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The distribution of iron sand on surface substrate of Leungah fluvial system, Aceh Besar, Indonesia

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Abstract. Iron sand content is obviously observed at Leungah River which downstream into the beach. The study examines the distribution of iron sand at the surface around the coast and river sediment of Leungah. Data sampling was done on February 2017, a total of 20 stations with each of 10 sampling locations are stationed in the river and coastal areas. Sediment samples were collected by applying a coring method using a PVC tube with a diameter of 2.5 inches and a thickness of 15 cm from the surface. The sorting of the sediment samples by its grain size was done by using a wet sieving method consist of: 2 mm; 1 mm; 0.5 mm; 0.25 mm; 0.125 mm; 0.063 mm; 0.038 mm. The magnetite content is sorted from the bulk sediment from each sieve level using a neodymium n35 strong magnet and then weighed. The results showed that magnetite concentrations in surface sediment were found to be higher in the coastal areas than in the river area. Meanwhile, the coarsest magnetite grains were found in the upper reaches of the river. These conditions provide an early indication of the relationship between Leungah River watershed and the distribution of iron sand down to the Leungah coast.

1. Introduction

The cycles of sediment transport in a waters require complex studies related to many factors that control the process of transport and sinking of sediments [1, 2, 3]. Disclosure of origin and sediment transport process is generally carried out using the sedimentary physics-chemical study approach [4, 5, 6, 7, 8, 9, 10].

Clastic sediment composition is generally characterized by physical features, where grain size distribution is the most important parameter [11, 12, 13]. Grain size statistical approaches have been used extensively to describe the conditions of a depositional environment, related to various processes and energies that work in the region. Sediment grain size can describe the condition of a deposition environment and energy work in the in the region [14, 15, 16].

Determining the source of sediment by its mineral content is a common used in geology. The minerals can reflect the origin area since different rock types contain a specific compilation of minerals. Moreover, the composition and mineralogical of whole or individual grain of sediments are certainly crucial in provenance studies [17, 18, 19]. This overall composition is controlled by a number of factors, starting with the composition of the mother rocks which are then followed by various sediment transport events

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which modify the sediment along the way to the deposition area [4, 20]. The provenance analysis becomes very complicated as it comes to the depositional area, thus the sediment composition is controlled by various factors such as weathering processes, hydrodynamic sorting, and mixing with other constituents.

Coastal areas have abundant availability of natural materials, one of them is iron sand. The dominant mineral content in iron sand is magnetite (Fe3O4) which is usually found in coastal areas, rivers and volcanic mountains [21]. The coastal area of Aceh Province has abundant availability of iron sand [22, 23, 24, 25]. The presence of iron sand in Aceh is located in several area specifically at Aceh Besar District, Southwest Aceh District, Pidie District, Subulussalam, East Aceh District, Gayo Lues District, and South Aceh District with a total deposit of 92.3 million tons [26]. Specifically, several studies [27, 28] found the iron sand content found in the Pulau Kayu estuary and East Labuhan Haji estuary, each located in the Southwest Aceh District and South Aceh District. Considering that there is still a few of research on the distribution of iron sand, generally Indonesia and particularly in the province of Aceh, a number of more intensive studies are needed to study the pattern of iron sand distribution at other locations. The objective of this study is to describe the characteristic of the iron sand sediment and the Fe content at Leungah Fluvial System, whereas the magnetite was processed further to analyze the sediment distribution process. Furthermore, this study provides information on sediment distribution patterns and the distribution of magnetite concentrations in Leungah fluvial system.

2. Materials and Methods

The sediment samples were collected on February 2017. The data collection was carried out at Leungah Village, Seulimuem sub-district, Aceh Besar District. The sampling stations are divided into two regions, i.e., the rivershed and coastal areas (Figure 1). In the coastal area, 10 sampling sites are stationed in the intertidal region with 2.5 km distance of the coastline. River sediment data is obtained from 10 sampling locations along 2.5 km from around the estuary to the upper part of the river.

Sediment sampling were taken using a modified tube core from a 2.5 inch diameter PVC pipe with a thickness of the sediment layer was 15 cm above the surface. Sample analysis was performed using a multilevel sieve method with 7 level sieves, i.e., 2 mm; 1 mm; 0.5 mm; 0.25 mm; 0.125 mm; 0.063 mm; 0.038 mm and a lid. The sediment samples left at each filter size were dried, and the dry weight is calculated. The sample is then repaired using a strong magnet type neodymium n35 to sort the iron sand (magnetite). The total weight of the sorting results of each station is used to determine the iron sand content (in percent) of each sediment sample (eq. 1). The mean grain size value (phi scale) of magnetite at each observation station was obtained using the Folk Graphical Method (eq. 2).

$$magnetite\ weight\ percentage = \frac{total\ weight\ of\ separated\ magnetite}{total\ weight\ of\ sediment\ sample} x100\% \quad (1)$$

$$Mz = \frac{Ø16+Ø50+Ø84}{3} \quad (2)$$

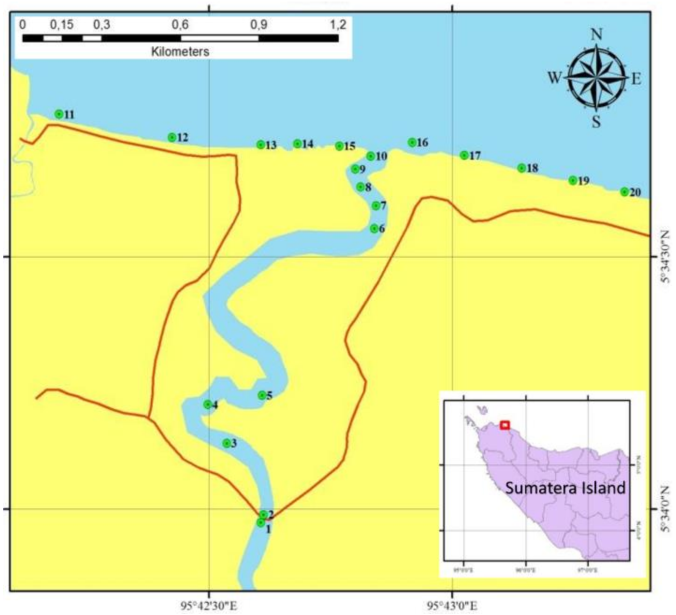

Figure 1. The sediment sampling station is located at Leungah village, Aceh Besar district.

3. Result and Discussion

The magnetite sorting results from sediments at each level of sieve screen are shown in Figure 2. The uneven distribution of sediment size fractions at Leungah River is used as an indicator of sediment transport patterns [14, 29, 30, 31].

Using the Gradistat V.8 software [32] it is observed that the distribution of sediment sizes in the upper layer, both in the river and sea area, shows an unimodal curve. The bimodal curve is more commonly found at lower sedimentary layer. This then led to a poorly sorted sediments condition which was dominantly found in the sediment samples. Meanwhile, a moderately sorted is found in the rest. The tip of the distribution curve on the lower layer, specifically in the coarse grain fraction, shows a higher percentage value than in the upper layer, thus it becomes an indication that the sediment in the lower layer has less uniform distribution of sizes. It is assumed that there are coarse-sized magnetite granules that have not experienced a weathering process, as happened in the upper layer.

The calculation of magnetite mean grain size (using Eq. 2) confirm the allegations above, where in the lower layer produces coarser grain than the upper layer, both in the coastal area and in the river area (Figure 3). On horizontal distribution, it is observed that coarse grains are found in the river flow area (station 1 to 5) and coastal areas, meanwhile in the estuary area (Station 6 to 10) a finer size is found. The coarser size of magnetite granules could be interpreted as the condition of waters with higher energy, and can also be interpreted as proximity to the source of the parent rock [7, 24].

The percentage of magnetite found is higher in the lower layer than the upper layer, where specifically the watershed (station 1 to 5) appears to have a high percentage (Figure 4). We speculate that magnetite has been transported in the past from the upstream direction of the river to the coast and settles to the lower layer of the riverbed and ends at the coast. Thus lower magnetite percentage on the upper layer is a result of weathering of magnetite rocks which then mixed with other constituent materials and impacting a lower percentage value of magnetite in the surface sediment.

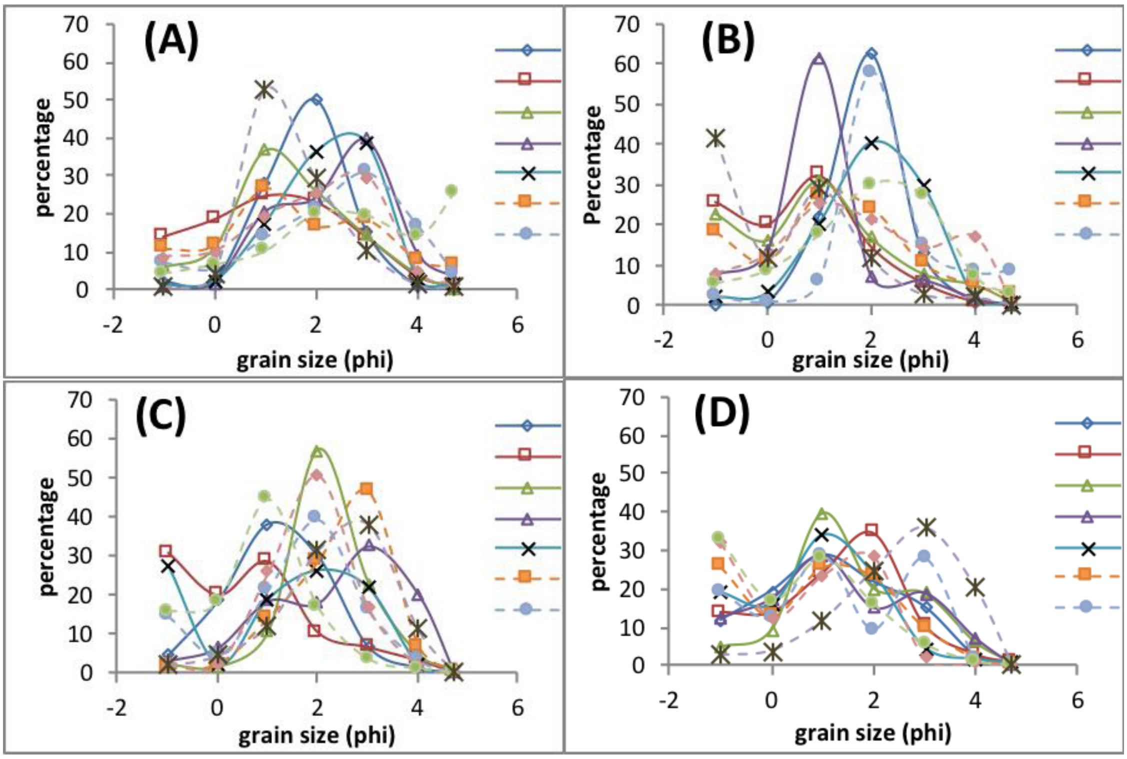

Figure 2. Magnetite grain size distribution at each station: (A) Upper layer of river sediments; (B) lower layer of river sediments; (C) upper layer of beach sediments; (D) lower layer of beach sediments

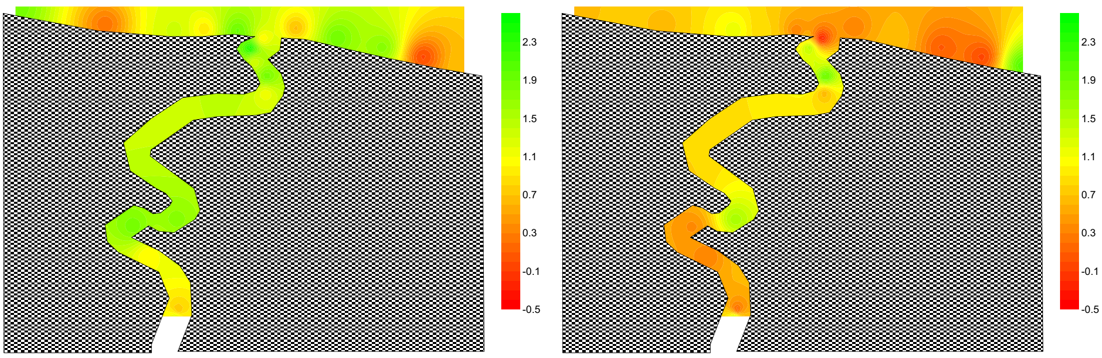

Figure 3. Magnetite grain size distribution based on fractions at each station on Leungah Fluvial for upper (lef) and lower layer (right)

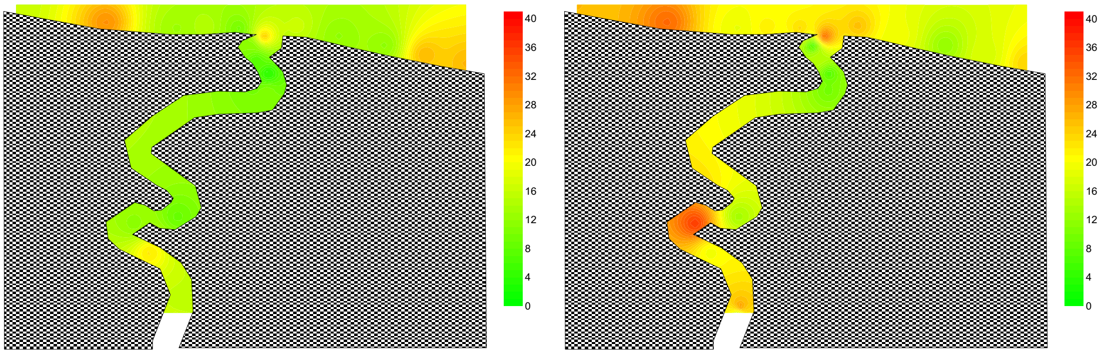

Figure 4. Percentage of magnetite presence at Leungah Fluvial for upper (left) and lower layer (right)

4. Conclusion

A distribution process of a higher content and coarser grain in the lower layers of the sediment provides an indication of the occurrence of the magnetite distribution in the past. A smaller percentage of magnetite in the surface area indicates the process of mixing with various source of rocks (constituents), which occurs in the current period, as the parent rock has no longer sufficient magnetite content. Finer magnetite grains are obtained as the result of the weathering process from larger magnetite (parent rocks), as weathering produces finer grains, it results in the distribution of fine grains to the estuary and coastal areas.

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