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Seafloor Sediment Characteristics and Heavy Mineral Occurences at Betumpak Cape and Adjacent Area, Bangka Strait, Bangka Belitung Province

Karakteristik Sedimen Permukaan Dasar Laut dan Keberadaan Mineral Berat di Tanjung Betumpak dan Sekitarnya, Selat Bangka, Provinsi Bangka Belitung

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ABSTRACT: Thirty seafloor of sediment samples have been taken by using gravity corer and grab sampler at Betumpak Cape, and adjacent area of Bangka Belitung. The result of grain size analyses show that there are four sediment units: gravelly sand, gravelly muddy sand, silt and silty sand. Identification of Scanning Electron Microscope (SEM) image on several samples shows the presence of clay mineral such as smectite, alunite, chlorite etc., may resulted from plagioclase weathering of granite. Based on heavy mineral analyses, its highest content is found at MTK-27 (northwest of Betumpak Cape). High content of apatite (0.94% wt and 1.07% wt) is found on coarse sand fractions (115-170 mesh) at MTK-29 (northeast Ular Cape) and MTK-30 (north of Ular Cape). Generally, the heavy mineral accumulation is occurred on medium sand fraction (60-80 mesh) as magnetite (7.86% wt), ilmenite (4.9% wt) and zircon (1.32% wt). Based on these data, it shows that heavy mineral is accumulated on medium to coarse sand.

Key words: sea floor sediment, grain size analysis, heavy minerals, and Betumpak Cape, Bangka strait.

ABSTRAK: *Sebanyak 30 sampel sedimen dasar laut telah diambil dengan menggunakan pemercontoh jatuh bebas dan comot di Perairan Tanjung Betumpak dan sekitarnya, Bangka Belitung. Hasil analisis besar butir menunjukkan adanya 4 satuan sedimen, yaitu pasir kerikilan, pasir lumpuran sedikit kerikilan, lanau dan pasir lanauan. Hasil identifikasi citra Scanning Electron Microscope (SEM) terhadap beberapa sampel, memperlihatkan kehadiran mineral lempung seperti smektit, alunit, klorit dll., kemungkinan sebagai hasil pelapukan plagioklas dari granit. Berdasarkan analisis mineral berat kandungan tertinggi terdapat di lokasi MTK-27 (baratlaut Tanjung Betumpak). Akumulasi mineral berat umumnya terdapat pada fraksi pasir ukuran sedang (60-80 mesh) berupa magnetit, ilmenit dan zirkon masing-masing dengan kandungan 7,86 % berat. 4,9% berat dan 1,32% berat. Pada fraksi pasir kasar (115-170 mesh) dijumpai kandungan apatit tertinggi di MTK-29 (timurlaut Tanjung Ular) dan MTK-30 (utara Tg. Ular) sebesar 0,94% berat dan 1,07% berat.*

Dari data tersebut terlihat, bahwa secara umum mineral berat terakumulasi pada pasir sedang hingga pasir kasar.

Kata kunci: *Sedimen permukaan dasar laut, analisis besar butir, mineral berat, dan Tanjung Betumpak, Selat Bangka.*

INTRODUCTION

The Islands of Bangka and Belitung and the adjacent area, have been known since a long time ago as a main tin-producing area in Indonesia. Geologically, due to granite presence this study area also has potential of rare minerals, such as monazite, xenotime, apatite, pyrochlore and zircon that strategically as a radioactive carrier. These heavy minerals which initially only in tailing form, but nowadays with the development of technology can be processed more efficiently from originally a by-product into the main-product.

The trend demand of sand and minerals increased rapidly along with the rapid development in all sectors. The potency of mineral resources at coastal and offshore areas, become an alternative choice due to the increasingly limited exploration target reserves and resources in mainland and it has the potential to improve the economy of region. Tin minerals based on its geological characteristics, always present with its association minerals, that have been imposed only as tailings that has not been used optimally. Otherwise, through time where tin is no longer can be expected as one's strong point product, it would be found other minerals that could taking over the role of local goverment income contributor. For that required a study, it is focused to aspects of mineralogy in order to determine the content of other minerals that found in marine sand sediments.

The study area located at Betumpak Cape, Bangka Strait, where administratively included Muntok District, West Bangka Regency, Bangka Belitung Province. Geographically, it located at coordinate 105 00'E - 105 15'E and 1 52'30"S - 2 05'00"S (Figure 1). The study area can be reached by vehicles easily, it takes approximately 2.5 hours from Pangkalpinang due to good road conditions.

According to Mangga and Djamal (1991), the oldest rock in the study area is Paleo-Perm metamorf Pemali Complex (CPp) consisted of: phyllite, schist with quarzite intercallation and calcareous lenses. Penyabung Diabase is younger than Pemali Complex (Permo-Trias, PTrd), composed of: diabase that intrudes Pemali and then is intruded by Klabat Granite (TrJkg). In the early Triassic, along with the formation of diabase was formed Penyabung Tanjunggenting Formation (Trt) which is composed of interlayered metasandstone, sandstone, clayeysandstone and claystone with lenses of limestone, widely spread covering almost all parts of the Bangka island. In late Triassic to Middle Jurassic, magma activity formed Klabat Granite (TrJkg) that intrudes all early rock units. In Pliocene, Ranggam Formation (TQr) is deposited and consists of interlayering sandstone and claystone, while in Quaternary (Holocene) alluvial deposit is formed (Figure 2).

Geological structures developed on the Bangka island is consisted of reverse fault, shear faults, normal faults, folds structure, fracture and some other structural lineaments. Fold structures are generally formed in the Permian aged rocks. According to Mangga and Djamal (1991), deformation in this region occurred in 3 (three) phases, beginning in the Late Paleozoic with structure trending northeast - southwest and characterized by diabase intrusion, then (the phase-2) in the Upper Triassic-Jurassic with structure trending northwest - southeast and northeast - southwest is marked by granite dikes. The phase-3 or the youngest in Cretaceous, structures that trending north to south.

METHODS

Sea floor sediment samples had been taken using a gravity corer and a grab sampler which spacing between

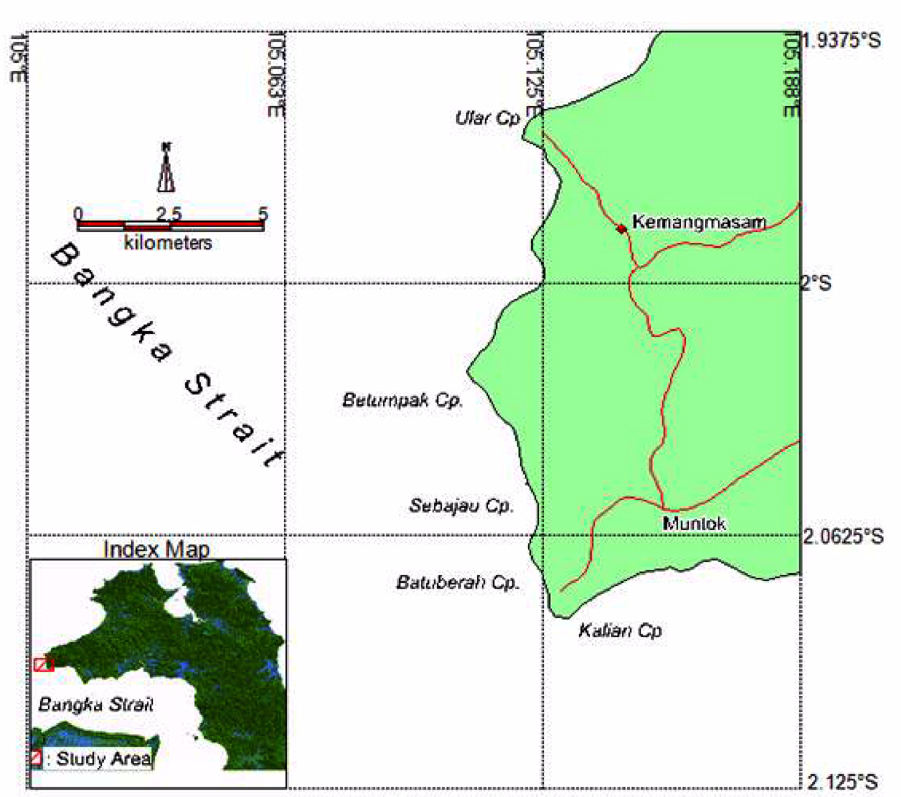

Figure 1. Study location map

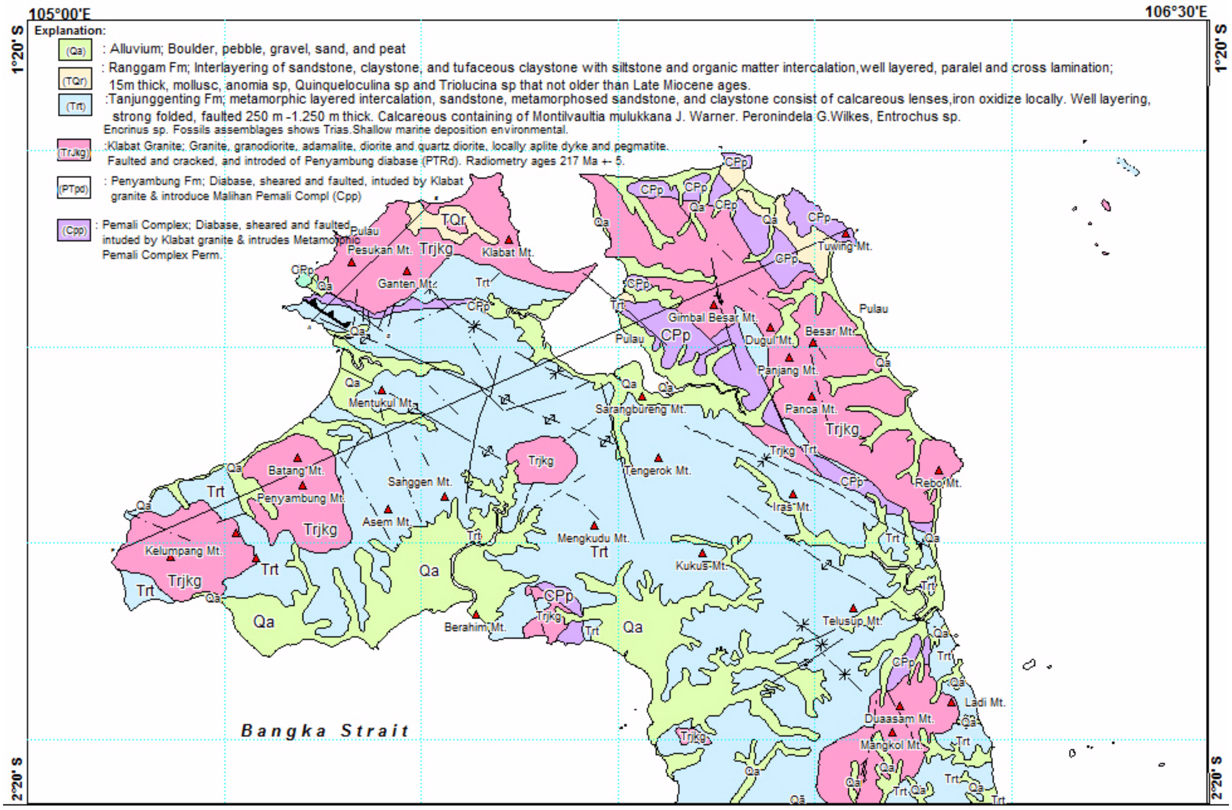

Figure 2. Geology map of North Bangka (Mangga and Djamal., 1991)

800 and 1400 m. Heavy mineral is analyzed by using bromoform heavy liquid, grain size analysis and mineral micrograph had been done at Marine Geological Iinstitute applied Nikon Eclipse LV 100 polarization microscope. Scanning electron microscopics (SEM) is used for clay mineral analyses that was done at Geological Survey Institute (GSI).

RESULTS

Based on grainsize analysizes of 30 sea floor sediment samples (Figure 3) and refers to the nomenclature of sediments (Folk, 1980) and the moment statistical parameters, it shows that seabed sediment in the waters of Betumpak Cape, is divided into 4 (four) units, namely: gravelly sand, slightly gravelly muddy sand, silt and silty sand (Figure 4).

Gravelly sand/ (gS)

Sediment unit is dominated by gravelly sand and it covers more than 95 square kilometers area. This distribution is more wide combined with results of previous studies on the east (Sheet map 1113-1014, Silalahi et al, 1998).

Sediment unit composition, is consisted of sand which varies between 70.1% and 98.8% and gravel ranges from 1.2% to 29.9% (Table 1). Sand particle is generally dominated by fine to coarse quartz sand, while gravel component is characterized by reef detrital and lithic particles.

Based on the grain size analyses, show that statistically the moment mean value is about 0.5 to 2.2; sorting 1.0 to 2.4; skewness -0.2 to -0.7 and kurtosis 1.9 to 3.1. The weight percent frequency curve versus grain size diameter (phi) on gravellysand sediment unit is represented by MTK-11 (Figure 5). The form of histogram shows only one maximum value (unimodal) which can be interpreted as sediment that derived from a single source, where the degree of skewness shaped very leptokurtic (kurtosis value of 3). It means the sorting degree is well sorted. The distribution of the grain particles tends more coarser (positively skewed).

The appearance of these sedimentary units, micrographically by SEM are represented by MTK-29 (78-85 cm), observations were made twice on the left and the right sample.

Based on the SEM results, sample consists of SiO_2 8.45% - 10.43%, Al_2O_3 at 4.23% and 2.10%. SEM images show alunite group minerals in the base mass of smectite and chlorite trio-octahedral shaped (Figure 6, magnification 5000x).

In this sample could be seen that the quartz grains is still clearly visible in the form of amorphous and crystalline surface is flat and embedded in a base mass of montmorillonite detrital.

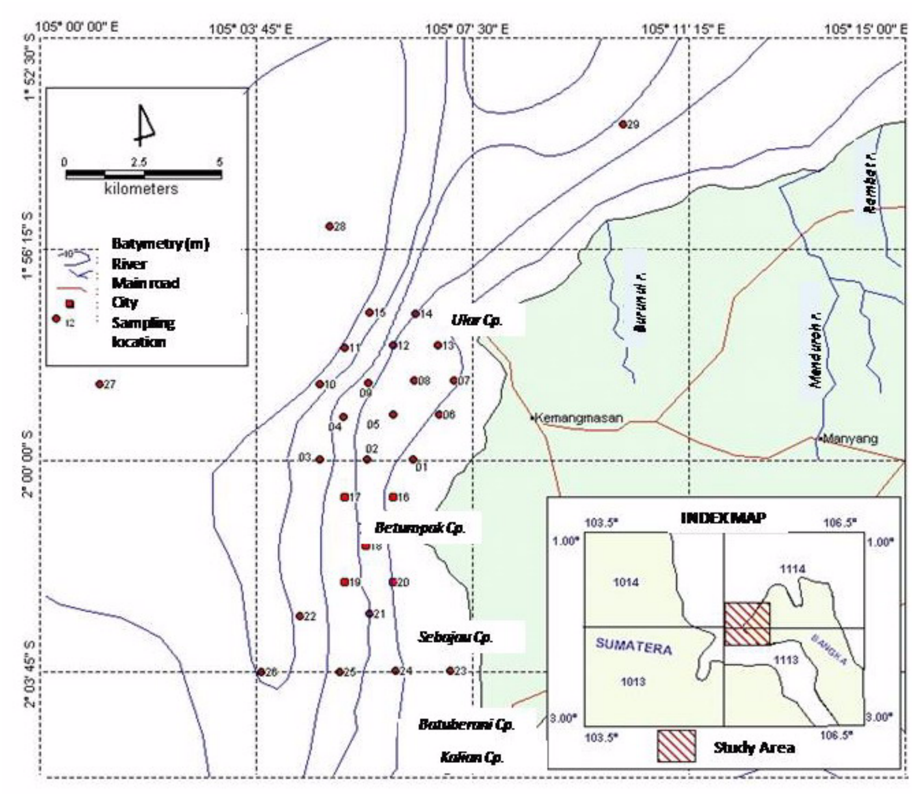

Figure 3.Sediments sampling location and bathymetry of the study area (Aryanto et al, 2010)

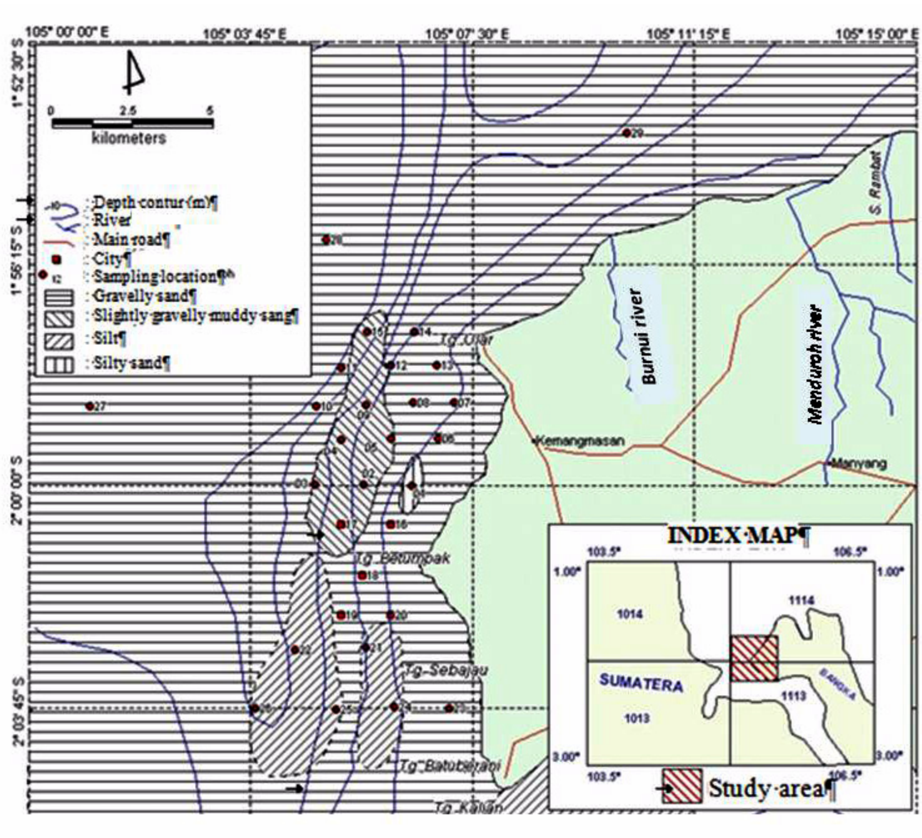

Figure 4. Seafloor sediment distribution map of the study area (Aryanto et al, 2010)

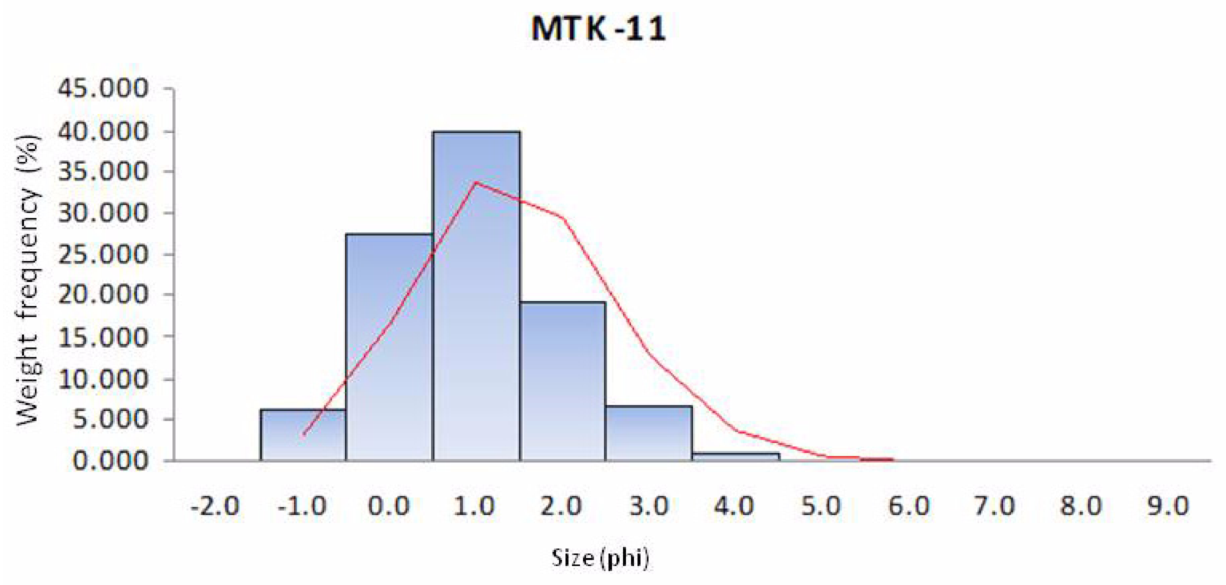

Figure 5 Histogram of grain weight frequency (%) to grain size diameter (phi) of gravelly sand sediment at MTK-11

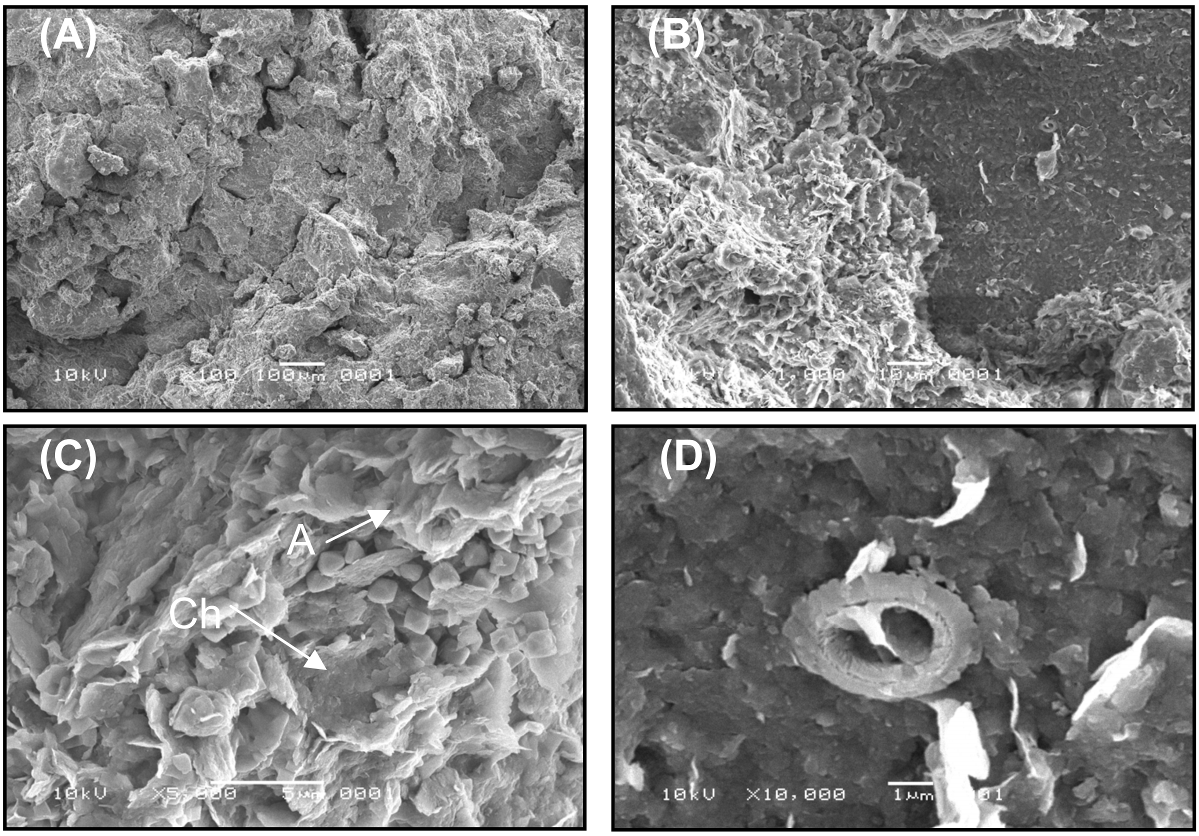

Figure 6. Microphoto SEM MTK-29 (78-85 cm). (A) magnification 100X; (B) magnification 1000X; (C) magnification 5000X dan (D) magnification 10.000X.
S= smectite; A= alunite; Ch= chlorite

Slightly gravelly muddy sand/ (g)mS

This sediment unit distribute widely approximately 11.8 km^2 from Ular to Betumpak Cape at water depths of 16 m to 36 m. The sediment unit consists of sand (ranging between 18.3% and 75.4%), silt (16% to 69%), clays (less than 3.2%) and gravel (2.9% o 16.5%) as shown at Table 1. Generally, sand is composed of quartz mineral, and fine to medium grained of mafic minerals. Gravel consists of reef detrital and lithic particles. Statistically, the moment mean value is about 1.0 to 3.8, sorting from 1.0 to 2.5; skewness -2.2 to -0.7 and kurtosis 2.5 to 7.1. The comparison between weight percentage of frequency curve (%) and grain size diameter (phi) on this sediment unit, is represented by MTK-04 (Figure 7). It shows histogram with two maximum values (bimodal) that can be interpreted as sediment derived from two sources. This condition is probably caused by change of flow direction which is shown by very leptokurtic skewness shape (kurtosis value> 2.5).

Silt/ Z

The second largest distribution after gravelly sand sediments is silt sedimentary unit. This unit coverage approximately 31.3 km^2 of study area. The moment of statistic parameters, show that the mean values are between 1.8 and 2.3; sorting from 0.8 to 1.6; skewness from 1.3 to 1.6 and kurtosis 2.7 to 3.5. At the study area, this unit is represented by MTK-21, 22, 24, 25 and 26.

Figure 8 shows that a histogram with the maximum value (unimodal) can be interpreted that the sediment derived from one source.

Silty sand (zS)

Silty sand is the least distribution sedimentary unit (approximately 0.9 km2) which is found in the north of Betumpak Cape and only represented by two sites (MTK-01 and 27). Composition of silty sand is sand (59.9% - 79%) and silt (20.2% - 34.9%). Sand fragment is composed of fine to medium quartz sand.

The average moment of statistic parameter of this unit, has an mean value 2.5; sorting 1.6; skewness 1.2 and kurtosis 4.4. The comparison of frequency curve between weight percentage and grain size diameter (phi) is represented by MTK-01 (Figure 9). The histogram shows two maximum values (bimodal) which can be interpreted as sediment derived from two sources or due to changes in current direction. Degree of skewness is represented by extremely leptokurtic (kurtosis value> 3) which means that the sorted degree is well sorted.

The appearance of these sedimentary units from identification image of SEM is represented by MTK-27 in the thickness of the sample (75-80 cm). A visible presence of mineral kaolinite and coated sheets (platy) assumed as the result of plagioclase weathering of granite which is exposed around the coastal area (Figure 10).

Mineral contents of sea floor sediments at the study area are examined through grain mineral analysis.

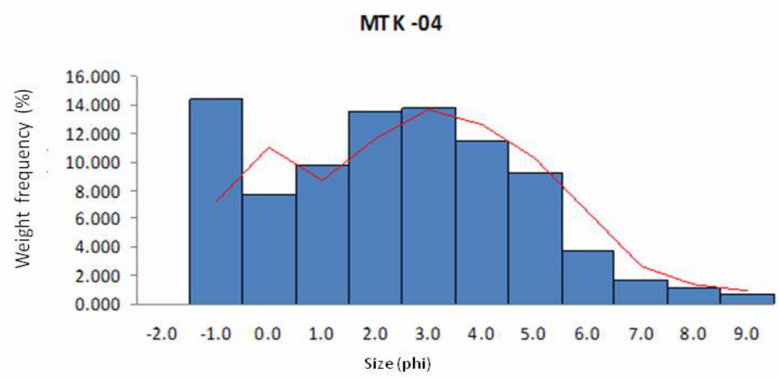

Figure 7. Histogram of grain-weight frequency (%) to grain size diameter (phi) on gravelly muddysand at MTK-04

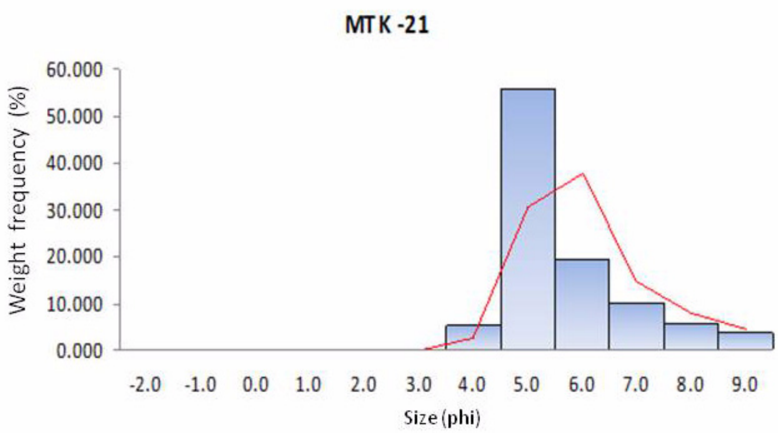

Figure 8. Histogram of grain weight frequency (%) to grain size diameter (phi) of silty sediment at MTK-21

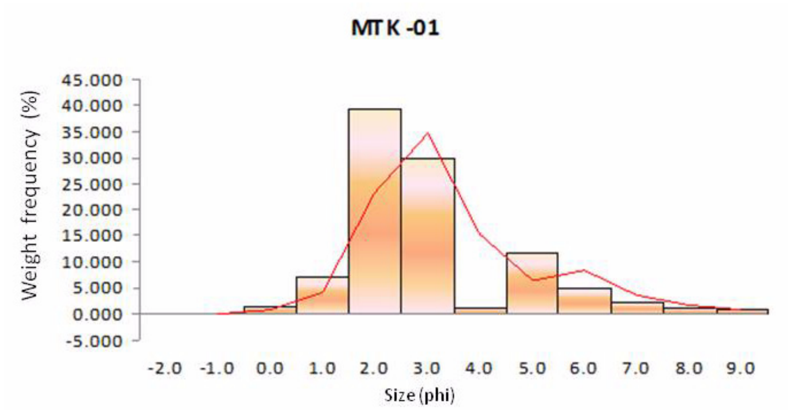

Figure 9. Histogram of grain weight frequency (%) to grain size diameter (phi) at silty sand sediment (MTK-01).

The heavy minerals from 4 sediment samples are dominated by: magnetite, ilmenite, zircon and apatite (Table 2). The presence of these minerals at every sample, generally accumulated at 60-80 mesh fractions as shown in figures 11 and 12.

Magnetite (Fe_3O_4) is a mineral that has high iron content. At study area, magnetite mineral is often found, characterized by the appearance of black with metallic luster, sub-rounded–sub-angular, found at medium and very fine sand. The presence of magnetite in medium sand (60-80 mesh), is mostly found at MTK-27 core sample (7.86 %wt), 8-13 cm depth below seafloor, in western of study area. The minimum content (0.82 % wt) is found at northern part of the study area (MTK-29).

Ilmenite ($FeTiO_3$) is the oxyde group. The chemical composition (textual) consists of 36.8% Fe, 6.31% Ti and 31.6% O. These minerals are commonly found in alkaline rocks. In a hydrothermal process at altered igneous rocks, ilmenite composition changes (decomposes) into leucocene (Betekhtin, 1996). At the study area, analysis of the seafloor sediment samples, showed a granular form of gray-black, submetalic luster, sub-rounded to the octahedral form of ilmenite (Figure 13). Mineral content in the medium sand (60-80 mesh) at study area ranged from 0.29 to 4.9 wt% which are found in the western part (MTK-27).

Zircon ($ZrSiO_4$), belongs to silicate group characterized by white or clear appereances, occurred in magmatic intrusive rocks (granitic), nepheline, syenite and diorite (Betekhtin, 1996). Mineralogical grain analysis give the appearance of a color variation between clear, white, yellow and brown, elongated prismatic forms, translucent to transparent (Figure 14). The presence of zircon in medium sand of the study area has concentration between 0.1 and 1.32 % wt. The high abundances encountered in the western part of the study area (MTK-27) accumulates on 8-13 cm.

Apatite (CA_5 (PO_4) 3 (F, OH, Cl) sometimes contain strontium (up to 15 % wt SrO), Cerium (up to

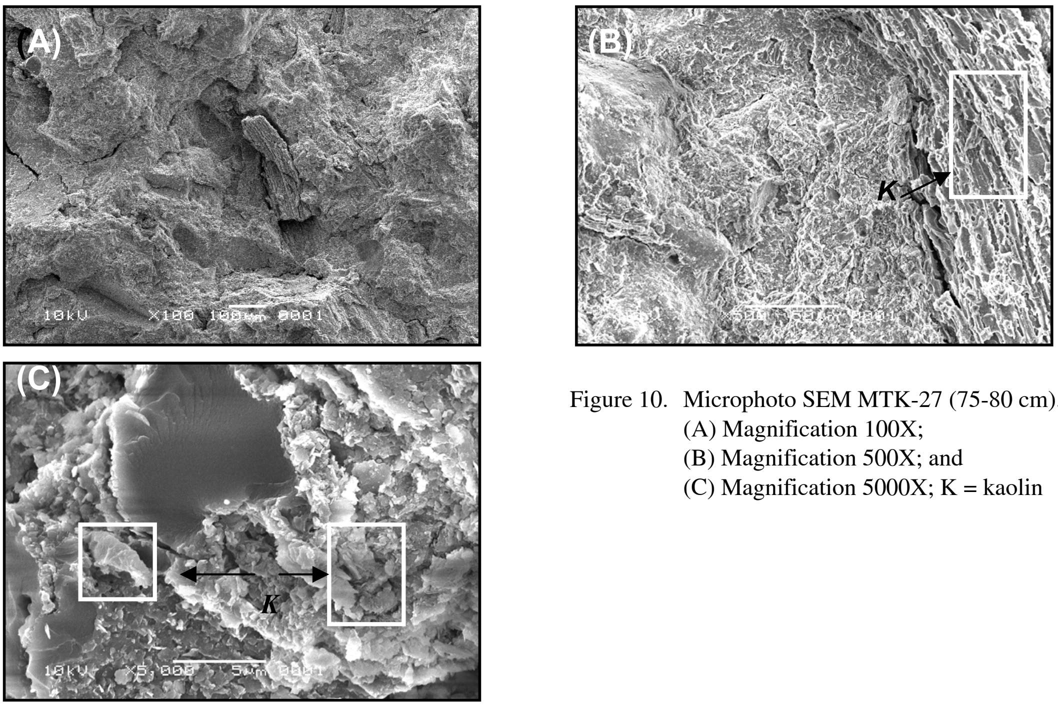

Figure 10. Microphoto SEM MTK-27 (75-80 cm).
(A) Magnification 100X;
(B) Magnification 500X; and
(C) Magnification 5000X; K = kaolin

Tabel 1. Sediment composition and statistical parameter of the study area

No.	Samples	x (phi)	Sortasi	Skewness	Kurtosis	Granule	Sand	Silt	Clay	Classification (Folk, 1980)
1	MTK_01	2.5	1.6	1.2	4.4	0	79	20.2	0	Silty sand
2	MTK_02	1.8	2.2	0.7	3.4	7.7	75.4	16	0.9	Slightly gravelly muddy sand
3	MTK_03	3.4	1	-1.5	4.4	3.6	27.3	69	0	Slightly gravelly muddy sand
4	MTK_04	1.9	2.3	0.3	2.5	16.5	64.6	18.1	0.8	Gravelly sand
5	MTK_05	3.8	1.6	-2.2	7.1	2.9	18.3	78.8	0	Slightly gravelly muddy sand
6	MTK_06	1.4	1	0.2	3.1	3.6	96.4	0	0	Gravelly sand
7	MTK_07	0.6	1.2	0.4	2.5	5.8	94.2	0	0	Gravelly sand
8	MTK_08	0.9	1.1	0.3	2.4	6.3	93.7	0	0	Gravelly sand
9	MTK_09	1	2.5	0.6	2.7	10	63	25	1.2	Slightly gravelly muddy sand
10	MTK_10	1.3	1	-0.4	2.9	1.2	98.8	0	0	Gravelly sand
11	MTK_11	0.5	1	0.3	3	6.2	93.8	0	0	Gravelly sand
12	MTK_12	1.6	1	-0.2	3.1	5.2	94.8	0	0	Gravelly sand
13	MTK_13	0.5	1.6	0.7	2.7	7.2	92.8	0	0	Gravelly sand
14	MTK_14	1.7	2.3	0	3.1	10.5	66.5	22	1	Gravelly sand
15	MTK_15	3.4	2.2	0.6	6.8	12.8	66.8	16.9	3.2	Gravelly sand
16	MTK_16	1.4	1.1	0.8	2.2	5.2	94.8	0	0	Gravelly sand
17	MTK_17	2.5	2.2	0.2	2.8	7.1	65.1	26.7	1.1	Slightly gravelly muddy sand
18	MTK_18	2.2	1.6	-0.2	1.9	29.9	70.1	0	0	Gravelly sand
19	MTK_19	0.5	1.3	-0.2	2.6	13.1	86.9	0	0	Gravelly sand
20	MTK_20	2.2	2.4	0.5	2.6	5.6	64.5	28.4	1.5	Gravelly sand
21	MTK_21	2	0.8	1.4	3.5	0	1.8	96.8	1.2	Silt
22	MTK_22	2.3	1.1	1.3	2.8	0	0.9	97.1	1.2	Silt
23	MTK_23	0.8	1	0.6	2.8	10.2	89.8	0	0	Gravelly sand
24	MTK_24	1.8	1.6	1.6	2.9	0	0.7	95.8	3.4	Silt
25	MTK_25	1.9	1.5	1.5	2.7	0	2.1	96.4	1.3	Silt
26	MTK_26	5.8	1.6	-0.2	3.2	0.0	7.9	81.8	10.3	Silt
27	MTK_27	3.4	2.5	0.5	2.1	0.0	59.9	34.9	5.2	Gravelly sand
28	MTK_28	0.4	1.8	-0.3	1.9	26.4	73.6	0.0	0.0	Gravelly sand
29	MTK_29	1.5	1.4	-0.7	2.7	8.1	91.9	0.0	0.0	Gravelly sand
30	MTK_30	3.4	2.3	0.6	2.5	0.0	66.8	28.2	5.0	Silty sand

Tabel 2. Heavy minerals content

No. Samples (core depth)	Fraction mesh	Mineral (% weight)			
		Magnetite	Ilmenite	Zircon	Apatite
28 (5-15 cm)	32-42	0.51	-	-	-
	60-80	3.51	2.58	1,08	0.41
	115-170	2.83	1.74	0,56	0.18
	200-300	0.37	0.22	0.07	0.06
27 (0-8 cm)	32-42	-	-	-	-
	60-80	3.91	5.55	-	-
	115-170	4.4	2.79	0.77	0.43
	200-300	0.98	0.69	0.36	0.32
27 (8-13 cm)	32-42	-	-	-	-
	60-80	7.86	4.9	1.32	0.40
	115-170	3.8	2.23	0.7	0.32
	200-300	0.58	0.32	0.13	0.12
29 (0-5 cm)	32-42	-	-	-	-
	60-80	1.87	1.03	-	-
	115-170	2.59	1.37	1.43	0.69
	200-300	1.06	-	0.58	0.29
29 (55-63 cm)	32-42	-	-	-	-
	60-80	0.82	-	-	-
	115-170	1.85	1.11	0.68	0.94
	200-300	0.73	0.43	0.34	0.19
29 (78-85 cm)	32-42	-	-	-	-
	60-80	-	0.29	-	-
	115-170	1.12	0.69	0.76	-
	200-300	0.59	0.65	0.27	0.23
29 (93-95 cm)	32-42	-	-	-	-
	60-80	-	0.71	-	-
	115-170	1.47	0.97	0.71	-
	200-300	-	0.42	0.44	0.24
30 (0-5 cm)	32-42	-	0.94	-	-
	60-80	3.29	1.55	-	-
	115-170	5.45	5.77	2.51	1.07
	200-300	0.78	0.86	0.36	0.16
30 (23-27 cm)	32-42	-	-	-	-
	60-80	2.42	1.71	0.89	0.49
	115-170	3.21	2.12	1.47	0.57
	200-300	0.98	0.54	0.33	0.34
30 (75-80 cm)	32-42	-	-	-	-
	60-80	-	-	-	-
	115-170	2,84	1,50	-	-
	200-300	0,92	1,08	0,84	0,44

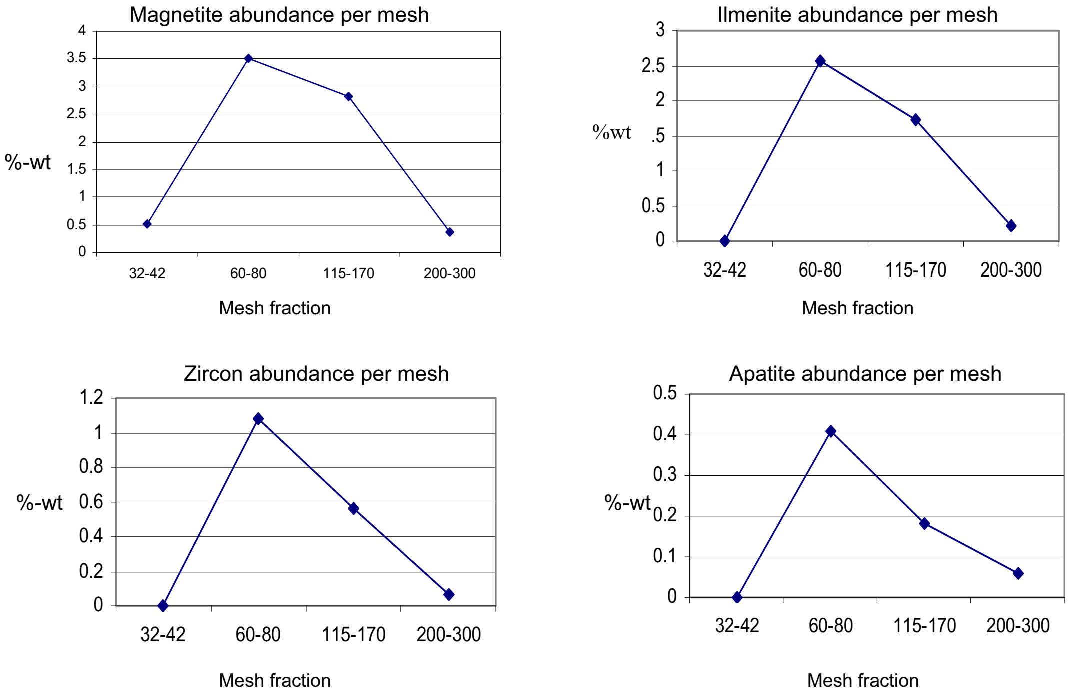

Figure 11. Heavy mineral occurences at MTK-28 (5-15 cm) on 60 mesh fraction

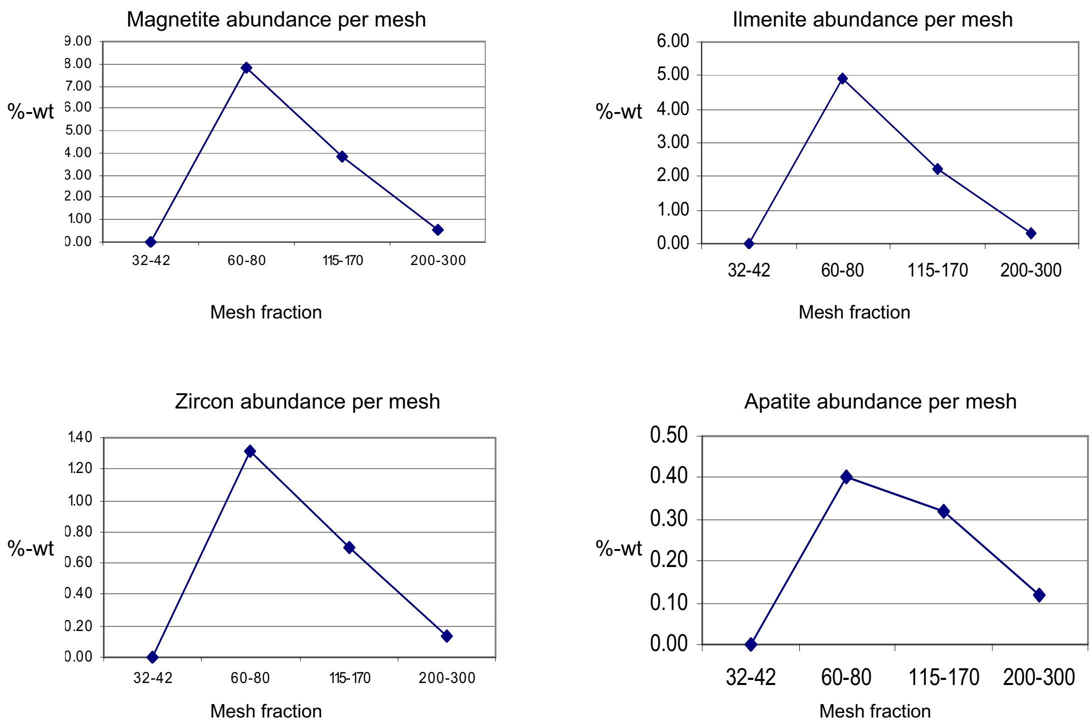

Figure 12. Heavy mineral occurences at MTK-27 (8-13 cm) on 60-80 mesh fraction

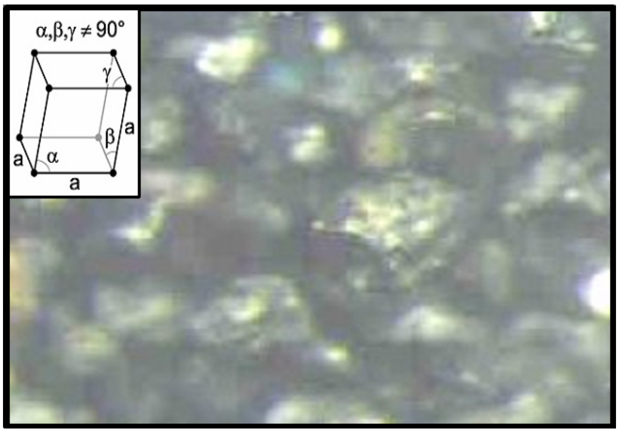

Figure 13. Ilmenit mineral grain, gray-black, subrounded-rounded and octahedral

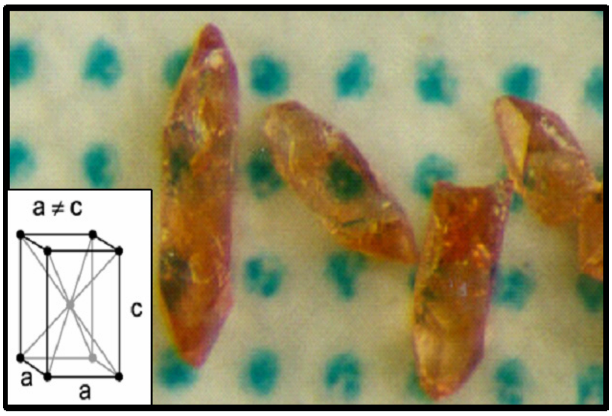

Figure 14. Zircon mineral grain, yellow to pink, elongated prismatic forms, translucent to transparent

12% wt Ce_2O_3) and some other elements (Wenk and Bulakh, 2004). These minerals are characterized by rhombic crystal structure with hexagonal crystal system and the level of hardness is about 5. It is usually found in granular form and generally associated with other silicate minerals such as zircon (Betekhtin, 1996). Based on mineralogical observations, the presence of mineral at study area is characterized by a greenish colour and clear appearance. The highest content (0.94%wt) of apatite encountered at MTK-29 (Northeast of Ular Cape) on 55-63 cm below seafloor. It is accumulated in coarse sand fraction (115-170 mesh). The apatite is also found at MTK-30 (north of Ular Cape) at the same coarse sand fractions with percentage of 1.07% wt.

DISCUSSION

Based on the statistical analysis of the grain size parameters of the sea floor sediment, shows a sediment source and deposition deferences. Therefore, it is really common for sediment deposition processes at the seabed, where the hydro-oceanography effect such as velocity and currents direction changes. However, to determine the exact source of mineral provenance studies need to be done separately.

CONCLUSIONS

The seafloor sediments in the Betumpak Cape, Bangka Strait, Bangka Belitung Province can be divided into 4 (four) units: gravelly sand, slightly gravelly muddy sand, silt and silty sand. Generally the gravelly sand and silty sand come from two sources due to the flow direction changes. The source is assumably derived from the land and along the coastal area. This condition is supported by the presence of clay mineral such as smectite, alunite, apatite as the results from weathering of plagioclase granite. Also visible are still clearly quartz grains with amorphous and flat crystalline surface embedded in a mass base of detrital montmorillonite (MTK-29). Based on megascopic observation, sand is generally dominated by quartz while the pebbles component are detrital and lithic particles. Heavy mineral (magnetite, ilmenite and zircon) are common found at study area that are accumulated in sand size fraction. The highest content of heavy minerals accumulating in the medium sand encountered in the 8-13 cm core depth as shown by the location of MTK-27. Even the location of MTK-30 (in the core depth 0-5 cm) mineral apatite was found in the form of coarse sand. Based on these data, it shows that heavy mineral is accumulated on medium to coarse sand.

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