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Geological Mapping of Silica Sand Distribution on the Muda Island and Ketam Island, Estuary of Kampar River, Indonesia

Husnul Kausarian, Tiggi Choanji, Detri Karya, Evizal Abdul Kadir and Adi Suryadi

Abstract Silica sand is produced by weathered igneous rock where transported and deposited in the area such as banks of a river, lake, or beach. The study area of the silica sand distribution is on Muda Island and Ketam Island, Pelalawan Regency, Riau Province, Indonesia. Silica sand source deposits in this area are influenced by the northern part of the estuary of Kampar River which is dealing with the straits of Melaka that rich with sand sediments reserve. Melaka Strait in the northwest part of this estuary transports the sand materials from the Indian Ocean, while in the northeast part the sand sediment materials were obtained from the South China Sea and Riau Islands. Silica sand deposition process occurs due to the estuary system which is a bore tidal system. Landsat 8 that has been taken from June 2016 shows the significance of the sandbars development that almost thrives on the whole estuary of the Kampar River and the spread almost evenly from Muda Island and Ketam Island. From the result of laboratory testing using X-ray fluorescence (X-RF) for the sample of Muda Island contains the silica compound with the percentage is 92% and for the sample from Ketam Island, the percentage compound of silica sand in the sand

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sample is 90.5%. The result from X-ray diffraction (X-RD) analysis in the sample of Muda Island shows the high peak is quartz and miciocline compounds with the peak count of 3000 cps and for the silica sand sample from Ketam Island, the high peak are muscovite and quartz which has more than 32,000 cps.

Keywords Silica sand · Estuary · Kampar River · X-ray fluorescence X-ray diffraction

1 Introduction

Silica sand is one of the minerals are relatively abundant in Indonesia. This is possible due to the condition of Indonesia which almost half in the form of acid igneous rock as a source of the material forming the silica sand (Wicaksono 2012). Silica sand found in many coastal areas of rivers, lakes, beaches, and most of the shallow sea. Silica sand (quartz sands) formed by weathering of acid igneous rocks (Brown 2000; Kausarian et al. 2013) such as granite, gneiss, or other igneous rock containing the main mineral quartz (Rikke et al. 2010).

The result of the rock weathering is a process of sedimentation which will be transported and carried by water or wind as the sedimentation agents and then deposited on the bank of a river, lake or beach as the deposit/sedimentation environment (Holland and Elmore 2008; Carr 2013). Because the deposit numbers are quite large and look white along the banks of a river, lake, or beach, then in Indonesia, the famous name of this sand is white sand. This study aims to conduct an inventory and determine the potential (characterization and utilization) of silica sand resources in the area of Muda Island and Ketam Island, Pelalawan, Riau Province, Indonesia, as the basic information of the potential that can be used in the presence of silica sand in this area (Kausarian et al. 2016, 2017; Konstantinos 2014; Nugrahanti et al. 2014).

The location of Muda Island and Ketam Island (Fig. 1) is located in the estuary of Kampar River, Pelalawan, Riau Province, Indonesia as a part of Central Sumatra Basin (Heidrick and Aulia 1993; Dawson et al. 1997; Pubellier and Morley 2014; Rafat and Navneet 2011) which are located at 0° 17′ 5.82″N and 102° 52′ 28.46″E for Muda Island and 0° 20′ 5.73″N and 102° 57′ 35.51″E for Ketam Island.

2 Details of Experiments

Geological Mapping and Sample Collecting

The geological mapping has been carried out thoroughly to determine the distribution of silica sand contained in Muda Island and Ketam Island like observation point plotting, observation outcrops of silica sand, and sand sampling. Based on the field

Fig. 1 Map of study area in the estuary of Kampar River, Pelalawan Regency, Riau Province, Indonesia

observation (Lubis et al. 2017), determined observation points are ten locations, where seven observation points located in the area of Muda Island and four points in the Ketam Island (Fig. 2). The sampling of silica sand has been carried out at each point of observations (Fig. 3).

Laboratory Experimental

After sampling point at the represent locations, these samples were taken to the laboratory for further testing to determine the content and character of silica sand (Kausarian et al. 2016). The results of the laboratory test are needed to determine

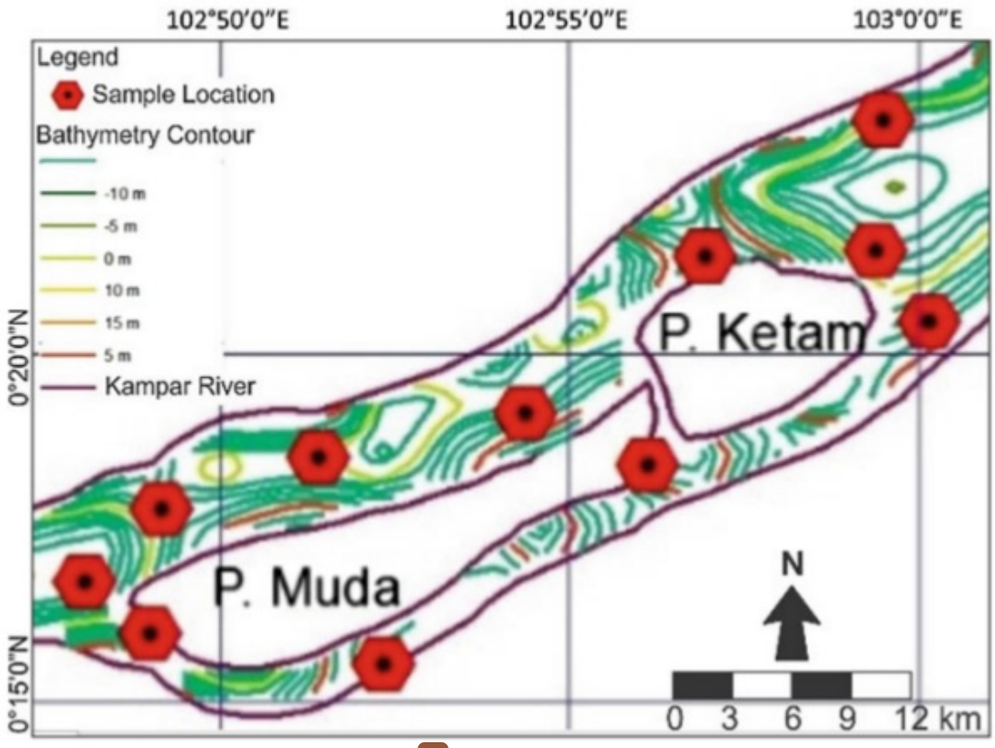

Fig. 2 Sample locations were collected on the Muda Island and Ketam Island

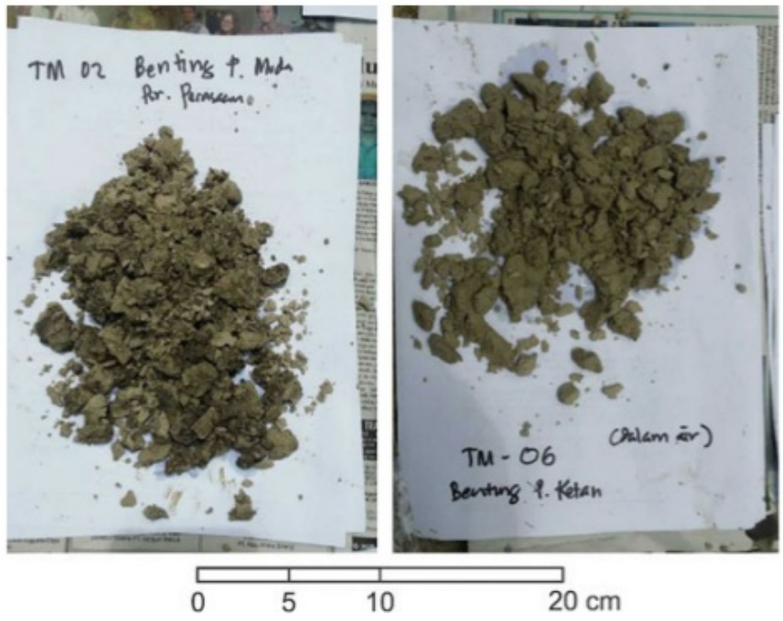

Fig. 3 Samples of silica sand from Muda Island (left) and Ketam Island (right)

the chemical analysis of silica sand samples to determine the types of elements, physical properties, and the percentage of the corresponding elements as well as the usefulness of the silica sand. The laboratory testing that was used is X-ray fluorescence (X-RF) (Murthy and Rao 2016) and X-ray diffraction (X-RD) (Ghalya et al. 1994), this testing is focused on determining the chemical composition, mineral deposits, the percentage composition, and others of compounds/minerals inside of silica sand. Another laboratory test is grain size for the particle of silica sand. This analysis will help to find the character of the silica sand. The size will give the explanation of the origin and the disturbing process that happens to the silica sand, for the explanation of the uniformity of the grain size will give the interpretation for distance of transportation process from the source/origin to the sedimentation area in this current time.

3 Result and Discussion

Silica Sand Sedimentation Process

Silica sand is a sediment deposit comes from rocks that contain silicon dioxide (quartz SiO_2) such as granite, rhyolite, and granodiorite. Silica sand deposit occurs after the process of transportation, sorting, and sedimentation. Therefore, deposit of silica sand in nature is never found in a pure state. Natural quartz grains, in general, are mixed with clay, feldspar, magnetite, ilmenite, limonite, pyrite, mica (biotite), zircon and hornblende and organic material from plants, and so on. In this area, water controls the process of transportation which caused the sandstone becomes increasingly subtle and relatively purer. The pollutant material generally gives color to the silica sand, so that the color produced can be shown the degree of purity. Sources of silica sand contained in these areas come not from in situ rock or soil from the Muda Island and Ketam Island because these areas are consisting of peat soil which has high carbon content, making it impossible to produce the deposit of silica sand. Silica sand source in this area comes from the Riau Islands Province which is located in front of the estuary of Kampar River. Riau Islands Province consists of igneous rock that potentially was weathered by the main agent sedimentology which is seawater and produces silica sand.

The main formations that made the estuary of Kampar River are young surface sediment formation (Qh) and old surface sediment formation (QP). The northern part of the estuary of Kampar River is dealing with the straits of Melaka which rich with sand sediments reserve, while the southern part is the land area. Melaka strait obtains sand sediment supply by its current. Melaka Strait in the northwest part of this estuary transports the sand materials from the Indian Ocean, while in the northeast part the sand sediment materials were obtained from the South China Sea and Riau Islands. Estuary of Kampar River which is located directly in front of this

Fig. 4 Current of Melaka Strait comes to the open wide of the estuary of Kampar River (shown by red arrows)

strait gets the sand sources in large numbers. It is caused by the movement of the currents that carries the source of these sediments into the estuary of Kampar River, where the morphology of this estuary shaped as a very open and wide and allows the deposition of the large sand sources in this area (Fig. 4).

Silica sand deposition process occurs due to the estuary system which is a bore tidal system. The significant influence from the tidal wave has occurred throughout the Kampar River, and the waters in the downstream area bring the large sand source and subsequent sedimentation occurs around the Muda and Ketam Island. The sand materials brought by the tidal wave and deposited when the current speed conditions weakened due to the convergence of tidal current from the river wave.

Satellite Data Interpretation

The results of satellite image processing from Landsat 8 in 2016 (Fig. 5) also support the information of silica sand distribution in this region which shows the significance of the sandbars development that almost thrives on the whole estuary of the Kampar River and spread almost evenly from Muda Island and Ketam Island. This is evident from the emergence of sandbars recorded by satellite imagery, which shows the appearance of the sand appears up to the surface and not submerged by the water.

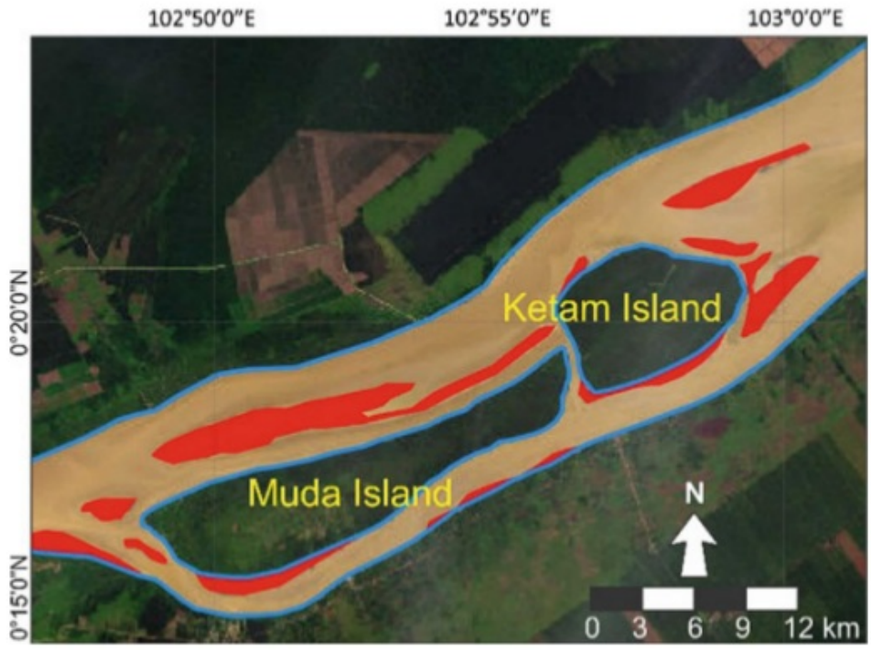

Fig. 5 Landsat 8 image shows the distribution of silica sandbar (red color) on the Muda and Ketam Islands on June 2016

Table 1 Result of silica sand compound percentage from the sample of Muda Island and Ketam Island

Compound	Percentage (%)	
	Muda Island	Ketam Island
MgO	0.5	0.54
Al_2O_3	5.491	5.571
SiO_2	91.847	90.47
P_2O_5	0.686	1.288
Cl	0.002	0.021
K_2O	0.874	1.016
CaO	0.144	0.266
Ti	0.109	0.169
V	0	0
Cr	0.001	0.003
Mn	0.001	0.003
Fe_2O_3	0.269	0.48
Zn	0.001	0.001
As	0	0
Rb	0.004	0.007
Sr	0.002	0.003
Y	0.001	0.003
Zr	0.01	0.057
Ag	0.057	0.101
Pb	0.001	0.001
Eu	0.001	0.004
Re	0	0

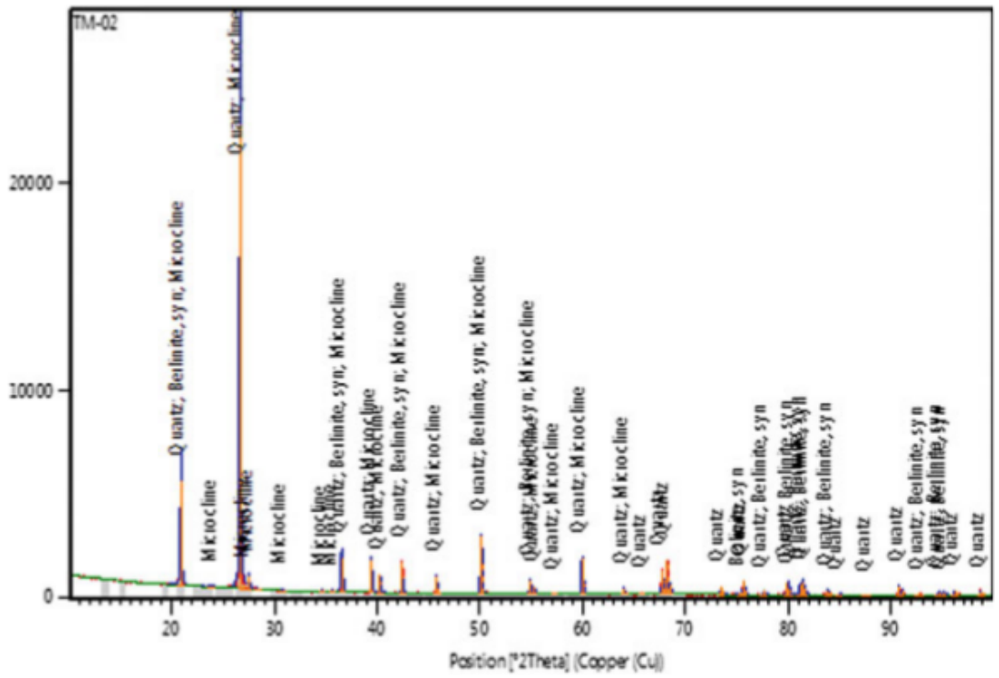

Fig. 6 X-ray diffraction (X-RD) result shows the abundance of quartz and miciocline compounds as the high peak in the sample of Muda Island

Laboratory Test Result

From the result of laboratory testing using X-ray fluorescence (X-RF) for the sample of Muda Island (Table 1) has an abundance of compounds such as SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5. The result shows the compound of silica (SiO_2) is the highest percentage compared to other compounds. From X-RF result, the silica content in this location showed 92% and followed by mineral/aluminum compound is 5.5% and potassium compound is 0.7% as the major minerals. The results of these percentages prove large silica content. The result from X-ray diffraction (X-RD) analysis in the sample of Muda Island (Fig. 6) shows the high peak is quartz and miciocline compounds. The compound miciocline and quartz has a peak count of 3000 cps.

The result of laboratory X-RF (see Table 1) for the Ketam Island sample shows silica (SiO_2) is the highest percentage 90.5%, followed by the aluminum compound is 5.5% and potassium compound is 1.3% as major minerals. The result of X-RD analysis (Fig. 6) in the Ketam Island sample shows muscovite and quartz compounds are the high peak in the calculation of the points using X-RD which is more than 32,000 cps.

4 Conclusion

The study of silica sand distribution in the area of Muda Island and Ketam Island in the estuary of Kampar River shows around these islands completely surrounded by silica sand deposit. Distribution is seen very clearly based on the result of geological mapping that has been done and supported by the interpretation result of Landsat 8 satellite image that was taken in June 2016. The sand deposits are proven as silica sand based on the result of laboratory tests of X-RF and X-RD which shows the content of silica is very high in this sand. The results expected from this research of silica sand distribution is being a source reference data for the government in the effort to develop the potential areas that could be optimized for the processing of silica sand as the mining industry and others.

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