Characteristics of Quaternary Deep Sea Sediment in the Sumba Strait based on Grain Size and LoI (Lost on ignition Analysis)

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Abstract. This research was conducted in the Sumba Strait, southwest of Sumba East Nusa Tenggara. The purpose of this study is to determine the depositional facies characteristics of the Quaternary deep sediment. The sample was taken at a depth of 1858 m by gravity core in board of RV Baruna Jaya VII by the geology team of Ekspedisi Widya Nusantara LIPI 2016. The length of the sample was 246 cm. Sedimentology analysis was conducted to measure grain size distribution, organic material and carbonate content in the core. The characteristics of the sediment were dominated by coarse silt, poorly sorted, symmetrical skewness and mesokurtic kurtosis. Generally, the percentage of carbon and carbonate is 20.09% carbon and 9.67% carbonate; it shows that grain size is very influential on organic material in the sediment. The finer the grain of sediment the higher the organic material, which in the sediment results from the grain size analysis indicates the dominant grain size of the fine (Coarse silt).

1. Introduction

Marine sediments are an accumulation of mineral and fragment of rock mixed with the destruction of shells and bones from marine organisms and several other particles formed through chemical processes that occur at sea [1]. This sedimentology study of the Quaternary deep-sea sediment was carried out in the Sumba strait, in the southwest of Sumba, East Nusa Tenggara.

Granulometric analysis is an analysis of sediment grain size. All the size frequency of sediment is sensitive to the processes of the depositional environment [2][3][4]. Analysis of spatial changes in grain size parameters (mean, sorting and skewness) is one method that used to identify the transportation routes. According to [5], there are three factors that influence the grain size of sedimentary rock, namely the variation of the original sediment grain size, the transport process and the precipitation energy.

Loss on ignition (LoI) is a common and widely used method for determining the levels of organic material and carbonates from sediment [6][7]. Determine the percentage level of weight of organic material and carbonates in sediment with LoI based on sample hearting using muffle furnaces [6]. Many research, refined LoI method [6] to provide more accurate determination of organic matter content in terrestrial soils. The focus of the research is to analyze the characteristic of Quaternary deep sea sediment.
through a grain size and LoI analysis of the sediment samples taken by conducting gravity core from the Sumba strait.

2. Regional Geology
The Sumba strait is separated Flores Island (in the north) form Sumba island (in the south). The subduction activities cause volcanic activities along the island of Bali, Lombok Sumbawa, Flores to Alor to form active volcanic arc. Active deformation zones are located adjacent to the Jave and East trenches forming ridge bounded by the face arc in the north [8][4,9–14]

3. Materials and Methods

3.1 Materials
Sediment samples were taken by the geology team of the Ekspedisi Widya Nusantara 2016 LIPI. Sediment samples were taken by conducting a gravity corer on the northern part of Sumba Island (Figure 1). The total length of the samples was about 257 cm. Then the sample is sampled per 1 cm every 5 cm for an analysis of grain size and LoI. Total samples 49 to analysis grain size and LoI.

Figure 1. Location of the sample taken in the Sumba Strait.

3.2 Method
Grain size analysis was carried out using the Malvern Mastersizer (grain size analysis) in the Micropaleontology Laboratory, Research Center for Geotechnology, LIPI, Bandung. Every sample needs approximately 2 gram of sediment for this grain size separation process. The grain size parameters were (mean (x), skewness (Skφ), kurtosis (Kφ), and sorting (σφ)) were calculated by using Gradistat v.4.0 software[15]. The grain size classification is defined by Gradistat classification [15]. After drying the sediment sample with an oven with a constant weight (usually 12-24 hours at 105 °C in the first stage the organic material burns to ash and carbon dioxide at a temperature of 550 °C. LoI can be calculated using the following equation:
\[
\text{LOI}_{550} = \frac{(\text{DW}_{105} - \text{DW}_{550})}{\text{DW}_{105}} \times 100
\] (1)

\text{LoI}_{550} \text{ is a LoI at 550 °C (%), DW}_{105} \text{ is a dry sample weight before combustion and DW}_{550} \text{ is the sample weight after being heated at a temperature of 550 °C (grams). The weight loss must be proportional to the amount of organic carbon content in the sample and [15] shows a strong correlation between LoI at 550 °C and organic carbon content [16]. In the second stage, the carbon dioxide into carbonates, oxides and LoI leave can be calculated with the following equation:}

\[
\text{LOI}_{950} = \frac{(\text{DW}_{550} - \text{DW}_{950})}{\text{DW}_{105}} \times 100
\] (2)

Where the \text{LoI}_{950} \text{ is the LoI at 950°C (%), DW}_{550} \text{ is the sample dry weight after burning organic material at 550 °C, DW}_{950} \text{ shows the dry weight of the sample after heating at 950°C, and DW}_{105} \text{ is the initial weight of the dry sample before burning organic carbon (grams)[17].}

4. Result and Discussion

Grain-size characteristics of the Quaternary deep-sea sediment in the Sumba strait were showing a dominant of coarse silt with bad sorting, symmetrical skewness and mesokurtic kurtosis. The LoI indicates that carbon material content was bigger than the carbonate material content. Table 1 shows the result of the grain size data analysis. Figure 5 Bivariate plots are used to show the relationship between grain size and sorting, grain size and skewness, grain size and kurtosis, sorting and skewness.

Table 1. Result on grain size statistical analysis

| Statistics | Mean | Sorting | Skewness | Kurtosis |
|------------|------|---------|----------|----------|
| Max        | 5.997| 1.820   | 0.110    | 1.116    |
| Min        | 5.484| 1.591   | -0.031   | 1.011    |
| Average    | 5.798| 1.692   | 0.012    | 1.056    |

4.1 Stratigraphy

Based on the result of grain size analysis, it can be concluded that there are two sedimentary layers, the silt layer A and the silt layer B.

4.1.1 Silt Layer A

The silt layer A identified at a depth of 0-65 cm. This layer has a brownish gray color with coarse silt grain size. There was thin intercalation of very fine sand depth of 15 cm, 50 cm, and 65 cm. There were mollusk shells at a depth of 10 cm and increasingly to the lower layer of smooth fossil shell with multiple.

4.1.2 Silt Layer B

The silt layer B silt identified at depth of 65-240 cm. This layer has a gray color, with coarse silt grain size. There was a fine sand intercalation at depth of 200 cm. There are fossils of fine shells and white patches that are thought to be granules of foraminifera fossils.

4.2 Granulometric analysis

Steward diagram analysis, the sorting value is plotted with the value of M (Median). The result of cross plot is slow deposition form calm water wherein the area of sedimentary Sumba strait sediment with a slow sedimentation and show that precipitation occurs in the deep sea environment (Figure 3). CM diagram is used to identify sediment deposition mechanisms in Sumba strait, C (value of first percentile) is plotted with M value (median) in phi [18]. The result of CM diagram shows that the current transforms sediment material is uniforms suspension currents (Figure 4). This shows that the material has been transported far from its origin.
Figure 2. Stratigraphy description of silt layer A and silt layer B on research location.

Figure 3. Steward diagram shows that all sediments in Sumba straits are affected by slow deposition from quiet water.

Figure 4. The relationship between C and M show that all sediment in Sumba strait was obtained on uniform suspension.
Figure 5. The bivarian plot shows the relationship between (a) grain size vs. sorting (b) grain size vs. skewness (c) grain size vs. kurtosis (d) sorting vs skewness.

Figure 5a shows the relationship between grain size and sorting in Sumba strait. So the result obtained in the Sumba strait have a coarse silt with poorly sorted. Figure 5b shows the correlation between the grain size with kurtosis. The value of kurtosis describes the condition of sediment stored in certain energy (Friedman 1965). Where in the area Sumba strait have a coarse silt grain with mesokurtic to leptokurtic kurtosis. So almost all sediment deposited from the medium-low energy environment. Figure 5c show the relationship between the grain size with skewness wherein the area Sumba strait have a coarse silt with skewness near symmetrical - fine skewed. Figure 5d shows the relationship between sorting with skewness. Sorting analysis show that the deposition area is an oceanic area, wherein the oceanic area predominantly poorly sorted. The result of skewness analysis shows that the deposited material has fine particles, so that the skewness value obtained is positive (near symmetrical - fine skewed).

4.3 Loss on ignition (LoI) analysis

The result of lost on ignition value indicates that the total carbon content is higher than the total carbonate content (Table 2). Sediment comes from biogenous sediment (plants and animals). This was confirmed by the finding of many foraminifera shell fragment and root fibers in the sample.

|       | Total Carbon (%) | Total Carbonate (%) |
|-------|------------------|---------------------|
| Min   | 7.81609762       | 2.647977135         |
| Max   | 20.09639201      | 9.67044809          |
| Average | 16.6506931   | 7.742016963         |

5. Conclusion

Analysis of grain size shows the dominance of coarse silt, poorly sorted sediment with symmetrical skewness and mesokurtic kurtosis. Sediment in the Sumba strait is deposited from the medium-low energy environment. CM diagram shows that all sediment is deposited in uniform suspension. Steward diagram shows that slow deposition from quiet water influences deposited sediment. The LoI (lost on ignition) analysis show that the total carbon is greater than carbonate. Many sources of sediment come from land from the sea.
6. Acknowledgment
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