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Provenance of Sediment Deposits in Lake Tempe, South Sulawesi

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ABSTRACT

Sedimentation rate in Lake Tempe is a serious problem faced by the government and local communities due to the high sediment transport from upstream of several rivers that flow into Lake Tempe. This study aims to determine the source of the rock material based on analysis of heavy mineral sediment. The research area is located at the estuary of Bila River in Sidenreng Rappang Regency. The method used is test pit and surface sampling. Laboratory analyzes were performed is the analysis of grain size (granulometry), heavy mineral analysis (heavy mineral separation) and microscopic analysis. There are 14 types of heavy minerals found in the Tempe Lake namely: zircon, tourmaline, rutile (ZTR) as ultra stable mineral. The less stable minerals are epidote; and others are olivine, hipersten, augite, hornblende, biotite, casiterit,, brookit, apatite, magnetite and iron oxide. Source rocks of the minerals are interpreted from igneous and volcanic rocks of acidic to intermediate type.

Keyword : Provenance, Heavy Mineral, granulometry, Tempe Lake

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1. INTRODUCTION

Sedimentation occurred in Lake Tempe is a serious problem faced by the government and local communities. Several studies have revealed that the sediment influx is a source of sedimentation. However no study that examine the sorve of the sediment. The sediments accumulated in Tempe Lake through several rivers such as Bila and Walanae Rivers, Salo Talanggalung, Salo Tokade, Salo Lajokka, Salo Lamase, Salo Sapewalie, Salo Lamaganeng, Salo Dua. The riverare different in size and form, therefore they trigger a different sediment transport mechanism. The mechanism influences the shape and size of the material deposited within the Lake.

Tempe Lake is located in three regencies namely Wajo, Soppeng and Sidrap. But in this discussion focused on the Bila River located in the Sidenreng Rappang Regency. This study aims to determine the grain size distribution patterns, type and weight, and the

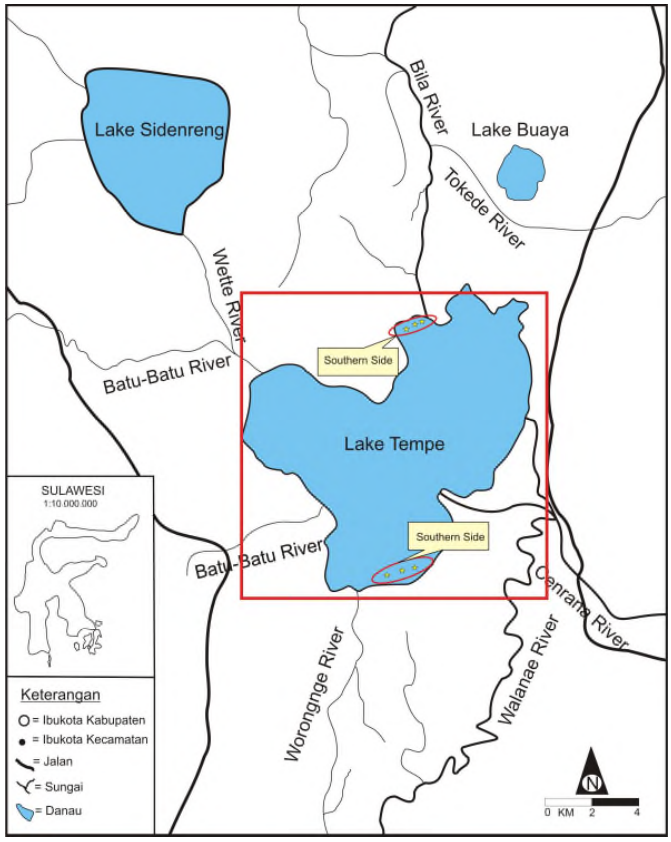

Fig. 1 Research location showing at least 3 large rivers flowing into the Lake Tempe

provenance of teh sediments based on heavy mineral analysis.

Bila River is a part of the Bila Watershed consisted of various types of rocks such as shale, chert and clastic and carbonate sedimentary rocks, metamorphic rocks such as phyllite, quartzite and marble, acidic to alkaline intrusive rocks [1]. The rock was dated from Cretaceous to Holocene in age.

1. METHODOLOGY

Research method applied was field survey, surface sampling of random system. Laboratory analyses performed was grain size analyses, heavy minerals and petrographic analyses. Eleven samples were collected within Tempe Lake in Siderenreng Rappang Regency.

Sampling was carried out at the delta of the river which closes to the coast. Grain size analyses and heavy minerals analyses were done in Sedimentology Laboratory of Hasanuddin University. Heavy mineral analysis, has 5 gram and size of 0.125 mm or 2 phi, was done to separate the mineral using bromoform (CHBr3) with specific gravity of 2.88 at a temperature of 20^{O}C and changed at 0,023 / ^{O}C (acoodind to Douglas, 1937). For the analysis of heavy minerals was used ZTR index analysis (zircon, and rutile tourmalin) which were

obtained from the calculation of the number of non opaq heavy mineral and mineral ZTR combination of the following formula:

$$ZTR\%INDEX = \frac{Zircon + Tourmaline + Rutile}{\sum non - opaque} \times 100$$

Where the ZTR index expressed as a percentage was calculated for the samples to ascertain the mineralogical maturity index.

Fig. 2 Showing Lake Tempe surrounded by housing. Taken from Sengkang side.

2. Result and Discussion

A. Bila Watershed

Grain size analysis indicates that the characteristics of sediment vary. Characteristics of sediment are coarse to fine sand, has a moderate to poorly sorted. This characteristics is more and less influenced by the climate. In the rainy season sedimentation is high and tend to deposit a coarser grain and vice versa in the dry season.

Analysis of heavy minerals are considered from 3 rivers (Bila river, Salo Lamase and Salo Tokade. Heavy mineral analysis results showed, as follows:

- Bila River

Types of heavy mineral that occurs in this river is olivine, epidote, hipersten, augite, hornblende, casiterit, brookit, apatite, zircon, tourmalin and magnetite. The mineral assemblage indicate that the parent rocks of the mineral are vary. The presence of the mineral magnetite, casiterit, epidote, and brookit indicate their source of hydrothermal alteration rock. On the other hand the presence of hipersten as Volcanic rocks origin. Metamorphic rocks origin is characterized by the presence of mineral epidote, tourmalin and hornblende. Alkaline igneous rock characterized by the presence of mineral hornblende, augite, olivine and hipersten. Igneous rocks of acid to intermediate indicated by the presence of the mineral apatite, casiterite, hornblende and tourmalin. The similar analysis was done from Pulau Bintang by Setiady and. Sarmili [2]. They describe the presence of Magnesite and casiterite originate from acid igneous rocks. Sedimentary rocks characterized by the presence of zircon and tourmalin.

- Salo Lamase

Types of heavy minerals found in Salo Lamase are olivine, augite, hornblende, apatite, zircon, tourmalin and magnetite. The mineral assembly shows parent rocks of intermediate to alkaline

igneous rocks and a rock that undergo a process of hydrothermal alteration as well as a digenetic sedimentary rock.

Fig. 3 Sediment deposits deposited in Bila River form as a channel bar.

- Salo Tokade

Heavy minerals found in this river are olivine, epidote, augite, hornblende, casiterit, rutile, zircon, tourmalin, magnetite and iron oxide. Those minerals were eroded from intermediate to alkaline igneous rocks and transported to the Lake Tempe. The presence of mineral magnetite, casiterit, epidote and iron oxide suggests the parent rock of a hydrothermal alteration. Metamorphic rock characterized by the presence of tourmaline, rutile and epidote as well as th sedimentary rock characterized by the presence of zircon and tourmalin.

B. Provenance of the heavy Minerals

- Bila River

Bila River flows from Enrekang in the north to Sidenreng Rappang (finish at Tempe Lake) in the south. It flows around 100 km and forms meander. The width of the river ranges 70-200 meters with capacity to reach 340-1130 m3/sec [3]. The river contributes significantly as a source of sediment deposits to the Lake Tempe. This research found at least 11 types of heavy minerals (olivine, epidote, hypersthene, augite, hornblende, casiterite, brookit, apatite as a meta-stable mineral, and zircon, tourmalin as an ultra-stable mineral as well as magnetite as an opaque mineral (Table 1).

Based on grain size and type of mineral indicates that the source of the sediment is vary in distance and transport mechanisms. The mineral shape is vary depending on their stability and transportation mechanism. Minerals that have sub-angular shape - sub rounded are hornblende, olivine, hipersten, tourmalin and augite. While the minerals of epidote, zircon, casiterit, brookit, apatite and magnetite are sub-rounded. The size of minerals which are sub-rounded is smaller than that of mineral-shaped of sub anggular.

The presence of hornblende, hypersthene indicates of volcanic rock origin. Setiady [4] has studied the origin of hornblende and biotite minerals which indicate the source rock of intermediate igneous rocks (such as andesite). While epidote, brookit and augite is interpreted to be an origin of metamorphic rocks such as schist. and hornblende, augite, olivine and hyperstene indicate alkaline igneous rocks in origin. The minerals of apatite,

hornblende and tourmalin indicate igneous rocks of acidic to intermediate in origin. Sedimentary rock origin is represented by zircon and tourmalin. Meanwhile, the presence of the minerals of magnetite, cassiterite, epidote and brookit indicate hydrothermal alteration processes or resedimented sedimentary rock.

Based on the shape and stability of mineral can be concluded that the minerals consisting metamorphic rocks are epidote, brookite, and augite. Fine grain size of minerals with shape of sub rounded indicates that the parent rocks of the mineral locate in the long distance at upper stream of Bila River. An acidic - intermediate igneous rock composes of apatite, hornblende and tourmaline minerals. The minerals have sub-angular - sub rounded shape and vary in sizes indicate that the parent rock of igneous rocks within Bila Watershed. Sedimentary rocks containing zircon and tourmaline are interpreted as a re-sedimentation of sedimentary rocks. The presence of olivine derived from alkaline rocks is likely an anomaly.

The interpretation of the parent rocks of sediments in the northernpart of Tempe Lake can be derived from volcanic rocks, metamorphic rocks, acidic to alkaline igneous rocks, sedimentary rocks.

Table 1. Mineral Distribution of Northern Part of Tempe Lake.

Minerals	Northern part of Lake Tempe			Parent Rocks
	1	2	5	
Olivine	6.25	6.72	17.05	Basic igneous
Zircon	2.78	5.88	11.36	Acid igneous
Tourmaline	4.86	7.56	13.64	Low rank metamorphic, Acid igneous
Epidote	11.81	5.04	-	High rank metamorphic, Acid igneous
Hypersthene	11.11	-	-	-
Augite	6.94	12.61	18.19	Basaltic igneous rock
Hornblende	15.28	20.17	2.27	intermediate igneous
Biotite	-	-	-	Low rank metamorphic, intermediate-acid igneous
Cassiterite	9.03	3.36	-	acid igneous
Rutile	-	10.08	-	Basic igneous
Brookite	11.8	-	-	Basic igneous
Apatite	7.64	-	18.16	Acid igneous
Magnetite	12.5	26.05	19.32	acid igneous
Iron Oxyde	-	2.52	-	

- Salo Lamase

Salo Lamase locates in Wajo Regency. This river is a periodic river flowing into Lake Lapompaka to Lake Tempe. Heavy mineral contents of sediments from Salo Lamase within Lake Tempe consist of 7 type of minerals. They are olivine, augite, hornblende and apatite (metastable minerals), zircon and tourmalin (ultra-stable minerals), and magnetite (opaque mineral).

The sediment size are dominated by coarse sand and has sub angular - sub rounded shape. It shows a vary distance of transport. Mineral shape which is sub-

angular – sub rounded is hornblende and olivine. While the sub-rounded one is zircon, apatite, augite, magnetite and tourmaline. They are smaller than the mineral which is sub anggular shape. This characteristics is highly influenced by the distance and mechanism of transportation. Minerals ofolivine, augite and hornblende i ndicate an intermediate – alkaline igneous rocks. While zircon and tourmalin which are very stable mineral indicate a resedementation of sedimentary rocks in origin. The indication of hydrothermal alteration of parent rocks is characterized by the presence of magnetite and tourmaline minerals.

Based on the above characteristics it can be interpreted that the parent rocks of sediments from Salo Lamase come from different rocks. They are intermediate to alkaline igneous rocks, sedimentary rocks and hydrothermal alteration processes.

- *Salo Tokade*

Salo Tokade locates in Wajo Regency flowing to the The rivers include permanent rivers flowing into the Lake Lapompaka and to Tempe Lake. The heavy minerals found in the sediments from this river are olivine, epidote, augite, hornblende and cassiterite (metastable mineral), rutile, zircon and tourmaline (ultrastabil mineral), magnetite and iron oxide (opaque mineral).

Based on grain size analysis dominated by fine sand and sub rounded shape it indicates that the distance of sediment transport of the sediments afar from it parent rocks at the upper stream.

The parent rocks of the sediments, based on the above characteristics, are generally derived from intermediate to alkaline igneous rocks, marked presence of hornblende, augite and olivine minerals. The hydrothermal alteration of rocks characterized by the presence of magnetite, casiterit, epidote and iron oxide concentration minerals. Metamorphic rock is interpreted as a parent rock characterized by the presence of tourmaline, rutile and epidote mineral. Rutile is widely distributed as an accessory mineral in metamorphic rocks ranging from greenschist to eclogite and granulite facies but is also present in igneous rocks, mantle xenoliths, lunar rocks and meteorites [5].

Meanwhile, the re-sedimentation of sedimentary rocks are characterized by the presence of zircon and tourmaline minerals. These sediments was originated from the rocks outcropping Bila Watersheds in the north Lake Lapompaka.

Based on the Fig. above there are three zones of mineral assemblege in the Bila Watershed. The apatite minerals are only found in Bila River and Salo Lamase. Rutile and iron oxides minerals was deposited only in Salo Lamase and Salo Tokade. The Assemblege of epidote and casiterit minerals are only found in Bila River and Salo Tokade. While the mineral

assemblege of olivine, hornblende, augite, tourmalin, zircon and magnetite is found in all of the streams. The distribution of heavy minerals in the Bila Watershed can be seen in Figure 4.

Based on the above discussion, the type of parent rocks in Bila Watershed are igneous, sedimentary and metamorphic rocks and indications of alteration process. Igneous rocks found in Bila Watershed are from acid – alkaline type, even possible ultramafic igneous rocks that are characterized by the presence of olivine mineral in the three rivers. Sedimentary rocks are also as an indication of parent rocks of sediments deposited in Lake Tempe characterized by tourmalin, rutile and zircon minerals. The sedimentary rocks are probably resedimentation. Low grade metamorphic rocks such as schist is also a parent rocks characterized by epidote, brookit and augit mineral.

The presence of the olivine mineral in this area to be an interesting thing because olivine is a metastable mineral. The mineral is not a resistant mineral and rarely found in sediment deposits transported faraway from the parent rocks. It is interpreted that the mienrals was transported in short time by a huge power of water current. This kind of transpost mechanism is most probably transported by "banjir bandang".

According to modification of heavy mineral association and provenance by Feocodecido [6] the presence of zircon, Rutile and tourmaline indicates an acid igneous rock source of the sediments. The possibility of the source rock being basic igneous rock is very low because augite, diopside, hypersthene or olivine are largely absent from the heavy mineral assemblage. Instead rutile occur in relatively fairly large quantities with respect to Epidote and Sillimanite, which are indicative of dynamo thermal metamorphic rock source.

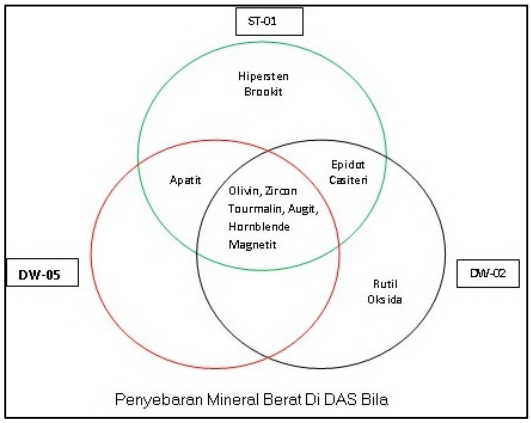

Fig 4. Heavy mineral distribution according to the sampling station in Bila Watershed.

Based on the regional geology, rock type that exposes in Bila Watershed in the north of Lake Tempe is Latimojong Formation (Kls) consisting of shale, phyllite, chert, marble, quartzite and breccia. The rocks are intruded by intermediate - alkaline igneous rocks. The intrusion rock (Tmpi) and Lamasi Formation consist of acid-intrusive rocks such as granite, granodiorite, diorite, sienit, quartz monzonite and rhyolite and in several places is found gabbro and andesite

and basalt. Loka Formation (Tml) is composed of volcanic rocks, Walanae Formation (Tpw) and Date Formation (Tomd) consists of sedimentary rocks such as sandstones, conglomerates and carbonate rocks. In addition to this rock type is also found mineralization and alteration from Toraja Formation (Tets).

The rock correlation showed as follows:

– Plutonic rocks that are intermediate to alkaline volcanic rocks indicated by the presence of the olivine, hornblende and augite minerals. This hypothesis is supported by the presence of brookit and hypersthene minerals. The presence of these minerals can be correlated with the rock from Lamasi Volcanic (Tolv), Loka Formation (TML) and intrusive rocks (Tmpi).
– The hydrothermal alteration process forms iron minerals characterized by magnetite mineral. While the cassiterite, epidote and iron oxide minerals are locally present. This condition refers to the parent rock of Toraja Formation (Tets) and Latimojong Formation (Kls).
– Metamorphic rocks of green schist facies formed by contact metamorphism. This most probably as a parent rock of sediments deposited in Lake Tempe. It characterized by the presence of epidote, rutile, hypersthene and brookit minerals. This refers to the Latimojong Formation (Kls) which is formed of metamorphic rocks.
- Sandstones and reworked sediments can be seen with the presence of the apatite and zircon minerals. This refers to the Latimojong Formation (Kls), Walanae Formation (Tpw) and Date Formation (Tomd).

3. Conclusion

The presence of the sediments is mostly non-opaque minerals such as zircon, tourmaline and rutile (ZTR) minerals is an indication of igneous and metamorphic provenance for the sediments.which are mainly igneous and metamorphic. The rocks are greatly distributed in Bila Watershed. In the northern part is commonly found and zircon. These minerals was sedimentary and igneous rocks in origin. While in western part commonly composes of olivine mineral. The mineral is interpreted to be formed in alkaline to ultrabasic igneous rocks.

The presence of all this

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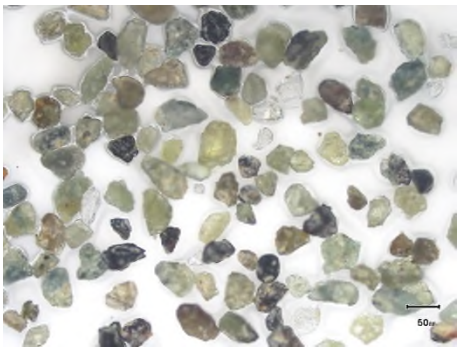
Attachments Mineral appearances from research area



A. Heavy minerals from Bila River.

B. Heavy minerals from Salo Lamase.

C. Heavy minerals from Salo Tokade