Coastal Characteristics of Papela and Adjacent Area, Rote Island, East Nusa Tenggara

Karakteristik Pantai Papela dan Sekitarnya, Pulau Rote, Nusa Tenggara Timur

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ABSTRACT : Coastal typhology as data base that describes the result of interaction among geophysical element to geological elements and anthropogenic aspects. This data can provide any information of morphological development processes which is reflected in the coastal characteristics map. Identification of the Papela coastal area, Rote Island, about 60 km length, based on indirect and direct methods. Direct method is done by field observation such as : geological condition, relief, shoreline character and dominant process. While indirect method is done by imagery satellite interpretation and related previous data.

Observation results of coastal condition, that the study area is divided into four coastal types, there are rocky cliff, sandy pocket beach, muddy and sandy beach.

Coastal geology of study area composed of Holocene Alluvium, Quaternary Coral Limestone and Tertiary Bobonaro Complex that has low to high rocks resistance. Coastal morphology form by alluvium plain until slope rugged hills with low-high relief.

The coastline characters consist of the rocky cliff, sandy pocket, sandy and muddy beach, with dominant process that influenced by fluviatil which is characterized by mangrove. Beach face material composed of sand and float stone, from 15-30 meters width with 5^{O}-15^{O} slope. Although the coastal area is relatively stable but erosion active process occurs at some places. It is characterized by float stone, and notches accompanied by rock fall. While, accretion occur in muddy coastal type that is characterized by mangrove plants.

Key words : Coastal type, marine process, abrasion, accretion, Papela coast, Rote Island.

ABSTRAK : *Tipologi pantai sebagai data dasar yang menggambarkan hasil interaksi antara unsur geofisika terhadap unsur geologi dan aspek antropogenik. Data ini dapat memberikan informasi proses pembentukan morfologi yang tercermin di dalam peta karakteristik pantai. Identifikasi pesisir sepanjang lebih kurang 60 km di sekitar pantai Papela, Pulau Rote, Nusa Tenggara Timur menggunakan pendekatan metode langsung dan tidak langsung. Metode langsung dilakukan dengan pengamatan lapangan seperti kondisi geologi, relief, karakteristik garis pantai dan proses dominan. Sedangkan pendekatan tidak langsung melalui kajian citra satelit dan data terdahulu yang terkait.*

Hasil pengamatan kondisi pantai, bahwa daerah penelitian dibagi mejadi empat tipe pantai yaitu pantai bertebing batuan, berkantong pasir, berlumpur dan pantai berpasir.

Geologi pantai daerah penelitian disusun oleh Alluvium Holosen, Batugamping Koral Kuarter dan Komplek Bobonaro Tersier yang mempunyai resistensi batuan rendah sampai tinggi. Morfologi pantainya berupa pedataran pantai alluvium sampai kaki/lereng perbukitan bertebing dengan relief rendah-tinggi.

Karakter garis pantainya terdiri dari bertebing batuan, berkantong pasir, pantai berpasir, dan berlumpur dengan proses dominan yang dipengaruhi oleh fluviatil dicirikan oleh tumbuhan bakau. Paras muka pantai disusun oleh material pasir dan rataan batuan, memiliki lebar berkisar 50 meter dengan kemiringan datar-landai pada tipe pantai berpasir. Meskipun terjadi kesetimbangan pantai atau merupakan pantai yang relatif stabil tetapi di beberapa tempat proses abrasi tetap aktif. Hal ini dicirikan oleh adanya rataan batuan, dan takik-takik yang disertai oleh jatuhan batuan. Sebaliknya, sedimentasi terjadi pada tipe pantai berlumpur yang dicirikan oleh tumbuhan bakau.

Kata kunci: *Tipologi pantai, proses laut, abrasi, akrasi, dan pantai Papela*

INTRODUCTION

Rote Island is one of the outers Indonesian island directly adjacent to Australia. One aspect of the issue in this study area is how to optimize the potential that exists in the East Rote coastal especially coastal and marine tourism aspects and potential geological resources (minerals and gas). Environmental problems facing them are coastal erosion. Inadequate infrastructure such as roads, bridges, docks that connecting remote areas is one of the factors that hinder the development of the region. Some exploitation of minerals in the land and the sea, often left damage condition of post-mining environment.

Coastal characteristic data to support the development of the study area, this has not been done. Regional geology of Rote island, is a part of the Timor island and surrounding discussed by geologists such: Hamilton (1979); Rosidi (1979); Price and Audley-Charles (1987); and Barber, et. al (1986).

Based on the literature above, it can be identified the condition of geology, mineral resources, and the environment in general coastal of Rote island. The process of change in the environment, including biodiversity decline partly coastal of Rote island is the impact of change on the hinterland in addition to a change of local coastal communities' livelihoods.

Timor island in the outer arc ridge Banda, where Timor island is on the south side, and Buru island and Seram in the north, in the Banda Arc collision and Australian continental shelf (Figure 1).

East Rote which is administratively part of Rote-Ndao regency, East Nusa Tenggara Province. Geographic location of the study area is located at coordinates 10 ° 25'-10 ° 38 'South latitude and 123 ° 19'-123 ° 29' East (Figure 2). While the base map used for the study area based on a map taken from Hydro-Oceanographic Office, 1992, Map Sheet 322, Nusa Tenggara, Roti Island, Jakarta.

Coastal characteristics describe the diversity of morphology formation process, which characterize the spatial changes resulting from the interaction between the elements of the geophysical to elements of geological and anthropogenic aspects (human intervention).

Study area is a plain with low hills that supporting aspects, include : wide bay, sandypocket, mangrove, sandybeach, low sedimentation, blue waters and deep seas, overlooking the Indian Ocean. Inhibiting aspects, include : the waves are relatively high, rock cliff and rock flats in the form of limestone outcrop at low tide the sea water.

The purpose of the study is to collect and inventory the basic data about the type of beach that is reflected in Coastal characteristics map. The goal is identifying and providing information about coastal characteristics, especially its relation to the coastal environment as a material consideration in the management and development of coastal areas.

Based on the Geological Map Sheet-Atambua Kupang, Timor (Rosidi, et al., 1979), lithology coastal

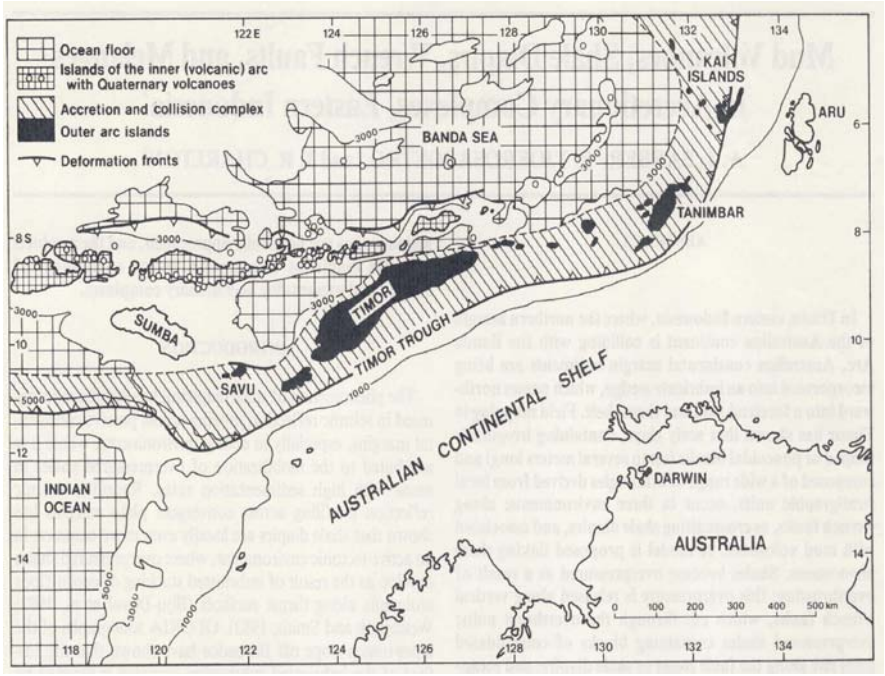

Figure 1. Accretion complex and collision of Banda arc and Australian continental shelf (Barber, et al., 1986).

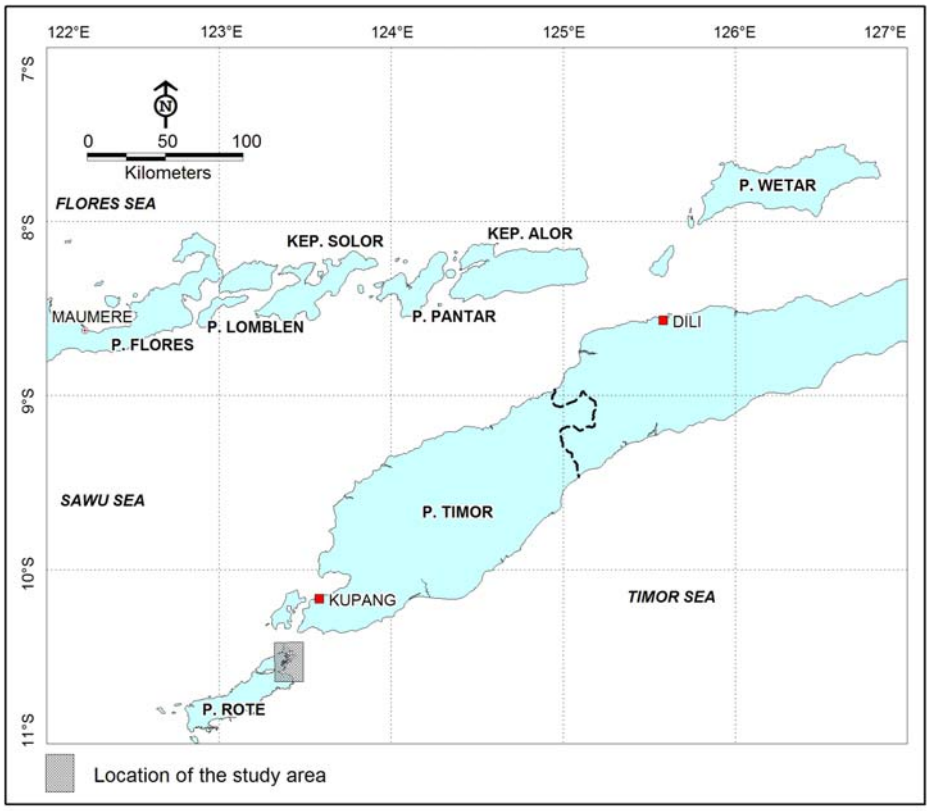

Figure 2. Study area

study area from old to youngest age occupied by Bobonaro complex the Middle Miocene-Pliocene, Plio-Pleistocene Noele Formation (consists of sandy marl alternate with sandstones, conglomerates and some dacite tuff), coral limestone Pleistocene (composed of coral limestone is yellowed white and sometimes redness and marl limestone, locally grown coral limestone with rough surface hollow), and Alluvium Holocene (composed of sand-sized grains of loose gravel). Bobonaro Complex lithology consists of two parts scaly clay and xenolith of varying sizes. Scaly clays have a variety of colors: maroon, greened, grayed green, browned red, blue-gray and pink, and a matrix of xenolith derived from older rocks. Xenolith consist of miccaceous sandstone of Bisane Formation; limestone of Cablac Formation; chert, ultramafic rocks, pillow lava and krinoida limestone of Formation Maubise; rock of Mutis Complex; Ofu Formation, Nakfunu Formation and other rocks.

One kilometer from the shoreline, both of Bobonaro Complex rocks, Noele Formation, coral limestone and that Alluvium occupies is formed coastal plain , hilly slope which low-high relief with low-high rock resistance.

METHODS

Coastal characteristics map depends on the scale of the map and the object of research. Global scale based on geomorphology and geology (Mc. Gill, 1958 in Dolan, 1975), and based on the movement of the plates, the morphology and dynamic processes (Davies, 1964 in Dolan, 1975), has a low level of accuracy because it only displays the dominant topic. Finally, Alexander based on the description form the beach which is then refined by Dolan (1975). Local scale with field mapping to show you an idea of ??the type of sandbar, changes in grain size and slope of the beach.

Identification of coastal along the ± 60 km is used indirect and direct methods. Indirect method is done by literature study includes the selection of methods to be applied, a review of topography, satellite imagery, geological and physical condition. Direct method is done by orientation field through the nearshore on foot, by boat and motorcycle in a qualitative description of the aspects of geology, relief, shoreline character and the dominant process (Dolan, et al., 1975) with some modifications to the legend and scale of the map.

Location of the sample point selection is done based on the points that represent locations along the coast representative study areas such as cape, bays, beaches which have different characteristics with the

surrounding, etc. Beach slope is measured by using a compass, while the width of berm and beachface use rollmeter.

In the geological aspect as resistance rocks and reliefs as elevation contours shown on the map as far as one kilometer inland from the shoreline. Acquisition data and images guided by the "global positioning system" (GPS) III Plus Garmin types using 1:250,000 scale maps. Finally recent interviews with officials or community leaders and fishermen.

RESULTS

Based on a qualitative description of the aspects of geology, relief, shoreline character and the dominant process (Dolan, et al., 1975) the type coast from north to south, the study area can be divided into the type of Rock cliff, Pocket beach, Mangrove and sandy beach (Figure 3).

Type of rocky cliff coast

Type rugged coastal rocks composed by Tertiary limestone coral resilient, rugged hills slope morphology occupies berelief low to high with the marine process dominant. Field observations indicate that most of cliff coastline do not have a beach, both averaged rocks or sandy pocket because of the influence of the tides to the relatively shoreline cliffs. But the locals still see the traces of residual falling rocks (Figure 4).

Rock cliff that reflects the relief of the face and Shoreline character has a height of 5 - 50 m. At the base of the cliff at high water level developed Notchs effected by marine process in the wave erosion partly accompanied by rock fall caused by gravity (Figure 5).

Rock and cliffy coastal type formed by the Coral Tertiary limestone composed by hard rock resistance. This type can be regarded as relatively stable beach caused by composed by rock resistance, but a cumulative abrasion process remains active with Notch

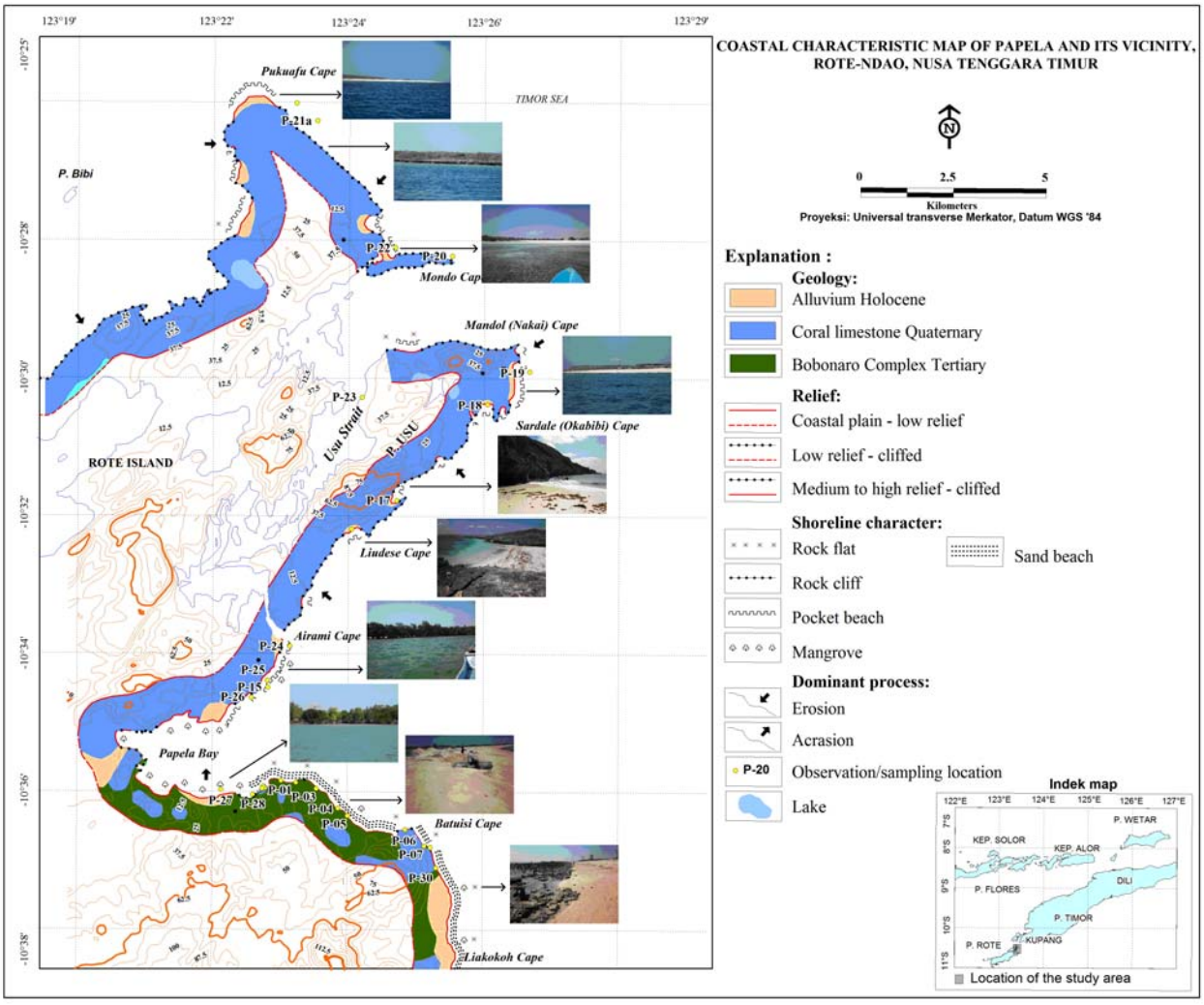

Figure 3. Papela Coastal characteristics and adjacent area

Figure 4. Type of rocky cliff beach, this type does not seem to own "beach" because of its coastline remains unaffected by tidal (location P-20 at Cape Mondo)

Figure 5. Looks notch cliff erosion at high tide along said boundary falling rocks due to gravity (location P-21a in the southern Cape Pukuafu).

characteristics. This is interpreted as the relative is in the offshore are generally not protected by waves, despite of being supported by hard rock. Coastal type dominates the study area, evolved from Pukuafu cape to the middle of the study area (Papela Bay), and disconnected locally by the presence of sandy pocket beach type.

Type of pocket beach

Sandy pocket beach type composed by loose rock Alluvium Holocene and coral limestone Tertiary which low-high resilient, occupies the plain coastal morphology that low-slope hills with dominant marine process.

Alluvium that sand sized, some gravels and a sediment coastal composed by biogenic, while limestone is a marine sediment. It called pocket beach because the material only occupies the small cracks and dispersed separately among rugged coastal rocks type, as found on the Pukuafu cape, Maeoe beach, Usulain beach, Sardale cape (Okabibi), Liudese cape and Airami cape (Figure 3).

Beach Type has shoreline character as a sandy pocket and some mixed with rock flat. Nearshore resembles a crescent that follow the bay has a wide the middle reaches 25 m to disappear on both sides, with low slope (Figure 6). On the beach there is a local mangrove forests as found on the beach Sowau.

The physical properties material of white to browny white sandy pocket, fine-to-medium sized, rounded middle grain shape, either by sorting major composition in the form of granules bioclastic limestone, shell fragments and some coral fragments (Figure 7).

Materials sandpockets suspected to be the result of abrasion from both sides of the cliff rocks carried by currents parallel to shore, and then reshaped by marine processes such as accumulation by ocean waves.

Figure 6. Sandy pocket beaches type, sand occupies looking material gaps between rock cliffs (Area P-16 at Cape Liudese)

Figure 7. Looks physical properties of a whitish sand, smooth, roundeds responsibility, either by sorting major composition bioclastics (Area P-16 at Liudese Cape

Type of mangrove and sandy coastal

Central coastal type of study area, specifically in Papela Bay generally mangrove forest. Mangrove coastal type composed by Holocene Alluvium - Bobonaro Complex Tertiary that have low to high resistance, occupy plain coastal - slope hills low-medium relief with Mangrove live dominant process are partially affected by river sediment/ fluviatil process (Figure 8).

Beach type above the shoreline character as mangroves live on silty sand material and in part on the average rock. Mangrove type generally rhizophora and some avicennia, Young to old age with low-medium density (Figure 9). Mangroves function as sediment traps, breakwater and marine biota life. Mangrove coastal type in accretion process cumulative remains active that met some of the young vegetation growth towards the sea.

Type of sandy beach

Type sandy beach compiled by Holocene Alluvium geology, tertiary Coral limestone and Tertiary Bobonaro Complex that have resistance low to high, occupies the coastal plain morphology low-slope hills relief with dominant marine process which is partly influenced by fluviatil.

That alluvium come from a beach and river sediment origin, sized between sand-gravel. Coral Limestone yellow whity colored, sometimes reddish and limestone that locally grown coral limestone with rough surface hollow. While Bobonaro complex consists of two parts clay and scaly chunks of varying sizes (Rosidi et al., 1996).

Sandy beach is growing in the southern study areas start from Papela bay to Liakokoh cape (Figure 3). This type is characterized by Shoreline character Sandy beach, which found the rock flat and coastal structures such as sea walls. Sandy beach has a width Beach face between 15 - 30 m with a slope between 5 - 15 . While

Figure 8. Type of coastal mangrove forest, low density, seem influenced by fluviatil Area P-27 Papela Coast (Google earth)

Figure 9. Muddy coastal type characterized by mangrove trees such as Rhizophora (P-27 Location Papela Coast)

the average rock has a width between 10 - 40 m with a relatively flat slope. There is coastal structures such as sea walls in this area as found sea harbor in Papela bay.

Sandy beach levees generally formed by Berm with a height between 1 - 2 m and form a resembling Beach ridge with a flat surface (Figure 11). Dike beach is formed by marine process in the form the accumulation of material beach by ocean waves. The width of the beach face is inversely to the slope or can be said; for the study area, the width of the beach face relatively cumulative widened to the north. Cross section of the beach depends on height, width and angle beach face, shape are closely related, especially to height waves that build it.

Beach material whitish-brown, sand-sized, some of gravels, rounded to middle rounded grain size, either by sorting major bioclastics in form granules of limestone, shell fragments and some coral fragments.

Low resistance alluvium always synonymous with shoreline retreat, but in the study area is relatively stable because of the equilibrium beach still awake as the establishment of mature mangroves (Figure 12). Locally looks a sandy beach accretion results were influenced by the marine sediments fluviatil. Accretion found in estuaries, such as on-site observations of P-04 (Figures 14 and 15). In addition, the average rock surface is relatively flat, rough and hollow, supposedly formed by wave agitation that shows traces of sea level at the time of the rock abrasion occurs. Another thing, in the location of P-04 there is human intervention (anthropogenic) that small-scale mining of mineral sands C group such as building materials that not consider border coast line (Figure 13). The

Figure 10. Type of sandy beaches, the low slope beach face and rock flat (Area P-01 on the east Coast Papela)

Figure 11. Type of sandy beaches. At Berm, a height of 1-2m, flat surface (location P-03 in the eastern Coast Papela)

Figure 12. Type of sandy beaches. Background, mangrove with low density (P-05 Location Horoes Coast)

Figure 13. Type of sandy beaches. Background, beach sand mining and sand dikes beach (Area P-04 Horoes Coast)

Figure 14. Type of sandy beaches, it appears the formation of marine sandy beach affected by fluviatil (Area P-04 on the beach Horoes)

Figure 15. Type sandy beaches, it appears the sandy beach marine formation is influenced by the sediment of rivers (location P-04 on the beach Horoes)

environmental impact is not felt now but in the future, shore stable will be very vulnerable or becomes unbalanced when factors of land and marine that both interaction changed.

DISCUSSIONS

Coastal characteristics can illustrate variety of the coastal morphology formation process, which its spatial change reflected results from interaction between geophysics to geology elements, and anthropogenic aspects. Qualitative description of the coastal characteristics showed that the typology of Papela coast and its vicinity can be divided into rock cliff, pocket beach, mangrove and sand beach coastal type.

Rock cliff coastal type shows that its coast does not have beach face because of the tidal sea water influence to coastline is relatively fixed as steep cliffs. The rock cliff at high tide sea boundary develops notches due marin process in the form of wave erosion, in part accompanied by rock fall due to gravity. This coastline is relatively stable due to the rock arranged high resistance, but cumulative process will continue with the abrasion encountered traces of the notches. Abrasion will continue because this area is relatively facing the open sea is not protected by sea waves action.

Type of pocket beach has a shoreline character as the sand which forms sand bag. Its beach face like a crescent that fill the gap or embayment is flanked by

rock cliff with gentle slope. Pocket beach material is thought to be the result of erosion from both sides of the rocks cliff carried by longshore currents, and then reshaped by marine processes such as accumulation by sea waves.

Type of mangrove beach has a shoreline character as mangroves wich growing on mud-sand material and partly on the rock flat. Mangrove type consists of *Rhizophora* and partly *Avicennia* who has a young-mature age with low-medium density. On this mangrove type acration is still running with the mangrove live dominant process which is influenced by fluviatil.

Type of sand beach has a shoreline character as sand which forms sand beach, and part locally presence of rock flat. Sand beach type has a wide of beach face between 15 m - 30 m with a gentle slope between 5 - 15 , While flats rock has a width between 10 m - 40 m with a relatively flat slope. At the back of the beach face there are berm which forms like beach ridge with a flat surface. This berm was formed by marine processes such as accumulation of sand-sized materials by sea waves. On the sand beach, locally seen the accresion marine process results that are influenced by fluviatil. Besides, rock surface are relatively flat, rough and hollow, supposedly formed by wave agitation that shows traces of sea level at the time of the rock abrasion takes place. Another thing, there is human intervention (Anthropogenic) is a small-scale mining of sand as a building material which do not pay attention worth the coast line. The environmental impact is not felt now but in the future, will be very vulnerable stable beach or becomes unbalanced when the factors of terrestrial origin and marine origin that interact to change.

CONCLUSIONS

Coastal characteristics describe the diversity of morphology formation process, which characterizes spatial changes the result of the interaction between oceanography (waves and currents) on geological (rock resistance) and anthropogenic aspects (human intervention).

Qualitative description coastal characteristics show that the beach type type include to Rock cliff, sandy Pocket beach, mangrove forest and sandy beach. These types of beach have specially characteristics .

Rugged rock coast type with high resistance to the base of the cliff at high water level developed Notchs due process in the form of marine wave erosion occurs mostly rock fall due to gravity. Type of crescent-shaped sand beach with deep marine processes generally occupy relatively narrow gaps between rocks rugged coastal type. Type coastal mangrove forested with mangrove live process growing on the mud flats of sand and rocks in the bay area is relatively quiet / safe from wave action. Lastly, the type of coastal the dominant process which is partly influenced by fluviatil (stream sediment) generally develops in Holocene Alluvium low resilience.

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REFERENCES

[1] Barber, A. J., Tjokrosapoetro, S., and Chariton, T. R., 1986, *Mud Volcanoes, Shale Diapirs, Wrench Faults And Melanges In Accretionary Complexes, Eastern Indonesia*, Am. Ass. Petroleum Geol Bull., 70, 1729-1741,

[2] Google Earth, 2012, *Google Pro*, NASA.

[3] Hydro-Oceanographic Office, 1992, *Map Sheet 322, Nusa Tenggara, Roti Island*, Jakarta

[4] Dolan, R., Hayden, B.O. and Vincent, M.K., 1975, *Classification of Coastal Landform of the America, Zeithschr Geomorphology, in Encyclopedia of Beach and Coastal Environments*.

[5] Friedman, G.M., and Sanders, J.E., 1978, *Principles of Sedimentology*. John Wiley and Sons, USA

[6] Hamilton, W., 1979, *Tectonics of the Indonesian Region*. U.S. Geol. Survey Prof. Paper, pp. 1078

[7] Price, N.J. and Audley-Charles, M.G., 1987, *Tectonic Collision Processes After Plate Rupture*. Tectonophysics 140, 121-9.

[8] Rosidi, H. M. D., *Tjokrosapoetra, S., and Gafoer, S., 1979, Geological Map of Kupang-Atambua Sheets, Timor, Scale 1 : 250.000*, Research and Development Geological, Bandung.