

Coastal Dynamics of Singkawang, West Kalimantan

Dinamika Pantai Singkawang, Kalimantan Barat

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(Received 18 July 2012; in revised form 30 November 2012; accepted 10 December 2012)

ABSTRACT: Morphologically, Singkawang and adjacent area consist of zones beaches, undulating hills, and steep hills. Granitic rocks and alluvium as a based rock of Singkawang coasts. Generally, Singkawang coasts was developed for coastal farms, fishery pond, and beach resorts, where most of these area have been eroded. Geological and physical oceanography condition are the aspects that build the characteristics of Singkawang coast. Human activities also play an important role in managing the equilibrium and dynamics of this coastal region. This research is to determine the dynamics and coastline changes of Singkawang coasts based on the characteristics of the coastal element and sediment. The high erosion was occurred at Semalagi–Cape Bajau. The Cape Bajau - Cape Banjar is relatively stable due to headlands of this coast is characterized by igneous rocks which resistant to the erosion. The Cape Banjar – South Coasts is very intensive erosion coast. Modern shorelines of the Singkawang coast might be as a shallow marine environment which were occurred thousands years ago (pre-Recent). The high of sedimentation process is generated by global sea level change, where was occurred at that time, and might be changed the area become part of the mainland coast of Singkawang.

Keywords: coastal dynamics, erosion, sedimentation, Singkawang, West Kalimantan,

ABSTRAK: Secara morfologi, Singkawang terdiri atas daerah pantai, perbukitan bergelombang, dan perbukitan curam. Batuan granit dan alluvium mengalasi kawasan pesisir Singkawang. Pesisir Singkawang sebagian besar berupa daerah pertanian, tambak ikan, dan tempat wisata yang umumnya merupakan kawasan pantai erosi. Geologi dan oseanografi fisika merupakan aspek yang membentuk karakteristik pantai Singkawang. Aktifitas manusia juga memainkan peranan penting di dalam mengelola keseimbangan dan dinamika pesisir daerah ini. Penelitian ini untuk mengetahui dinamika dan perubahan garis pantai Singkawang berdasarkan karakteristik dan sedimen pantai. Pantai Semalagi – Tanjung Bajau merupakan kawasan pantai erosi kuat. Tanjung Bajau – Tanjung Banjar merupakan kawasan pantai nisbi stabil ujung-ujung Tanjung Tanjungnya dicirikan oleh batuan beku yang tahan terhadap erosi. Tanjung Banjar – Pantai Selatan merupakan kawasan pantai erosi sangat kuat. Garis pantai Singkawang pada saat ribuan tahun sebelum sekarang (pra-Recent) diperkirakan berupa kawasan lingkungan laut dangkal. Karena proses sedimentasi cukup kuat yang ditimbulkan oleh perubahan muka laut global pada saat itu mengubah kawasan tersebut menjadi daratan pantai Singkawang.

Kata kunci: Dinamika pantai, erosi, sedimentasi, Singkawang, Kalimantan Barat.

INTRODUCTION

Singkawang coasts are commonly developing area and are characterized by erosion and accretion processes. The landuse of Singkawang coast are commonly developed as coastal pond fishery, coastal palm farms, coastal construction aggregates and coastal tourism. Geological and physical oceanography condition is one of the aspects that build the characteristics of Singkawang coast. In addition, human activities also play an important role in managing the equilibrium and dynamics of this coastal region. The regional geology data is used to determine coastal

geomorphology and rocks resistance of Singkawang coastal areas. Coastal characteristics is analyzed based on morphology, coastline, geological and oceanographical processes. Hand auger drilling was carried out to identify a subsurface sedimentary environment and coastal dynamics. The purpose of this research is to determine the dynamics and coastline changes of Singkawang coasts. Administratively, the research area belongs to the Singkawang District, West Kalimantan Province and geographically is located at coordinates 108°48'E - 108°51'E and 0°48 'N - 0°51'N (Figure 1).

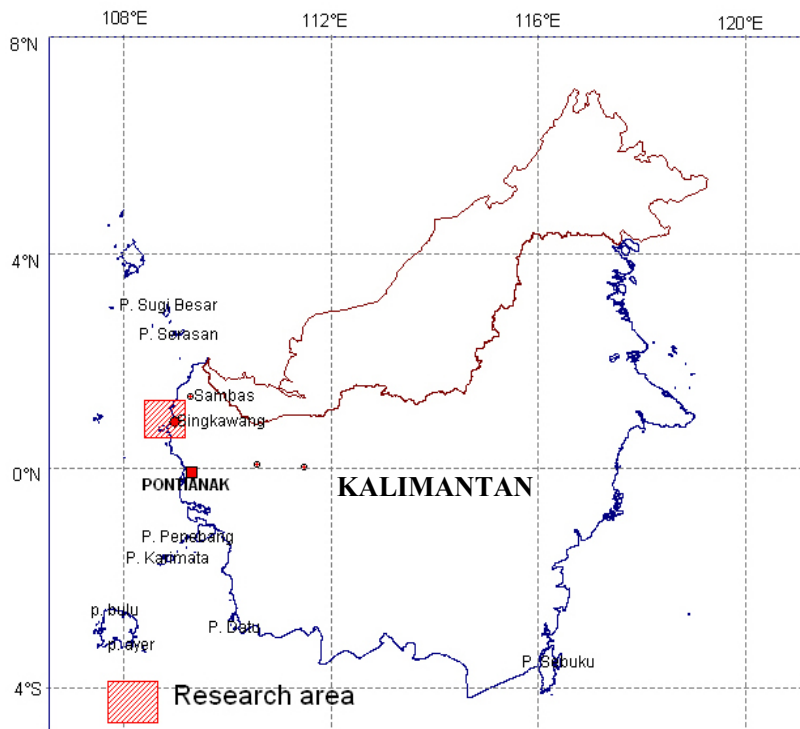


Figure 1. Map of the research area

Morphologically, Singkawang and adjacent area is divided into coastal plain, undulating hills and steep hills (Thorp et al., 1990, Suwarna et al. 1993, Sujatna et al., 1985). Geologically, the coastal area are characterized by Holocene (5500 years old) of alluvial deposit which is consist of sand beach ridge and white sand dunes. During this period, it is interpreted that the sea level condition is between 3 m and 6 m above present sea level. Alluvial deposit consists of swamps and flood plains deposit which are characterized by clay and gray to dark brown of fine sand organic-rich. Sand dune was estimated to be a Late Pleistocene which is exposed up to 25 m above sea level. Undulating hills composed of Tertiary sedimentary rocks and granitic rocks that have been weathered. The highest elevation of undulating hill is about 75 m above sea level. The pattern of meandering rivers is partly influenced by the pattern of cracks in the granitic rock and trending northeast. The undulating hill is surrounded by steep hills, coastal plains and alluvial plains. These steep hills is characterized by hard and massive rock which is exposed around the coast, and the small islands off the coast. The hard and massive rock are composed of volcanic rocks and Cretaceous intrusive granitic rocks.

Stratigraphically, the oldest rocks (Early Jurassic to Late Triassic) of Singkawang region is characterized by the Raya volcanic rocks of Bengkayang group that consist of Banan and Sungaibetung Formation. This formation is formed as a steep hills and steep islands off

the coast. The Singkawang batholiths is established by Granodiorite Mensibau (Amiruddin, 1989) which were separated from the batholiths of Schwaner that mostly as a base of geological formation of southwestern part of West Kalimantan.

The layering of Setinjam Gabbro (Kuse) that can be correlated with the stock and plugs of Biwa Gabbro, it is intruded by the batholiths of Schwaner. The Serantak volcanic rocks and the Bawang Dasitic rocks are distinguished from the Raya volcanic rocks and the Sintang intrusion (Middle Eocene). Hamisan Formation consists of Sela and quartz sandstone. Layers of red sandstone of this formation is commonly found in the sandstone of Sekayam and Tebidah Formations of the Melawi Basin.

The intrusion rocks of Sintang forming stocks and sub?-volcanic plugs (diorite and tonalite) produce the commercial minerals such as

gold, copper and molybdenum. Porphyritic basalt dikes and stock intrude the Granodiorite Mensibau around the island. This rock and mafic dikes that distribute on the batholiths Schwaner are eroded by sea waves. The alluvial deposits of Terbiku are generally equal to the white sand dunes of Upper Pleistocene. The alluvial floodplain and marshes are covered by modern littoral sediments.

METHODS

The field data was obtained from the results of research conducted by the Marine Geological Institute of Bandung (Aryanto et al, 2008). The data such as sediment samples and coastal characteristic are extended and analyzed for this research.

Sediment samples were taken from each bore hole (BT-19, BT-20, BT-21, BT-22 and BT-23, Figure 2), in accordance with the purpose of analysis such as sediment characteristics, sedimentary environment, and paleo-environment of Singkawang coast (Pre-Recent). Data of coastal characteristics mapping used to illustrate the process of the unit of morphological variation. Coastal characteristic is resulted from interaction of physical oceanographic (wind, wave, tides and sea currents), geological aspects (structures, rock and topography), and the aspects of the human activity (anthropogenic).

The coastal characteristics mapping depend on the scale of the map and the object of inquiry (Dolan,

1975). This mapping was carried out by descriptive field observations at some locations, geological parameters, relief, and dominant process of shoreline characteristics. Dominant process includes marine, fluvial, mass wasting, coral life, mangroves or mixtures. This data is then plotted in the map of coastal characteristic and used to obtain an overview of coastal processes occurring at the present time.

RESULTS

The coastal type in the study area can be grouped into three regions, namely Coastal Zone of Semalagi - Sedau, Zone of Sedau and Banjar Capes, Zone of Banjar Cape - South Coast (Figure 2).

Zone of Semalagi – Sedau

Coasts of Semalagi - Sedau stretch approximately 20 km long from the Semalagi coast to the northern end of the research area until the Sedau coasts. Morphology of Semalagi - Sedau coastal zone is low relief, berm more than 100 m wide, beach slope relatively flat ($< 5^{\circ}$), mud shore platform more than 200 m wide. The width of the river mouth of this area is generally narrow (< 20 m) except the river mouth of Singkawang is approximately 50 m wide. Drainage pattern of this zone relatively parallel form as a canal, its river flow with low velocity and forming ponds. However, during the rainy season the river flow is quite high velocity. The coastline of this area tends to form straight beaches.

Geologically this zone is characterized by low-resistance rock that composed of alluvium plains (mud and mangrove). Coastal sediment consists of greenish gray and brownish gray mud, mollusk shells and organic material $> 45\%$, opaque minerals $< 10\%$, quartz $> 25\%$, light mineral $< 20\%$.

Shoreline characteristic of this zone is formed by sand, mud, mangrove and coastal infrastructures.

Energy process influencing the characteristics of the Semalagi - Sedau zone is marine dominant. Based on characteristics of the beach profile, coastal sediments, and the hydro dynamics, this zone belongs to the type of low-to moderate-energy beaches with erosion processes dominant. The human activity at this zone remains largely as fishery commodities. In demographic the coastal area has a very low population levels as fishermen, traders, coastal farmers, and labor.

Zone of Sedau – Banjar Cape

Zone of Sedau – Banjar Cape has coastline approximately 25 km long. Coastal morphology consists of alluvial plains, low relief, and drainage pattern of this zone consists of a trellis, relatively parallel, and seasonal flows, its river mouths are generally narrow less than 20 m wide. On the other

hand, cliff and rocky head morphology of this zone are located in the Banjar, Merah, Gondol, Batu Belat, and the Kiar Capes. Characteristics of the sandy beach profile on the Sedau – Banjar Cape generally consist of berms more than 50 m wide, beach slope more than 5° , and shore platform between 100 m and 500 m wide.

Geologically this zone composed of granodiorite igneous hills that have medium relief and high resistance are located around coasts of the Bajau, Gondol, Batu Belat, Kiar and the Banjar Capes, meanwhile low-resistance is located around the Bajau – Gondol Capes, Suak Bay, and the Sawah Kertamuning Bay that consists of rocky, sandy and mangrove beaches. Characteristics of coastline tend to form embayment beaches are found in the Bajau – Gondol Capes, and Batu Belat - Banjar Capes. Sandy beach is located in the Panjang coast as a tourist site that occurs between the Bajau and the Gondol Capes, sand pocket beaches are in the Suak Bay and the Banjar Cape meanwhile the muddy and mangrove beaches are located in the Sawah Karangmunting Bay. Sand of the beaches originally come from the surrounding rocks consist of sand - gravel dirty white to off white in color, quartz minerals more than 85% and light mineral less than 15%. Mud of the beaches is greenish gray in color containing quartz, organic materials and carbon in particle sizes.

The coastal characteristics affected by predominantly marine and dominantly non-marine process. The presence of sandy and sand pocket beaches in this zone is largely formed by long-shore current and sea waves eroded rocks around the shore. The Sedau - Banjar Cape Zone based on characteristics of the beach profile, sediment, and the hydro dynamics the Sedau - Cape Banjar coasts can be grouped into the type of medium to high-energy beaches with dominant erosion processes. The Teluk Sawah belongs to this zone has many coastal structures of rip-rap types to protect that coast from erosion.

Coastal lowland areas of the Sedau - Banjar Cape zone are mostly used as a beach resort and residential (Figure 3). Most of the area is used to be orange farms, palms, conservation forest and the bushes. The impact of development on coastal land area is still very small. Beach sand mining around the Tanah Merah Beach no longer will affect the coastal environment in the surrounding area.

Mud flat and mangrove beaches of the Sawah Bay derived from river deposits of the surrounding area as non-marine dominant processes. The spread of this mud around the Sawah Bay was formed by longshore currents as a marine dominant processes. The coastal area of the Sedau–Banjar Cape remains mostly as fishery commodities, and beach resorts. Demographically, the coastal area has a higher

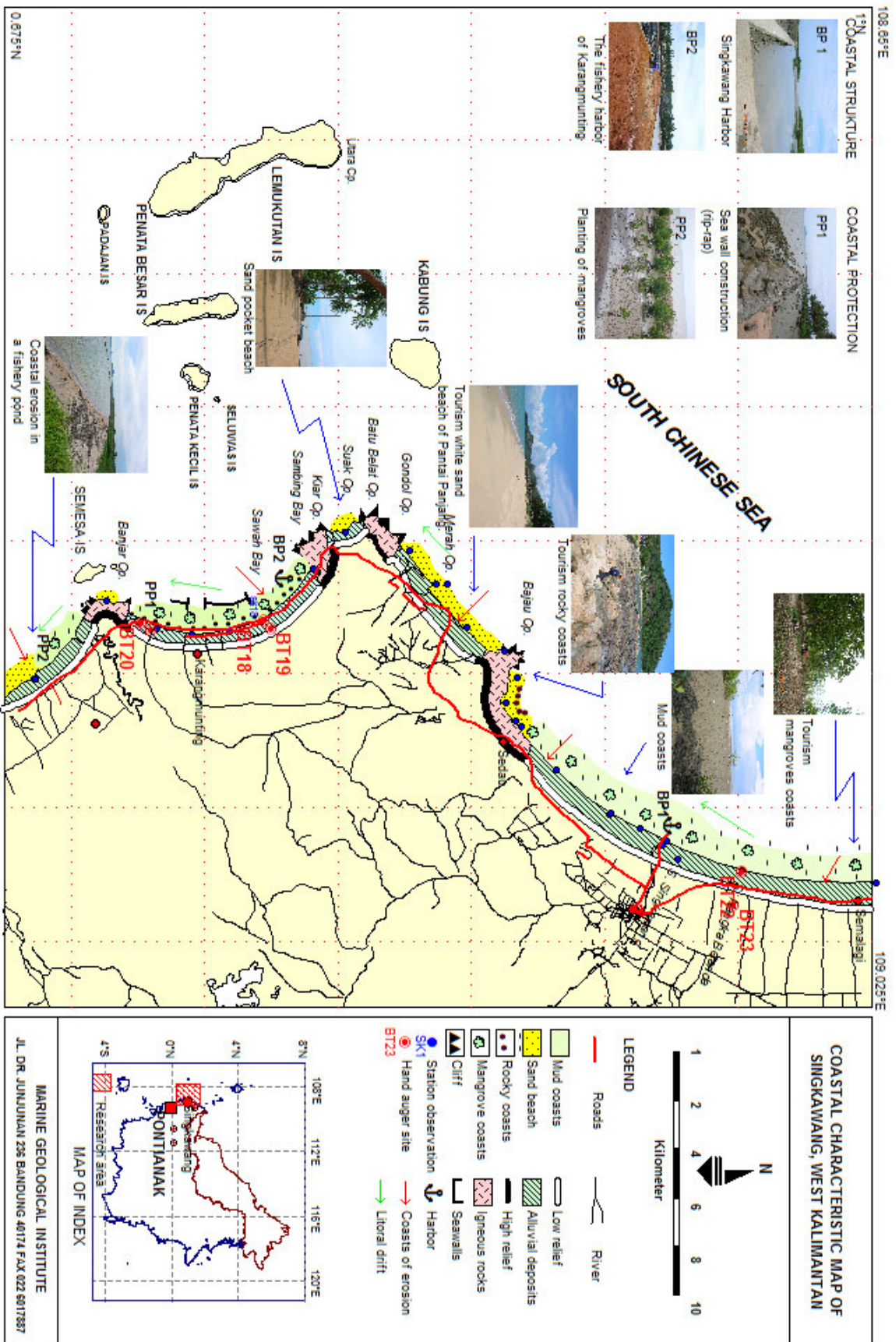


Figure 2. Coastal characteristic map of Singkawang, West Kalimantan



Figure 3 The Singkawang coasts mostly used as fishery ponds, farms, and beach resorts. Location: beach resort of Singkawang

population than the coastal area of the Semalagi - Sedau, and life quality of its people more modern as traders, farmers, laborers, and fishermen.

Zone of Banjar Cape – South Coast

The Banjar Cape - South Coast Zone extend from the Banjar Cape to southern part of the research area that has coast line about 5 km long. This area is part of the embayment coasts and extends to the south to form straight coasts.

Coastal morphology of the Banjar Cape - South Coast consists of alluvial plains, and low relief with low resistance rock. Previously, mainland coastal area of this zone as mangrove forest area but this has changed as shrimp ponds. The beach profile of Banjar Cape - South Coast commonly has beach slope more than 5⁰, berms more than 250 m wide and beach scarp more than 1 m high.

Geologically, coastal sediment of this area consists of greenish gray mud containing quartz, mollusk shells and organic materials; white and brown sand containing more than 50% quartz and mollusk shells more than 40%, and medium- coarse sands.

Coastline characteristics of these coasts is formed by muddy, mangroves, and sandy beaches. It has retreated more than 30m due to wave abrasion. According to shoreline characteristics, beach profile, sediment, erosion and sedimentary processes, the coast of Banjar Cape - South Coast can be classified to be as medium - high energy beaches with dominant erosion processes. The impact of these changes caused

increasing of coastal erosion of this area.

In order to minimize the impact of coastal erosion, the local government built coastal dikes (rip-rap) and mangrove reforestation. The Banjar Cape - South Coast area is reliable as fishery activities. Demographically, the research area low populated and the most of them work as famers, traders, and fishing pond labors.

The megascopic description result of sediments from the boreholes can be seen in Figure 4.

Borehole BT 18

Borehole BT 18 is located in berm of the Sawah Bay as shown in Figure 5. The maximum penetration is about 4.5 m depth. At the depth between 0.00 m and 0.80 m, sediment consists of dark brown sands containing quartz, organic fragments, roots, and regolith. From

0.80 m to 4.00 m depth, sediment consists of greenish gray clay, slightly sticky and wet in place. At the depth of 4.00 m to 4.50 m, it consists of greenish gray, light gray, and sticky clay.

Borehole BT 19

Borehole BT 19 is located in the east of borehole BT18. The BT 19 reached the depth equal to the borehole BT 18 is 4.5 m. At the depth of 0.00 m to 0.40 m sediment consists of dark brown sand, quartz mineral and organic fragments, soil regolith. At the depth of 0.40 m to 1.00 m sediment consisting of sand, light brown and fine size, and quartz. At the depths between 1.00 m and 4.00 m sediment consists of light gray clay and sticky. At the depth of 4.00 m to 4.50 m sediment consists of brown-blackish gray clay and mollusk

Borehole BT 20

The borehole BT 20 is located around the Cape Banjar. At the depth of 0.00 m to 0.40 m sediment consists of soil, brownish black regolith containing organic fragment of root plants. At the depth of 0.40 m to 2.50 m sediment composed of oxidized clay, brown in color and sticky. At the depth of 2.50 m to 6.50 m sediment consists of light gray and black clay and. At the depth of 7.00 m to 7.50 m sediment consists of light gray and soft clay in wet condition.

Borehole BT 21

The borehole BT 21 is located at the northeastern of BT 20. At the depth of 0.00 m to 0.20 m sediment

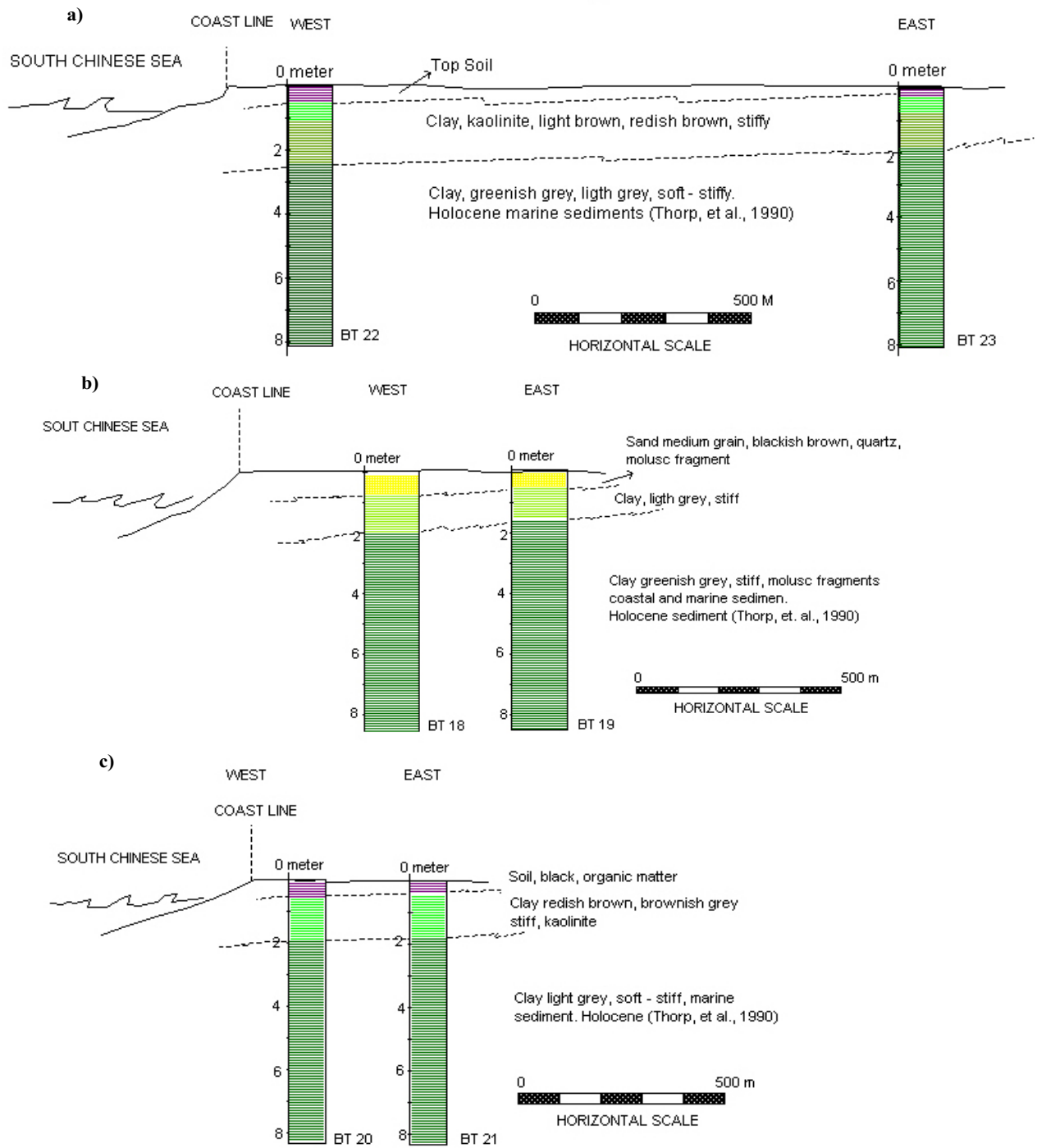


Figure 4 Data of sediment cores from hand auger at Singkawang coasts, West Kalimantan. a) bore holes of BT 22 and BT 23, north coasts. b) BT 18 and BT 19, middle coasts. c) BT 20 and BT 2, south coasts.



Figure 5 Location of hand auger drilling BT 18 at the Sawah Bay

consists of soil, brownish black regolith that containing organic fragment of root plants. At the depth of 0.20 m to 1.50 m sediment composed of oxidized kaolinitic clay, brown in color and sticky in wet. At the depth between 1.50 m and 7.00 m sediment consists of gray brown to light gray, soft and sticky clay. At the depth of 7.00 m to 7.50 m sediment consists of light gray and soft clay.

Borehole BT 22

The borehole BT 22 is located at the north of the research area around the Semalagi coast.. At the depths between 0.00 m and 0.50 m sediment consists of soil, dark brown regolith which contains organic fragment of plants. At the depth of 0.50 m to 2.00 m sediment composed of kaolinitic, brownish red, sticky, and slightly massive clay in wet. At the depth of 2.00 m to 3.00 m sediment consists of brown gray, sticky, and slightly soft clay in wet. At the depths between 3.00 m and 4.00 m sediment consists of gray and soft clay. At the depths between 4.00 m and 7.50 m sediment consists of light gray and soft clay in wet.

Borehole BT 23

The borehole BT 23 is located at the east of BT 22. At the depth between 0.00 m and 0.20 m sediment consists of soil, dark brown regolith, and organic fragments. At the depth of 0.20 m to 1.50 m sediment composed of kaolinite, red brown, sticky and massive clay in wet. At the depth between 1.50 m and 3.00 m sediment consists of brown gray, sticky, and slightly soft clay. At the depth of 3.00 m to 7.50 m sediment consists of light gray and soft clay which contain mollusk shells.

DISCUSSION

Modern Singkawang coasts, generally, are in erosional condition particularly in the Semalagi – Bajau Cape coast which is located in the northern part of Singkawang. This erosion is caused by high wave energy. The high erosion coast is also caused by the destruction of hard mangrove plants around the shoreline, shoreline retreat, and beach scarps.

The previous Semalagi –Bajau Cape coasts might be in sedimentation state or as accretion coasts. Meanwhile, the mangrove forest as indicator of coastal accretion still can be found at several locations of the coastal area. The erosion condition is occurred between the Bajau and Banjar Capes, which is located in the middle part of the Singkawang coastal area. However, the

rocks that is exposed at the coastal area, especially in headlands is characterized by resistant igneous rocks.

Therefore, the coastline is relatively stable, with less shoreline retreat, and the coastal area is protected by the presence of some islands as a buffer from wave energy. In contrast, in the Banjar Cape – South Coast (southern part of the Singkawang coastal area), is very intensive erosional condition. This erosion is shown by shoreline retreat up to tens of meters, and beach scarps 1.5 m high. This condition is becoming worst after transformation of mangrove forest into the coastal fish pond.

Referring to the data analysis of boreholes sediments from modern shorelines of the Singkawang coast, it might be interpreted as a shallow marine environment that was occurred thousands years ago (pre-Recent) as seen in Figure 6. This is proved by marine sediments as detrital sediment. It is as products of weathering and erosion of land which is supplied by streams and coastal erosion such as gravels, sand, silt, and clay. Those marine sediments also are composed of calcareous materials and carbonate minerals.

CONCLUSIONS

Singkawang coasts are mostly erosion. The Singkawang coastal land before (pre-Recent) assumed as a shallow marine environment. Due to changes of sea level it become from shallow marine environment to be a modern coastal plain. Modern shoreline retreats to tens of meters which is caused by the loss of mangrove forests act as a coastal buffer to protect the shoreline from erosion.

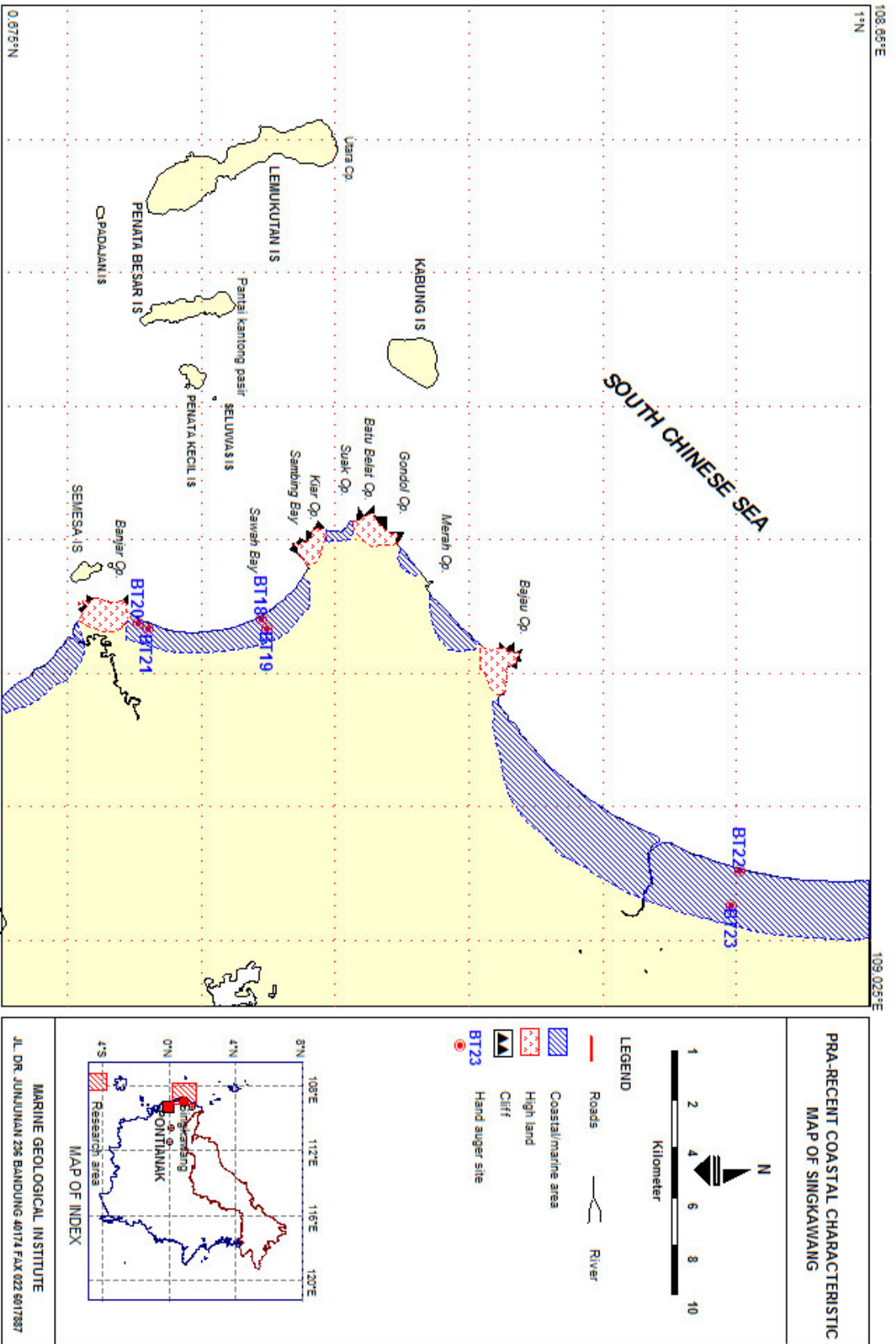


Figure 6 An interpreted coastline change of Singkawang West Kalimantan during pra-Recent based on sedimentary analyzes and coastal characteristics

ACKNOWLEDGEMENTS

The author would like to thank to Dr. Susilohadi, Director of Marine Geological Institute, for supporting to publish this paper. The author also would like to thank to colleagues who have provided input to this paper.

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