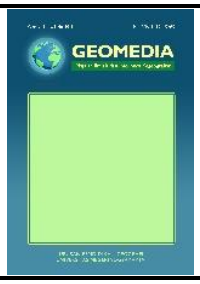

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Recent delta evolution based on mollusk shell record on sediment in Delta Wulan, Demak, Indonesia

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A B S T R A K

Penelitian mengenai perubahan lingkungan saat ini menjadi salah satu isu hangat yang banyak diteliti oleh ahli-ahli lingkungan. Penelitian dengan tema-tema tersebut semakin berkembang setelah dicetuskan sejarah baru dalam evolusi bumi, yaitu Antrhopocene. Tujuan dari penelitian adalah untuk mengetahui perubahan lingkungan wilayah pesisir melalui kunci identifikasi cangkang moluska yang terkandung dalam sedimen. Lokasi penelitian yang diambil adalah Delta Wula. Delta Wulan di Demak adalah salah delta yang cukup besar di Pulau Jawa. Moluska yang diambil sebagai sampel adalah moluska yang terkandung dalam sedimen serta moluska yang berada dipermukaan endapan sedimen sebagai perciri akibat adanya proses banjir maupun arus pasang. Hasil identifikasi menemukan bahwa terdapat dua jenis moluska yang, yaitu moluska aor tawar dan moluska air asin yang ditemukan pada wilayah berbeda. Pada bagian percabangan sungai, ditemukan moluska berjenis clam dan snail yang memiliki penciri hidup di air tawar. Selanjutnya, pada wilayah yang lebih mendekati laut, ditemukan moluska tipe chiton, scallop, dan ammonite yang merupakan moluska air asin dengan tipe moving/vagrant. Hasil ini menunjukkan bahwa lokasi sampling 1 diprediksi terbentuk sejak dahulu (sebelum 1925) Pada lokasi sampling dua terdapat 2 telah terjadi perubahan dari ekosistem laut menjadi darat dan mulai stabil sejak tahun 1925-1946. Pada lokasi sampling 3 dominan ekosistem laut, namun pada tahun-tahun mendatang dapat diprediksi akan menjadi landsapce seperti pada lokasi sampling dua.

Keywords:
Delta
Geomorphology
Mollusk
Sediment

A B S T R A C T

Research on environmental change is currently one of the hot issues that many environmental experts have investigated. These research themes have increasingly developed after a new history in the evolution of the earth is revealed, known as Anthropocene. The purpose of this study is to determine the environmental changes of the coastal area through the key to identifying shells of mollusks contained in sediments. The location of this research is in Delta Wulan. Delta Wulan in Demak is a large delta on Java. Mollusks taken as samples are mollusks contained in sediments and mollusks which are on the surface of sediment deposits as a sign of the process caused by flooding and tidal currents. Identification results showed that there were two types of mollusks, which consisted of freshwater mollusks and saltwater mollusks found in different regions. On the river branch, clam and snail that are found in this area have

characteristics of mollusks that live in fresh water. Furthermore, in areas closer to the sea, chitones, scallops, and ammonite mollusks which are vagrant saltwater mollusks were found. These results indicate that the sampling location 1 was predicted to be formed long ago (before 1925). At the sampling location 2, changes had occurred from the marine ecosystem to terrestrial ecosystem and began to stabilize from 1925-1946. Sampling location 3 is dominated by marine ecosystems, but in the coming years it can be predicted to become landscapes as in the sampling location 2.

Introduction

Recently, the environmental change studies to find proxies as identification keys for reconstructing paleoenvironment is very developing in earth scinces. For example, Sandeep et al. (2017) used sedimentology, the organic material geochemistry, and radiocarbon isotope to reconstruct the monsoon climate that causes summer time during the Holocene. In coastal areas, a proxy that is also widely used are through shells of mollusks or foraminifera. A study shows that the shell of a mollusk can be used as a key to the development of the Mae-Ho lagoon in Korea (Nakanishi et al., 2017). Dating from mollusk shell fossils shows that lagoons develop from transgressive lagoons, restricted lagoons, delta lagoons, and have now been converted into reservoirs. These changes can be recorded through shells of mollusks found in sediment deposits. All of the shells of the mollusks studied are shells of mollusks from sea water. The shell of a mollusk from freshwater (terrestrial) was also investigated by Wu et al. (2018), and stated that the shell of a mollusk can be one of the very potential keys for the reconstruction of peleoenvironment and paleoclimate since the Kenozoic era to the present.

Based on those previous studies crried out, this study is propose to find a marker in Delta Wulan, especially from the shells of marine and terrestrial mollusks recorded in sediments. Previous studies which stated that there had been a change from sea to land gradually, the markers was very potential to be found in the research area. Organisms that live in different conditions have different characteristics, therefore to approach environmental conditions in past times can be done by identifying fossils in rocks or sediments. When there is a type of organism found together with another organism (mixed), it can be indicated that there has been a mixing of sedimentation mechanisms, one of which can be caused by storms or other disasters (Anstey and Chase, 1974). Phylum Mollusca in which there is a class gastropod is one of the organisms that can live in freshwater and saltwater, also can live in calm waters to high sedimentary waters.

The development of the region on Java Island has focused mostly on coastal areas, even other regions throughout the world have this tendency. This condition is evidenced by the formation of large coastal cities such as Jakarta, Semarang and Surabaya. Those cities have long existed and began to develop rapidly. Meanwhile, cities on the southern coast of Java Island did not develop into large cities. This condition is strongly influenced by the natural conditions of the region, and human adaptation which has accelerated environmental change. For example, the west coast of Demak, in Delta Wulan. This region has a long history from the Pleistocene to the Holocene which originated from the separation of Java Island with the Muria Volcano. The merging process between Muria Volcano and the mainland of Java took place since 1700 years ago. Sedimentation and tidal flat formation occurred in the sea. In 1989 on the Serang River straightening work was carried out which accelerated the formation of Delta Wulan. The process has been reconstructed by Sunarto (2004), who also stated that the Delta formation

was very significant between 1925-1995 through the identification of coastline changes. Other identification of shoreline changes also conducted in the mouth of Pemali River. Identification from geomorphologic perspective showed that coastline provoke the dynamic changes from stable, progressed, and regressed (Priyono, 1998). Those studies is very interesting and can be used as a reference for future research and can be developed by linking human influence by finding a proxy or marker for changes in its environments.

This research is one of the most recent studies that has not been carried out yet in Indonesia, especially from a geomorphological perspective. This research also follows international research trends in the fields of paleogeography and the paleoenvironment. Research on environmental change has been started for a long time, for example in Java by Sunarto (2004) who examined pelogeomorphology in the area around Muria Volcano. Nearly a decade later, research in this field became popular and more developed. Other researchers examined environmental changes that occur in the karst region (Hartman, et al. 2013). The purpose of this study is to find the identification key (marker) of ancient environmental conditions at the study site, mainly from the identification of shells of marine and terrestrial mollusks and to reconstruct environmental changes that occurred from recent ancient times to the present as interpretation keys of future environmental changes. The results of this study are expected to provide a periodic description of environmental changes that have occurred during past times until present, so that it can be used as a reference for changes that will occur in the future. This is in accordance with one of the concept of geomorphology, "the present is the key to the past and the future" (Thornburry, 1965).

Methods

The chosen location of the research is an area that has significant environmental change. Sunarto (2004) states in his study that Delta Wulan is a dynamic area that has been formed up since the Pleistocene-Holocene epoch. The location choice is in accordance with the principle of environmental change research which states that delta is a suitable area for the analysis of the evolution of climate change, sea-level rise, and human influences that have been used as the best area by numerous researchers (Nian et al., 2018). The research location is presented in Figure 1.

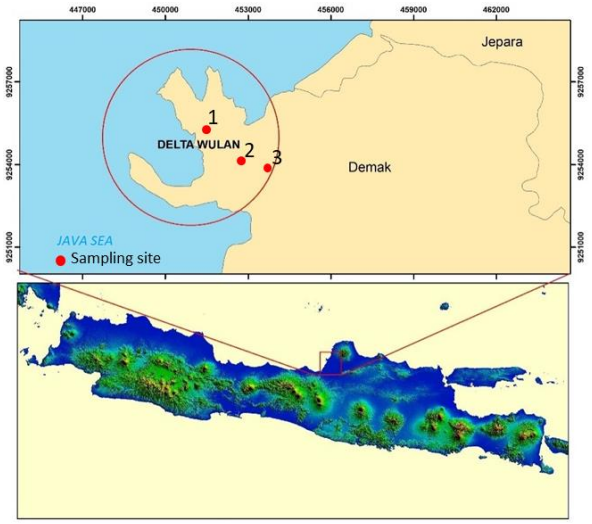

Figure 1. Research area, Delta Wulan, Demak, Central Java

Environmental change research requires primary data in the form of sedimentary deposits. Therefore, a drilling equipment is the main tool in this research. The tools are also used to support the field analysis and studio during the research. In determining the marker of the environmental changes, drilling at the selected areas is needed. These areas are chosen after literary study and spatial analysis of the study location have been conducted. The field survey begins by interpretation through imagery and aerial photographs. Furthermore, the results of this analysis are taken into consideration to select the sites for drilling. The drilling is carried out at different areas to find the stratigraphy and sediment layers in detail. In these sediments, it also attempts to find the key of environmental change through the shell of mollusks. The types

of phylum Mollusca that can be used as keys to identify the environmental changes are based on classification in Anstey and Chase (1974).

Result and Discussion

The formation of delta on the west coast of Demak has occurred approximately 46 years ago. Sunarto (2004) states that the delta has been formed since 1972, marked by changes in the coastline. In 1931, the coastline on the west coast of Demak was still straight and has not yet developed. The large amount of sediment supply from the Wulan River caused sedimentation and changed the coastline to form a delta in a period of 41 years (1931-1972). The Delta Wulan continued to grow because of the large sediment supply that enters from the tributaries of Wulan River. In 2000, it was identified that a land was formed, branched westward at Delta Wulan, so that the shape of the delta resembled a bird's foot. Afterwards, the government planned a program to create shortcut at Wulan River to reduce sedimentation rate, that actually caused land expansion that occurred on the branch of Delta Wulan on the west side. The development of Delta Wulan which is marked by changes in the coastline on the west coas of Demak is shown in Figure 2.

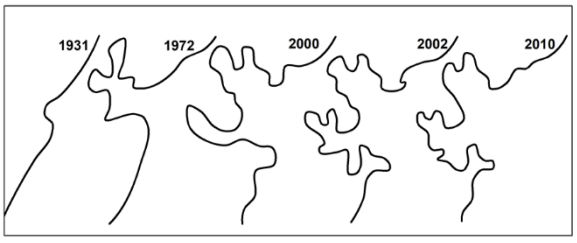

Figure 2. The Development of Delta Wulan (source: modified by Sunarto, 2004; Marfai et al., 2016)

The change in the coastline is due to the high sedimentation rate so that the land spread wider. The land on the west coast of Demak always increased every year, calculated based on its area. The land expansion that occurred in the period 1995 to 2000 reached 85,000 m^2/year, and decreased to 27,000 m^2/year from 2000 to 2011, then increased again to 60,000 m^2/year in 2015 until 2015 (Septiangga, 2017). The emerging Delta Wulan also influenced to the land use of its surrounding. There was an addition of 888,787.8 m^2 of land that was utilized from 2008 to 2016. The biggest land use type on Delta Wulan is shrimp farms (Fadlillah, et al. 2018).

Other research shows that there was sedimentation from Serang River. The formation of Delta Wulan is the result from erosion (welding) of the marine materials located in the north side (Figure 3). A research from Dutch expert also states that the coastline in the northern part of Delta Wulan has occurred a decline of 200-300 meters for 20 years (Ruswanto, 1995). From these findings, it is possible that the deposits in subsurface layer of deltaic sediments are formed due to these processes. This is also in line with the explanation from Ruswanto (1995) that marine erosion in the northern part of Delta Wulan began to decline since 1995, therefore the recent deposits (Layer 1st in Figure 5.) are deposits that have been formed since that time from the sediment supply of Serang River until now.

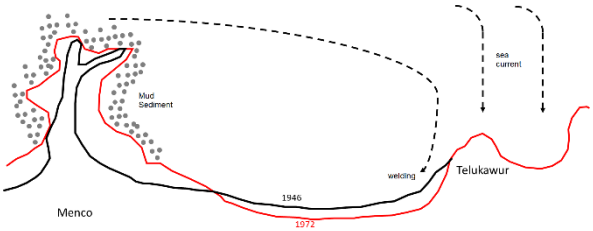

Figure 3. The process of abrasion that occurs in northern part of Delta Wulan and the impacts to the formation of Delta (after Ruswanto, 1995)

The process of erosion certainly also erodes the bottom of the ocean (offshore mud) so that it is deposited at the delta. In addition, due to the trapping that occurs also causes the offshore mud to be trapped and formed into land inside the delta on the backshore part. This condition causes the marine sediment type of material formed in the body part of the delta. This deposit has been around for a long time before being covered by new material from the sedimentation process of Wulan River (Figure 4).

Moreover, the formation of a longshore bar on the outside of delta indicates there is a process and environmental change in Delta Wulan. This formation is also a sign that the sand material has started to be produced by Serang River which shows the acceleration of erosion (tillage) along with the process of longshore that deposits it into longshore bar. This process at least has begun since 10 years ago (Atmojo, et al. 2016).

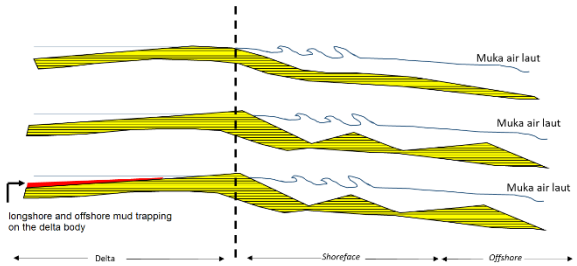

Figure 4. Series of Delta Wulan's growth (after Atmojo et al., 2016)

Analyzing the sediment layer on the sandbar is one of the way to identify environmental changes. However, the amount of clay and water contained makes the drill equipment (hand drill) difficult to penetrate the sediment layer on the sandbar. Besides, pit making is hardly possible to conduct at the sandbar close to the water. Sediment layer samples are taken on the sandbar of the river which is distant from the body of the river. Pit making is conducted with a depth of 25 cm because water will be found in the deeper dig. The results of the sediment layer in the pit is shown in Figure 5. This sediment pit in line with the explanation of Ruswanto, et al. (1995) and Atmojo, et al. (2016). Layer 1st is the recent sediment which supplied form Serang River and the third layer is formed from offshore mud which result from erosion and trapped on delta body as explained by Ruswanto, et al. (1995) and Atmojo, et al. (2016). The key of environmental change (mollusk shell) found of those kind of sediment layers, especially on the first layer.

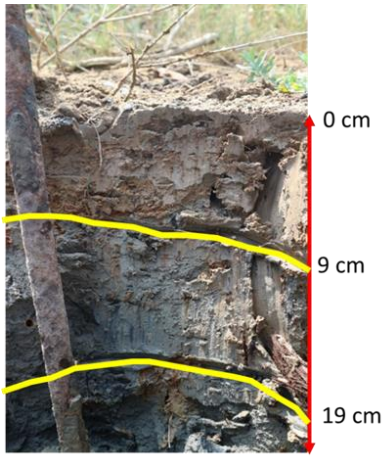

Figure 5. Expample of sediment layers in Delta Wulan

The mollusks that are found in the sedimentary deposits in the river branches are clams and snails that have the characteristics of mollusks live in freshwater. These mollusks are carried by the river flow and are deposited due to the large supply of sediment that enters to the sea. Meanwhile, there are also found 3 types of saltwater mollusks with the type of moving/vagrant. These three types of mollusks are chitons, scallops, and ammonites. These types of mollusks can be seen in Figure 6. Mollusks with the type of snail and chiton on the surface of the sediments are found in the sampling location 1. This condition indicates that the type of freshwater mollusk is dominant in this area and the tidal currents carry the mollusks from the sea. In the location 2, mollusks with the type of snail and clam are found on the surface, and type of ammonites and chitons are found inside the sediment. The difference between the surface of the sediment and inside the sediment indicates that there are two land processes which is almost as strong as the sea process (tidal). Tidal currents are able to carry the mollusks into the sampling location 2 and are covered by the sediments from the land. In the sampling location 3, mollusks with the type of scallop and chiton are found inside the sediments. This condition shows that sea process is more dominant so that the freshwater mollusks cannot live in this location.

Figure 6. (a) Types of freshwater mollusks, (b) Types of saltwater mollusks. The classification of those mollusks are absed on Anstey and Chase (1974)

These mollusk findings are then used as the key of landscape changes. Although there are limitations to using dating analysis, but with the analysis of shoreline changes from Sunarto (2004), Marfai et al. (2016) and sedimentation process from Ruswanto (1995) and Atmojo et al. (2016), it can be reconstructed that the mollusks are useful for the key of landscape in the recent environmental change. In the sampling location 1, it is predicted that the location has become a land since a long time ago (before 1925) so that until now, only freshwater mollusks can live in this area. In the sampling location 2, there are two types of mollusks which are freshwater and sea mollusks. It is because there has been changes from the marine ecosystem to become a land in this location. The terrestrial ecosystem at this location began to stabilize since 1925-1946. Terrestrial ecosystem has become dominant because no saltwater mollusks are found on the surface. In the sampling location 3, although the area has developed into a land, the marine ecosystem is still dominant. However because of sedimentation process still continues in this location, it can be predicted that in the coming years it will become a landscape as in the sampling location 2 or 1. This is because the delta will continue to move forward. Figure 7 showed the reconstruction of evolution in the Delta Wulan from mollusks shell record on sediment and matched with previous researchs.

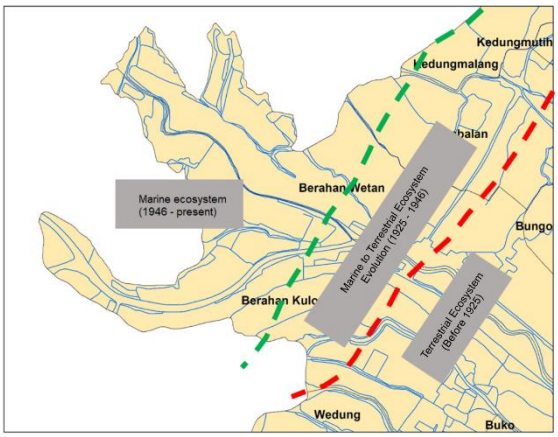

Figure 7. Reconstruction of the environmental changes of the Delta Wulan

Conclusion

The mollusks shell markers that are found at Delta Wulan as the key of environmental changes are freshwater and saltwater mollusks consist of clams, snails, chitons, ammonites, and scallops. According to sampling results of the three locations and previous finding from other researchs, it can be reconstructed that the environmental changes can be divided into three phases: a phase before 1925 which has now stabilized into a terrestrial ecosystem; the second phase from 1925 to 1946 which began to form a delta and the marine ecosystem turned to terrestrial ecosystem; and the third phase of delta formation since 1946 where marine ecosystem is still dominating. The development of the Delta Wulan will continue to change its ecosystem, specifically at the mouth of delta which will evolve the marine ecosystem into terrestrial ecosystem. However the sampling sites are minimal so the result may be less acurate. For future development its still need to detailing the sampling sites and adding for dating analysis.

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