	to NW 5- 9.9	to SE 1- 4.9	to WNW 5- 9.9	to NW 5- 9.9
0°-2°N	to SSE 10-14.9	irregular	to NW 15-19.9	irregular

line the prevailing currents are in a general northward direction for latitudes between 6° and 8°N during 9 months of the year including the entire rainy season. The SW-directed currents of December-February result in a northwestward drift because of the orientation of the shoreline at these latitudes.

Between 4° and 6°N.lat. the strongest current is SE-ward during the last part of the rainy season. Along this coastal tract the net current direction appears to be southward throughout the year. Prevalent northward currents are apparent along the remaining shoreline from 4°N.lat. south.

If one compares the general directions of offshore drift with the movement pattern on and near the shore discussed earlier, discrepancies are notable for the coastal tracts at 2°-4°N and 4°-6°N. Along these two coastal stretches the movement patterns onshore are generally opposite to those offshore (fig. 5a). The discrepancies are presumably caused by the fact that each current value of Table 1 represents that of an area measuring 2 degrees by 2 degrees during a quarter period of the year. In other words, the current data are generalizations, and therefore, on the original cur-

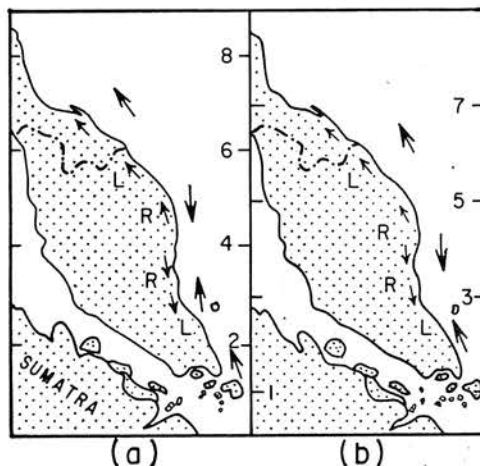


Fig. 5. Areas of influence of the prevailing currents along the eastern shoreline of Malaya; (a) according to Table 1, and (b) after a one-degree shift southward as implied by various coastal features.

rent distribution map each value may well extend over a larger area or may have a more restricted sphere of influence than the area it is shown to represent.

If one shifts the areas of influence of the surface currents one degree southward, the majority of the land and marine movement pictures show excellent agreement of directions (fig. 5b and fig. 1). The few and small deviations in the overall movement pattern are obviously due to local conditions, e.g. deflection of currents by the presence of large promontories or offshore islands.

The interpreted movement pattern of fig. 5b is supported by the loci of beach-ridge zones which are explained in the following way. Along the north-

ern shoreline of Java, Indonesia, beachridge zones are especially well developed on the east sides of river outlets (Verstappen, 1964; Tjia *et al.*, 1968), although the prevailing current in the Java Sea is westward during 8 months. This apparent contradiction is accounted for by the fact that the bulk of the river load is transported during the rainy season when the offshore current is eastward. It is not unusual that more than three-quarters of the annual denudation occurs during one single down-pour (see Rutten, 1938). During the dry season, on the other hand, the rivers have diminished in size and are transporting only a fraction of their annual load. By analogy, the eastward flowing rivers of Malaya probably transport most of their yearly load during the wet monsoon. The occurrences of beachridge zones on certain sides of river mouths would then indicate the direction of offshore currents during the rainy season.

Between the Kemasih River mouth and the Bebar River outlet, beachridges predominantly occur to the right of the rivers. Most course-changes along the same coastal stretch also indicate a preference toward the right hand side. This evidence is in accordance with the interpreted movement picture for this stretch of coast as shown on figures 5b & 1.

The headlands along the various coastal tracts are affected by the prevailing drift in that the "risers" which face into the current will be kept free from sediment relative to the other headland-sides. The sides facing toward the current direction will gradually develop smooth shoreline plans through deposition of sediment. In other words promontories with leeward "risers" only, like those at latitudes higher than 5°N, will rapidly lose their identities as such.

ACKNOWLEDGEMENTS

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