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Lithogenic and Antropogenic in Surface Sediment From Outlet of Tempe Lake, South Sulawesi

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Abstract. Prehistory of Central of South Sulawesi was a marine environment connecting Bone Bay and Makassar Strait through Tempe Lake. The influence of marine can be traced nowadays in outlet of Tempe Lake (Cenrana River). The concentration of SiO₂ decreases toward downstream, on contrary Fe₂O₃ and CaO tend to increase downstream. Heavy mineral (Zr and TiO₂) provides an increasing trend downstream. Most of the sediments originate from the rock covering the area and precipitation from the seawater. The latter can be found as far as 34 km from the coast of Bone Bay to the west.

1. Introduction

Lake Tempe locates in South Sulawesi in which several rivers as a inlet and only Cenrana River as an outlet of the lake. The lake faces serious degradation due to sedimentation from several rivers and population pressure surround the lake. Sedimentation rates reach 1 – 3 cm/ year [1]. Formerly, Lake Tempe had been connecting between Bone Bay in the east and Makassar Strait in the west in the form of depression as stated in the La Galigo legend, (Figure 1) [2]. Furthermore Gremmen [3] revealed that Lake Tempe had been inundated by seawater around 7,100 to 2,600 years ago based on analysis of pollen analysis. Furthermore Whitten et al. [4] detected sea levels of the southwestern peninsula of Sulawesi by 5 and 2.5 m higher than now in 4500 and 1600 years ago and Sulawesi separated between north and south by the Tempe Depression. Caldwell & Lillie [5] explained that in large inundation conditions, Lake Tempe became a link between Bone Bay in the east and the Makassar Strait in the west around 4,500 years where the sea level is a maximum of 6.55 m above the present surface.



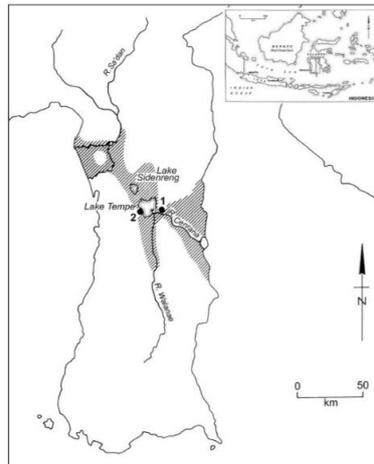


Figure 1. The estimated boundaries of formerly was sea water connecting Bone Bay in the east and Makassar Strait in the west [5].

An important outlet of Tempe Lake is Cenrana River in which the water flows to the Bone Bay. Assuming that the sediment influenced by marine and fresh water along the river, sediment deposited in the river gives characteristic showing marine and/or terrestrial minerals by studying geochemical characteristics of sediment.

2. Paleoenvironment of South Sulawesi

Tempe Lake was a part of small strait corresponding to the sea level fluctuation in South Sulawesi during late Pleistocene – early Holocene age. Sea level fall was as high as 5 meters above sea level today at 4.500 years ago recorded from the coral reefs of the Spermeonde Islands [6]. A decrease in sea level has also been studied on the Quaternary coral reef at the southern tip of South Sulawesi [7]. They concluded that sea level had reached as high as 20 m above sea level today during Pleistocene time. Sea level fall at Panambungan Island and Barrang Lompo Island occurred since 6000 years ago [8]. He finds that sea level was at altitude of 0.5 m Panambungan Island and 0.8 m Barrang Lompo Island around 5600 cal. yr BP of sea level today. Based on the data above, most likely the depression forming the Lake Tempe was once a strait.

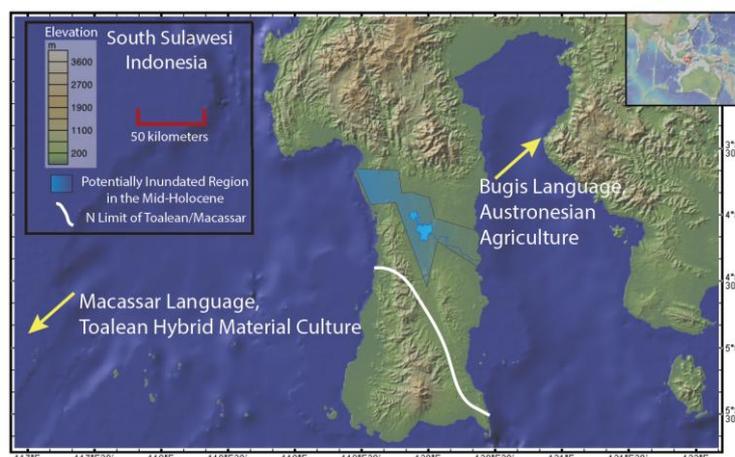


Figure 2. Physiography of South Sulawesi showing depression trending southeast through Tempe Lake. (from: Bulbeck et al., [9]).

Concentration of major element such as SiO_2 , Al_2O_3 , Fe_2O_3 , CaO and MgO is an important of depositional environment. SiO_2 tends to decrease toward downstream, on the otherhand Al_2O_3 , Fe_2O_3 , CaO and MgO tend to increase downstream [10]. Kasim et al. [11] explain that surface sediments in

Lake Tempe originate from terrestrial (land) which is characterized by the presence of heavy minerals such as zircons, tourmaline, rutile (ZTR) even present less stable minerals such as epidote, olivine, hypersten, biotite, magnetite and iron oxide.

3. Material and Method

Surface sediment was carried out along the Cenrana River in 9 stations collected by percussion core. Sampling locations were chosen in straight stream in order to get laminar water flow. Lithogenic and antropogenic minerals in surface sediment of Tempe Lake outlet is identified from grain size, mineral composition and geochemical analyses. Selected samples were analyzed by petrographic analysis, grain size siever and X-ray diffraction (XRD) at Geological Department, Hasanuddin University. Due to the sediments are loose, they were impregnated for sand size before cutting and analysed under microscope.

4. Result and Discussion

Grain size analysis shows a distribution along the stream dominated by fine sand – clay. Two zones of sediment distribution based on its grain size (fig 3): fine sand – silt which accumulated in upstream (Padduppi to Kampiri) and silt – clay deposited in down stream (Pincengpute to Kampoti). The grains size distribution implies that river current from the Tempe Lake dominantly influences sediment deposit in the river rather than sea current.

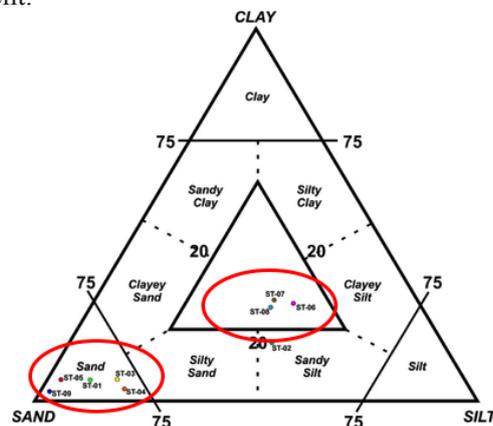


Figure 3. Sediment distribution of Tempe Lake outlet base on its texture plotted in Shepard's diagram.

4.1. Mineral Characteristics

Petrographic analysis on sediment shows vary in mineral type and even rock fragments. Most common mineral deposited along the stream are pyroxine. Others are rock fragments, quartz, plagioclase, biotite, and opac minerals (Table 1). There are three type of presence of mineral i.e a) undulating present such as rock fragments (max35%), Quartz (25%), Quartz (max 25%), b) other mineral increasingly occurs toward downstream such as pyroxene and opac mineral, and c) plagioclase decreases toward downstream.

XRD analysis on clay mineral shows a presence of marine influence toward downstream. Upstream of Cenrana River is dominantly composed of silica minerals (quartz, clay minerals and plagioclase), furthermore downstream consists dominantly of heavy minerals, salts (gypsum and halite), and sulfur. Silica minerals such as quartz, clay and plagioclase tends to decrease toward downstream, on the other hand halite, gypsum, sulfur minerals increase toward downstream (Table 2). Carbonate minerals are highly deposited in the ST05 (15,3%) due to intruding of sediment input from small river (such as Salo Lampoe) covered by carbonate rock formation. The statement is confirmed by decreasing volume even neglected toward coastal area of Bone Bay. Heavy minerals is mostly supplied from the basic rocks which covered the northern area of South Sulawesi. The minerals are transported through Bila River to Tempe Lake [11].

Table 1. Distribution of main components on surface sediment in outlet of Tempe Lake

Component	Mineral Composition (%)				
	ST-01	ST-03	ST-04	ST-05	ST-09
Rock Fragment	35,00	35,00	35,00	15,00	35,00
Quartz	10,00	5,00	25,00	25,00	5,00
Plagioclase	30,00	30,00	5,00	10,00	5,00
Pyroxene	15,00	25,00	10,00	30,00	30,00
Hornblende	0,00	0,00	20,00	0,00	0,00
Biotite	0,00	0,00	0,00	0,00	10,00
Opaque Mineral	10,00	5,00	20,00	20,00	15,00

Silicate group (quartz, clay, plagioclase and volcanic glass) shows decreasing trend downstream. On contrary saline minerals (halite and gypsum) begin to be present at ST-05 and increase toward downstream (Table 2). The concentration of mineral elements show a decreasing trend of SiO_2 toward downstream, on contrary Fe_2O_3 and CaO tend to increase downstream (Fig. 4). The trend of SiO_2 , Fe_2O_3 and CaO support the trend line proposed by Verma [9] in which the concentrations of SiO_2 tend to decrease to downstream reversely of Fe_2O_3 , CaO tends to increase downstream. Heavy mineral (Zr and TiO_2) provides an increasing trend downstream.

4.2 Sediment origin

Heavy mineral occurs without trend showing probably influence of sediment input from surrounding rivers. Lithology of the area is dominated by sandstone of Walanae Formation as main contribution of sediments in outlet of Tempe Lake (Fig.5). The limited present (ST-05 and ST-08) and decreasing trend of carbonate mineral on the stream indicates also limited origin of material. This case figures out lithogenic sediment origin which suppose from carbonate rock of Taccipi Formation in the southern part (Fig. 5).

Petrographic and geochemical data indicate sediment characteristics of outlet of Tempe Lake is partly influenced by marine and mostly by lithogenic origin. The data mentioned above suggests that the effect of sea water in Cenrana River (± 67 km long) as an outlet of Tempe Lake reaches Kampiri village (ST-06), Bone regency as part as ± 35 km northwest. The mineral characteristics inconsistently occur in outlet of Cenrana River. The phenomena suggest that the occurrence of mineral at the coastal area surround Cenrana River under pressure of man activities and sea water current. The factors allow fine sediments (clay) to reveal and be transported to the sea. The condition gives no chance to halite and gypsum minerals to develop in the coastal area.

The presence of SiO_2 , Zr, TiO_2 and CaO indicates that most of the sediment origin deposited in Cenrana River come from the rock composing the area. Others are from sea water precipitation.

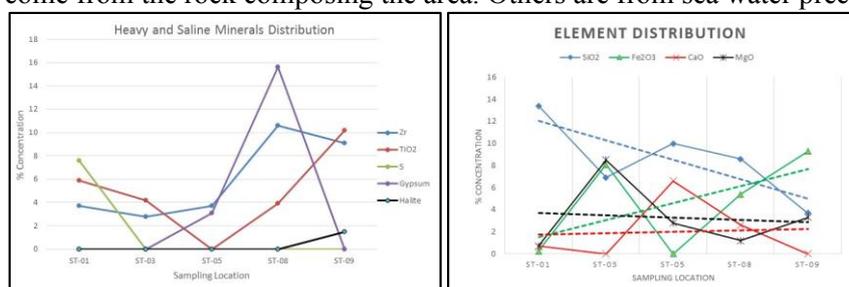


Figure 4. Concentration of element and saline minerals along the Cenrana River.

5. Conclusion

Minerals deposited in Cenrana River as an outlet of Tempe Lake originating from several condition: a) sediment transported from Tempe Lake which mainly fulfilled by Bila River and Walanae River. The type of sediments are mainly in small size grain and heavy minerals; b) lithogenic sediments transported through small stream from surround area covered by sandstone of Walanae Formation and carbonate rock of Taccipi Formation such as silicate mineral group and heavy mineral, and c) precipitation mineral

influenced by sea water of Bone Bay such as gypsum and halite. Beside that there is also influence from sea current and man activity. This influence can be traced by the irregularly present of mineral that should be increase or decrease trend.

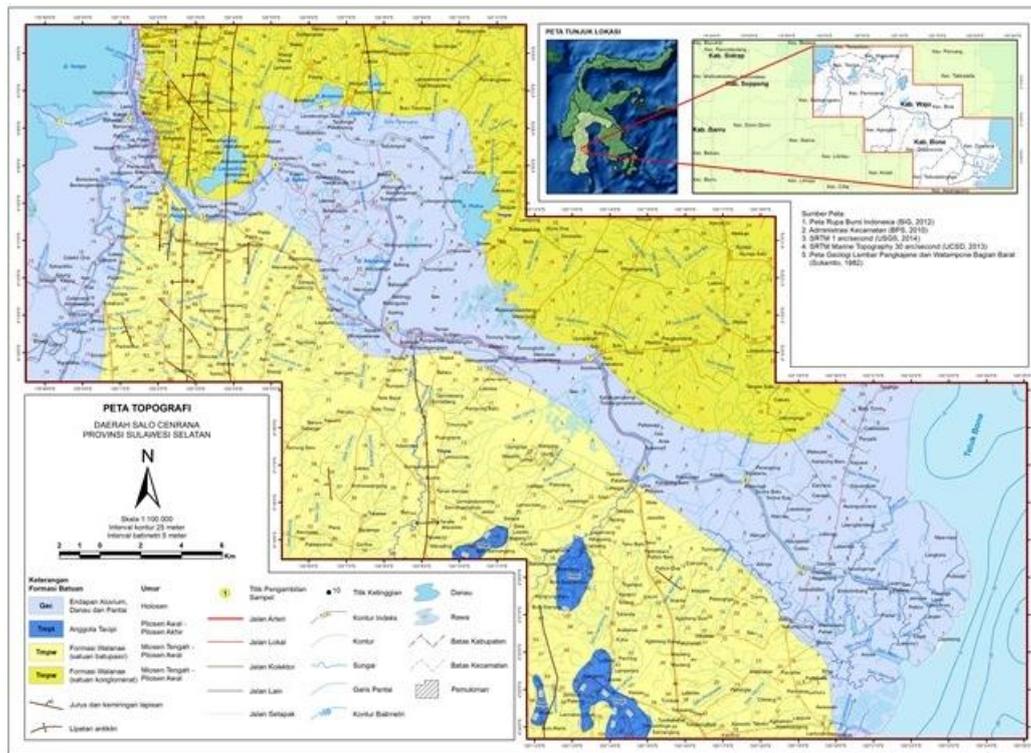


Figure 5. Geographical dan lithological map of Cenrana River.

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