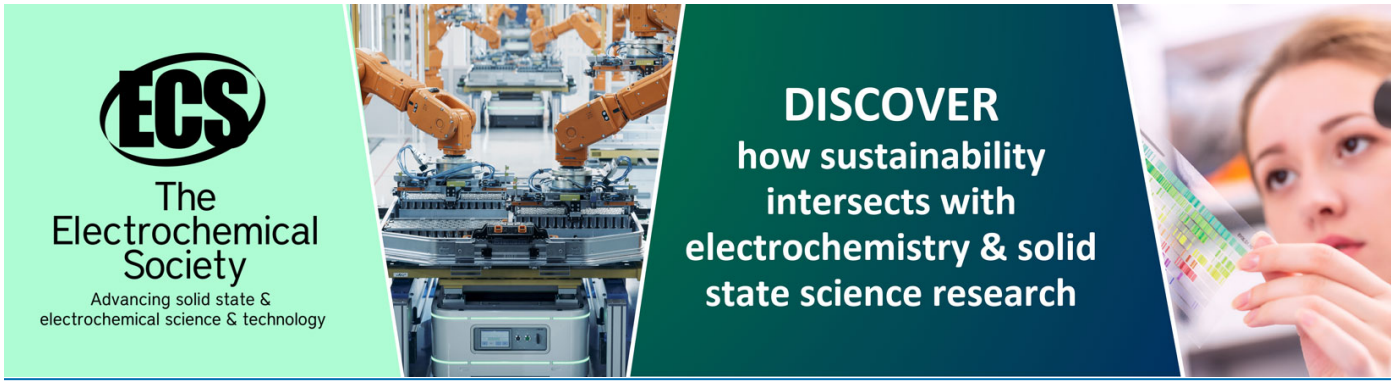
Grain-size characteristics of Aceh's coastal deposits



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Grain-size characteristics of Aceh's coastal deposits

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Abstract. This study investigates the grain size characteristics and sediment types of the Aceh's coastal deposits that are primarily based on the sieve analysis. This study is mainly driven by two reasons. Firstly, this study is a preliminary effort to identify coastal sediment in the Aceh coastal areas. Secondly, this information is important to interpret the support mechanism of sediment during transportation and depositional processes. In this study, many sediment deposits from both the east and west coasts of Aceh were collected. Laboratory sieve analysis was carried out to these samples. Then, further analysis of this sieve analysis results is carried out. The analysis reveals the past transport mechanism of this study sand deposits which is river's channel. However, such finding should be investigated further as all the tested sand were taken at the top surface and big main rivers are not indicated at both sand locations.

1. Introduction

Basically, clastic sediment and sedimentary rocks are made up of discrete particles. The texture of sediment refers to the group of properties that describe the individual and bulk characteristics of the particles making up sediment such as grain size, grain shape, grain orientation, porosity, and permeability. These properties collectively make up the texture of sediment or sedimentary rock. Each property can be used to infer something of: the history of sediment, processes that acted during transport, deposition of sediment, and behavior of sediment ([1]; [2]; [3]; [4]; [5]; [6]).

This study investigates the characteristics of clastic sediment of the Aceh's coastal deposits. The investigation is primarily based on the sieve analysis, and the results are presented in this paper. This study is mainly driven by two reasons. Firstly, this study is a preliminary effort to identify coastal sediment in the Aceh coastal area which was produced by ordinary coastal processes such as tidal- and along shore current-related processes or by processes other than tidal- and shore-related processes such as deposits associated with the tsunami event. Understanding this sedimentary deposit is important as Aceh's coastal was affected by the tsunami in 2004 and paleoseismic events may be recognized (see studies by, e.g. [7]; [8]; [9]). Secondly, this information is important to interpret the support mechanism of sediment during transportation and depositional processes [10]. In this study, 10 sediment deposits from both east and west coasts of Banda Aceh were collected. Laboratory sieve analysis was carried out to these samples. Then, an analysis of this sieve analysis is carried out. The analysis reveals the paleohydraulic condition and past transport mechanism of the deposits.

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2. Location

Two separated coastal areas, as shown in Figure 1, were selected to investigate the characteristics of Aceh's coastal deposits. One coastal area is at the western side of Aceh which is Lhoknga area, whereas another one is at the eastern side of Aceh which is Ujung Batee. The Lhoknga area is directly facing the Indian Ocean, whereas the Ujung Batee area is to the Melaka Straits. The Indian Ocean and Melaka Strait have a difference hydraulic current system which may contribute to the deposited sediment.

Morphology of the Lhoknga and the surrounding area is shown in Figure 2 which suggests a wide-open flat to gently sloping ground around the collected samples of this study. The collected samples at the Ujung Batee area are mostly close to the medium to highly sloping ground at the south-west part of the location.

Figure 1. The locality of Lhoknga & Ujung Batee areas

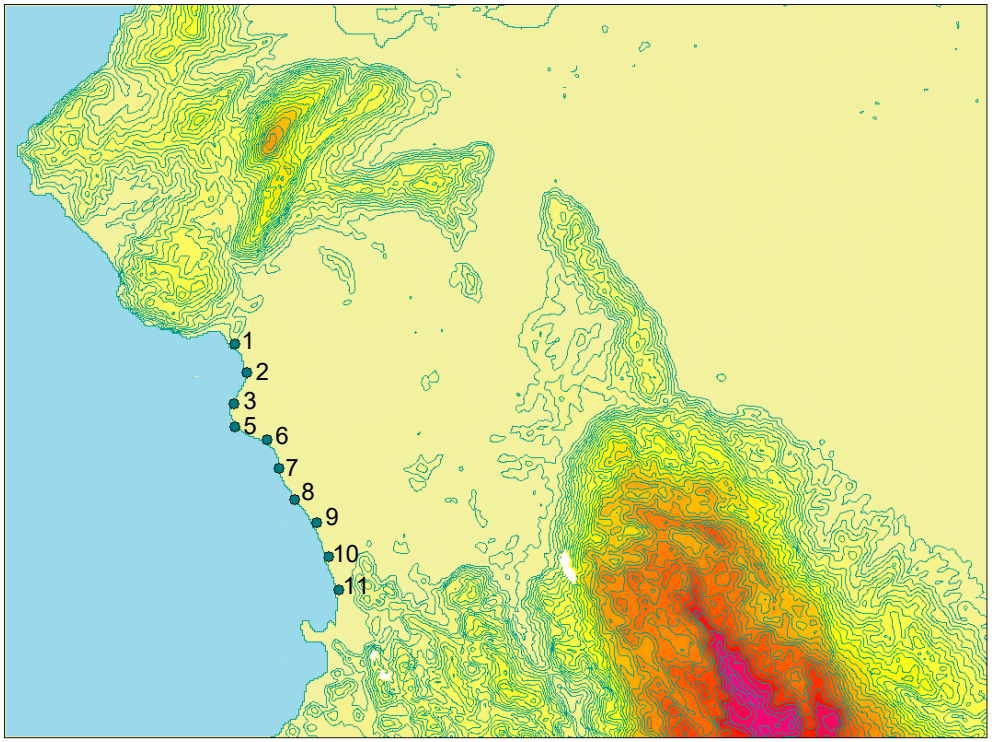

Figure 2. Morphology of the sampling points at Lhoknga area

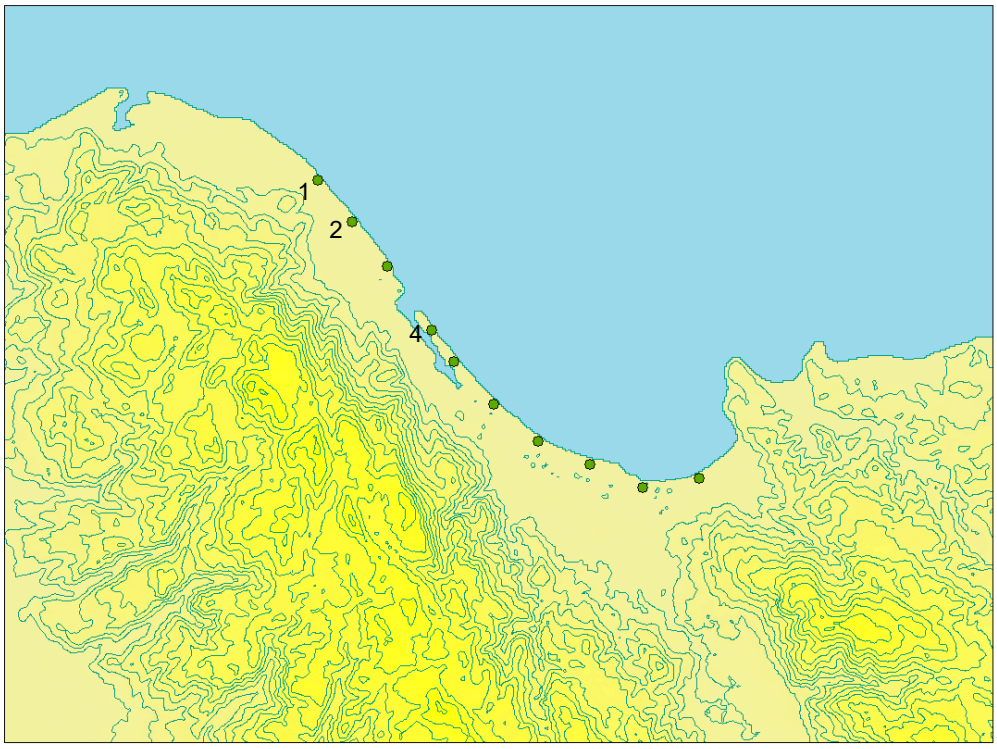

Figure 3. Morphology of the sampling points at Ujung Batee area

3. Methods

Samples for grain size analysis were dry heated at 105°C for at least 24 hours before analysis. Any organics debris (i.e., roots, grass stems, twigs, etc.) in the sample were removed. The samples were not rinsed before the sieve analysis.

3.1. Sieving

Sieve analysis is used to determine the grain size distribution of a sediment sample. This grain size distribution is a bulk property of sediment. After some treatment as mentioned above, a dry loose sample is passed through a vertically stacked set of sieves. The stacked sieves (largest holes on top, smallest on the bottom and follow by a pan) are shaken which can result in any grains that are larger than the sieve holes remain on the screen and the smaller grains pass through it. The distribution of the grain size is determined by weighting the grains collected on each screen are weighed.

3.2. Grade Scales

Grade scales outline limits to a range of grain sizes for a given class (grade) of grain size. The Udden-Wentworth Grade Scale is commonly used by sedimentologists (see Figure 4). This scale uses sets most boundaries to vary by a factor of 2. This scale provides a basis for terminology that describes grain size. e.g., medium sand falls between 0.25 and 0.5 mm. Generally, sedimentologists often use grain size in a unit of Phi (ϕ) which was originally defined as:

$$\phi = -\log_2 d(mm) \tag{1}$$

To make Phi dimensionless, it was later defined as:

$$\phi = -\log_2 \frac{d(mm)}{d_O} \tag{2}$$

where d_O = 1 mm. The correlation between ϕ and the millimeter size of soil particle is shown in Figure 4. Phi is the negative of the power to which 2 is raised such that it equals the dimension in millimeters.

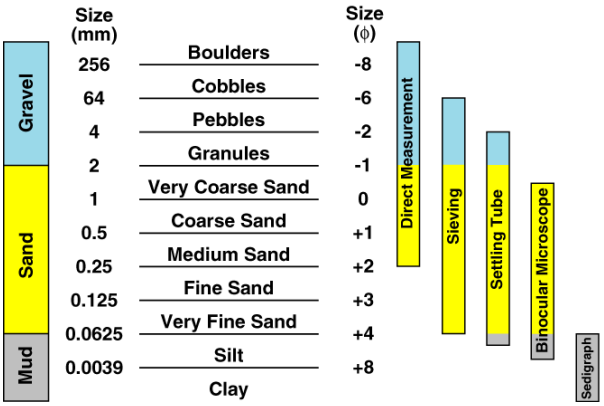

Figure 4. Udden-Wentworth grade scales and measurement techniques

3.3. Describing grain size distributions

To describe the grain size distributions at each tested sample, a distribution curve was developed from the sieve analysis result. This curve is used for further analysis, i.e. various ϕ size, Median of ϕ, Mean of ϕ, standard deviation and skewness (see [11]).

4. Results

Currently, 13 samples (10 Lhok Nga' samples and 3 Ujung Batee's samples) have been sieved. The results of the sieve analysis of this study are summarized in Table 1. The results of each sampling

were plotted into a graph from which are all phi values estimated. The summary of all estimated ϕ values is presented in Table 2.

Table 1. Sieve analysis results

No	Sampling Point	Sieve size (mm)								
		2	0.85	0.425	0.25	0.18	0.15	0.106	0.075	Pan
		(gr)	(gr)	(gr)	(gr)	(gr)	(gr)	(gr)	(gr)	(gr)
1	LO 1	0.29	38.78	50.56	69.87	27.2	6.55	2.53	0.1	-
2	LO 2	0.03	8.66	63.76	72.57	32.95	12.3	5.2	0.34	-
3	LO 3	0.93	15.35	25.21	120.4	34.12	0	0	0	-
4	LO 5	4.65	29.78	35.47	33.87	31.35	32.1	27.47	0.77	-
5	LO 6	4.02	34	51.49	51.24	29.35	17.58	9.25	0.25	-
6	LO 7	0.19	24.64	101.43	59.27	9.59	1.66	0.43	0.05	-
7	LO 8	1.83	92.74	70.14	26.41	4.09	1.01	0.9	0.17	-
8	LO 9	21.23	82	42.66	13.63	10.75	7.78	13.14	2.98	0.15
9	LO 10	1.23	14.77	38.97	43.79	38.14	28.92	26.19	2.3	0.3
10	LO 11	0	0.65	1.23	8.86	29.09	42.06	84.85	29.76	2.67
11	UB 1	0.14	3.06	17.08	43.46	44.81	38.53	46.19	3.33	0.18
12	UB 2	1.25	10.99	17.33	46.37	54	34.51	27.84	5.14	0.7
13	UB 4	2.08	28.21	46.28	59.77	32.48	13.2	12.4	1.54	0.06

Table 2. Summary of estimated ϕ from the curves

No	Sampling Point	Estimated ϕ from the curve						
		ϕ_5	ϕ_{16}	ϕ_{25}	ϕ_{50}	ϕ_{75}	ϕ_{84}	ϕ_{95}
1	LO 1	-0.67	-0.25	0.25	1.15	1.8	2.15	2.51
2	LO 2	0	0.4	0.7	1.35	2	2.25	2.75
3	LO 3	-0.35	0.8	1.2	1.5	1.85	2.1	2.25
4	LO 5	-0.75	0	0.5	2	2.75	3.2	3.7
5	LO 6	-0.8	-0.1	0.4	1.25	2.2	2.5	3.2
6	LO 7	-0.35	0.15	0.35	0.75	1.35	1.65	2.1
7	LO 8	-0.85	-0.7	-0.5	0.05	0.8	1.2	1.8
8	LO 9	-1	-0.8	-0.6	0.3	2.3	3.5	8
9	LO 10	-0.25	0.45	0.8	2	2.65	3	3.7
10	LO 11	2	2.35	2.65	3.25	3.8	4	6.2
11	UB 1	0.6	1.25	1.7	2.3	3.05	3.4	3.8
12	UB 2	-0.1	1.05	1.5	2.2	2.8	3.2	3.8
13	UB 4	-0.6	0	0.5	1.4	2.15	2.45	3.5

4.1. Sediment description

Most of the samples at the Lhok Nga are described as Medium SAND, shown in Table 3. Only at LO 7 the sample is very fine SAND. The rest samples at LO 7 and LO8 are described as Coarse to Very Coarse SAND.

The collected samples at Ujung Batee area are mostly Fine SAND. The Medium SAND is found at UB4. The sediment description is based on the Median or Mean of ϕ ([11]; [12]).

Table 3. Summary of estimated ϕ from the cumulative curve of Phi size

No	Sampling Point	Median of ϕ	Mean of ϕ	SD of ϕ	Skewness	Kurtosis	Soil description
1	LO 1	1.15	1.02	1.08	-0.16	0.84	Medium SAND
2	LO 2	1.35	1.33	0.88	0.00	0.87	Medium SAND
3	LO 3	1.50	1.47	0.72	-0.25	1.64	Medium SAND
4	LO 5	2.00	1.73	1.47	-0.24	0.81	Medium to Fine SAND
5	LO 6	1.25	1.22	1.26	-0.03	0.91	Medium SAND
6	LO 7	0.75	0.85	0.75	0.15	1.00	Coarse SAND
7	LO 8	0.05	0.18	0.88	0.27	0.84	Very coarse to coarse SAND
8	LO 9	0.30	1.00	2.44	0.60	1.27	Coarse SAND
9	LO 10	2.00	1.82	1.24	-0.18	0.88	Medium SAND
10	LO 11	3.25	3.20	1.05	0.16	1.50	Very fine SAND
11	UB 1	2.30	2.32	1.02	-0.02	0.97	Fine SAND
12	UB 2	2.20	2.15	1.13	-0.12	1.23	Fine SAND
13	UB 4	1.40	1.28	1.23	-0.06	1.02	Medium SAND

4.2. Sorting, skewness and interpretation

Grain size analysis determines the strength of currents that transported the sediment. Therefore, the paleohydraulic conditions size can be interpreted. In addition, the variations in sorting and skewness reflect the transport mechanism of the sediment. The result is presented in Figure 5.

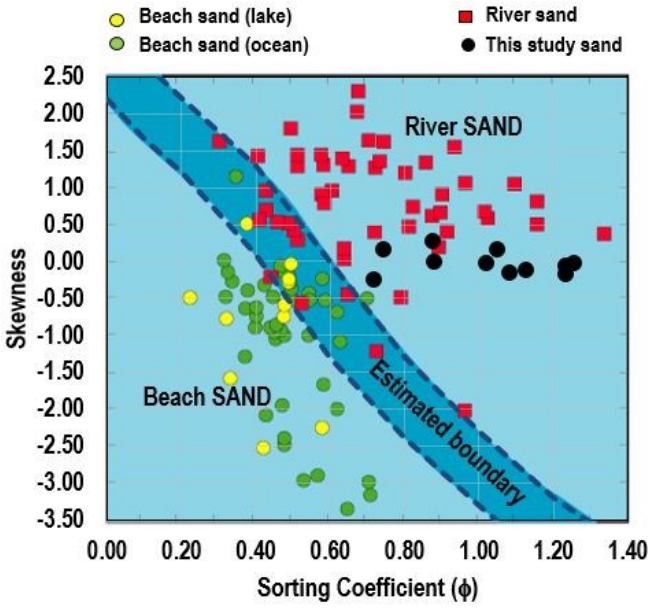

Figure 5. Depositional process interpretation ([11]; [12]).

5. Conclusions

Grain size characteristics and sediment types of the Aceh's coastal deposits based on the sieve analysis has been investigated. This study is mainly to interpret the support mechanism of sediment during transportation and depositional processes. Thirteen sediment deposits from both east and west coasts of Aceh were collected and tested using sieve analysis. Further particle size statistics analysis reveals the past transport mechanism of this study sand deposits which is river's channel.

6. References

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