The Mechanism of Sediment Depositional Environment of Core Drilling of Gilimanuk Coast, Bali and Ketapang, East Java, Based on Sediment Textures

Mekanisme Lingkungan Pengendapan Sedimen dari Pemboran Inti di Pantai Gilimanuk, Bali dan Ketapang Jawa Timur, Berdasarkan Tekstur Sedimen

Ediar Usman

Marine Geological Institute, Jalan Dr. Junjunan No. 236 Bandung-40174.

Corresponding author : ediar@mgi.esdm.go.id

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ABSTRACT: The analysis result of grains frequency curve and relation between grains size to cumulative have shown medium grains at Gilimanuk (Core drilling-1) and coarse grains at Ketapang (Core drilling-2). In general both of them are showed by pattern uniformity, which is represented by the similar of curve pattern. On the grain size of -2 phi as medium gravel with percentage between 6.47 to 35.88%, while core drilling -2 on the size of -2 phi between 6.86 to 61.11%.The average grains size of core drilling -1 are gravel about 21.3%, sand 60.2%, silt 5% and clay about 0.4% while core drilling-2 are characterized by 44.3%, sand 26.8%, silt 24.6% and clay about 0.6%. These result shows that at location of Core drilling -1 is dominated by sand where as at location of Core drilling -2 is dominated by gravel. These situation can be interpreted that the sediment at core drilling -2 location have influenced by strong marine current which can transport the large amount of gravel size compare to the location of Core drilling-1 which is dominated by sand. Based on the relation shape of grains size curve versus cumulative frequency shows that the sediment of Core drilling-1is interpreted as a beach sand deposits and only one sample which shows as a river sand deposits which was found at depth 0 – 3 m depth. In general, the sample of Core drilling –2 shows that the pattern of sediment tend as a beach sand deposits and only one sample which shows the combination between coastal deposits and river deposits (4 – 5 m depth). From this sample, the coarse to fine grains is deposited by coastal media and fine grains material (about 10%) is deposited by river media. The sample of river deposits is found as lamination because the only one which is created from combination between coastal and river depos its from all sample of core drilling-2.

Keywords: core drilling, grain sediments, media transport, environmental deposition

ABSTRAK: *Hasil analisis menggunakan kurva frekuensi butiran serta hubungan antara besar butir terhadap ~~ku~~mulatif menunjukkan dominasi ukuran butiran sedang di daerah Gilimanuk (Bor-1) dan kasar di daerah Ketapang (Bor-2). Pada kedua daerah tersebut, secara umum memperlihatkan pola keseragaman, yang ditunjukkan oleh pola kurva yang sama. Pada ukuran butir -2 phi (kerikil sedang) pada Bor-1 berjumlah antara 6,47 – 35,88%, sedangkan pada Bor-2 pada ukuran -2 phi berjumlah antara 6,86 – 61,11%.Kandungan rata-rata butiran pada Bor-1 adalah: kerikil 21,3%, pasir 60,2%, lanau 5% dan lempung 0,4%, sedangkan Bor-2 adalah: kerikil 44,3%, pasir 26,8%, lanau 24,6% dan lempung 0,6%. Hasil ini menunjukkan bahwa pada Bor-1 didominasi oleh pasir dan pada Bor-2 didominasi oleh kerikil. Hasil ini dapat memberi gambaran bahwa pada Bor-2 berarus lebih kuat karena mampu menstranspor butiran kerikil dalam jumlah yang lebih besar dibandingkan dengan Bor-1 yang didominasi oleh pasir. Berdasarkan beberapa kurva hubungan antara besar butir vs frekuensi komulatif pada Bor-1 menunjukkan endapan pantai (beach sand), hanya satu contoh menunjukkan endapan sungai (river sand), yaitu contoh B1 (0 – 3m). Pada Bor-2, secara umum menunjukkan pola yang lebih mendekati endapan pantai (beach sand), hanya satu contoh menunjukkan kombinasi endapan pantai dan endapan sungai (river sand), yaitu contoh B2 (4 – 5 m). Pada contoh ini, butiran berukuran kasar sampai halus diendapkan oleh media pantai dan ukuran halus dengan persentase sekitar 10% merupakan endapan sungai. Contoh endapan sungai adalah pada B2 (4 – 5 m) ini merupakan endapan sisipan karena satu-satu terbentuk dari kombinasi pantai dan sungai dari seluruh contoh pada Bor-2.*

Kata kunci: *pemboran inti, butiran sedimen, media transport, lingkungan pengendapan*

INTRODUCTION

The study area is located at Bali Strait between the Java and Bali Islands, at coordinates between 114°21' - 114°29' E and 08°05' - 08°12' S (Figure 1). At this condition, the location of the survey is a connecting between the Ketapang Port (Banyuwangi, East Java) and Gilimanuk Port (Jembrana, Bali). Administratively, this area belongs to the Banyuwangi District, East Jawa Province and Jembrana District, Bali Province (Figure 1).

The survey area having high waters currents which are capable to remove most coarse bed load sediments.

The result of field mapping of the coastal characteristics indicate sediments around the coastline consist of various particles sizes composed by quartz, minerals of iron sands and organic matterials.

The pattern of sea water movement is high and capable to move the various types of grains sediment, and also accelerate processes of sediment deposition around the coastline and offshore of survey area. In addition, the location of the Ketapang and Gilimanuk Port is located in the central part of the study area and directly affected by sediment depositional processes will affect to shallowing the Ketapang and Gilimanuk Ports. Therefore it is necessary for item analysis to determine the deposition process and sediment movement patterns will be able to know characteristic of precipitation and deposition management around the harbor.

The results of previous study (Usman et al, 2003) shows the problems in the port development because the sedimentation is increasingly active to the north. It is hoped by the survey results can contribute to the connecting development of Bali Strait between Java–Bali Islands. In addition, to support the expansion of the port area, it is necessary to know the characteristics of depositional environment of grains sediment at two locations as a drilling results of previous study, so that would be obtained the geological processes in the location survey.

Geological condition in the study area has not been much written and published, particularly the lithology and stratigraphy in the territorial waters. To get an understanding of the geological conditions of the Bali Strait, it needs to be studied the regional geological conditions in the survey location and the geology of the Ketapang and Gilimanuk Areas. Publications available today is the Geological Map Sheet of Banyuwangi, Java (Sidarto et al, 1993) and the Geological Map Sheet of Bali, Nusa Tenggara (Purbo-Hadiwidjojo et al, 1998) - (Figure 2).

The distribution of lithology unit in the Ketapang area include the Kalibaru Formations (Qpvk), Merapi Volcanic Rock (Qvm), Reef Limestone (Ql) and Alluvium (Qa).

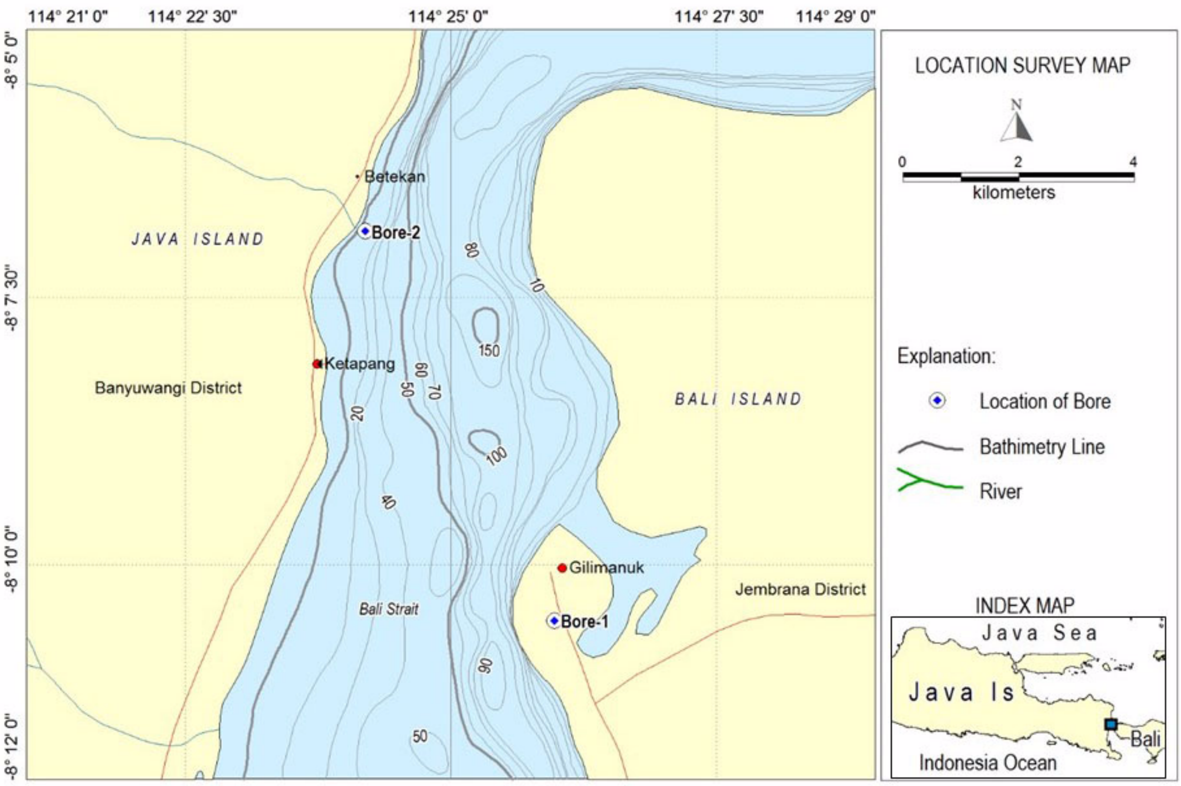

Figure 1. Location of bore holes and Bathimetry

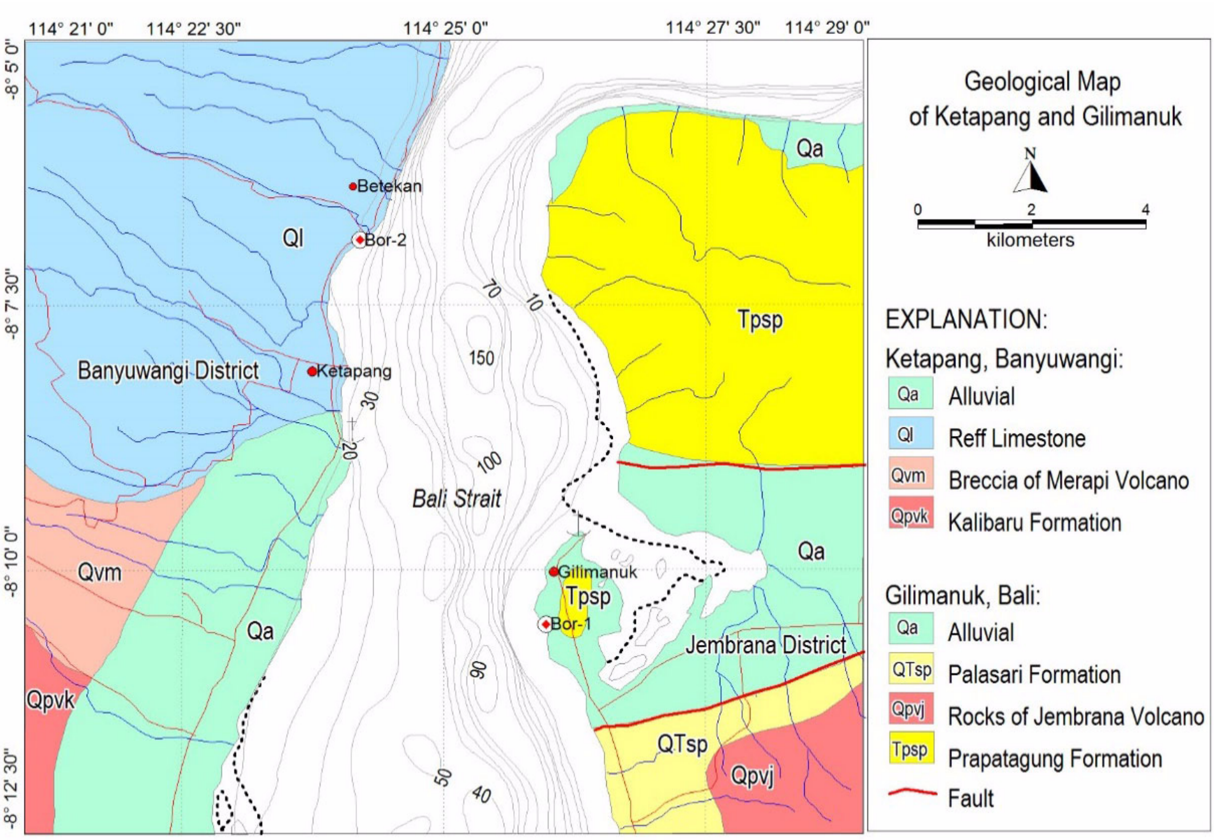

Figure 2. Geological map of study area and it's surroundings (modification from Sidarto et al, 1993 and Purbo-Hadiwidjojo et al, 1998; in Usman, 2007).

Formation Kalibaru (Qpvk) is the oldest formations are composed by lava breccias, conglomerates, tuffaceous sandstone and tuff. Lava breccias and conglomerates with component like brownish gray andesite, basalt, and in some places a gravel-sized dacite fragments found up to 50 cm in diameter, with past bad disaggregated basic tuffs, pack open, less well padded and in some places shows the flow structure.

Tuffaceous sandstone is gray-brown coloured, poorly to well sorted, dust and well layering. Tuff grayish brown, soft and fragile, contain pumices. The Kalibaru Formation covered nearly horizontal (20-40^{o}) that lie in the lowlands area. Rocks and sedimentary structures indicate the deposition in terrestrial environments are very distant from source; as deposition of lava from the volcano of oldest Ijen with Middle Pliocene old.

The rock of Merapi Volcano (Qvm) which interlayering with coral limestone (Ql) is formed in the Holocene age. Merapi Volcano rocks (Qvm) consists of breccia-volcanic, lava, lava and tuff. Brownish gray volcanic breccia, components consist of basalt and pumice, grained gravel to boulders angled responsibility, coarse tuff base period with an open container and solid.

Andesitic-basaltic lava, porphyritic, locally is structured the scoria and phenocrysts of plagioclase, pyroxene and mafic minerals in mass base of volcanic glass. The laharic with component consit of the brownish grey lava andesite - basalt and volcanic rock fragments (sand to boulder) with flow structure. The tuf with greyish brown, smooth and fragile sized contains of pumice sized lapilli to volcanic ash. Rock is sourced from the Merapi Volcano and parasite cones of Rante Volcano is still active at the crater of volcanic crater of Ijen Tua.

The reef limestone reef (Ql) is composed by coral limestone, tuff, and conglomerate. Reef limestone with colour yellow - white, fractions containing of shells of mollusks and corals, hard and hollow also rough surface. Conglomerates are black, white to grey coarse sand to gravel size, sub-rounded with the components are fractions of andesite, basalt, limestone, quartz and shells with mass base of quartz sand. Other lithology is calcareous tuffs are cloudy white to cloudy yellow and medium fine grain. These rocks are Holocene age and based on lithology interlayering with rock from the eruption of Merapi Volcano, is located in the western part of Ketapang. Distribution of rocks are located on the east coast of the north in the bay area of Ketapang to Tanjung Meneng.

Geological conditions of the Gilimanuk (Bali) has not been publicized, is currently only available Geological Map Sheet Bali, Nusa Tenggara (Purbo-Hadiwidjojo et al, 1998) that are regional areas. Based on these maps, Gilimanuk and it's surrounding are composed by Prapatagung Formation (Tpsp), Limestone Jembrana (Qpvj), Formation Palasari (QTsp) and alluvium (Qa).

Prapatagung Formation (Tpsp) is composed by limestone, calcareous sandstone and marl deposited in the Early Pliocene age. Further, limestone of Jembrana (Qpvj) is composed by lava, volcanic breccia and tuff primarily generated by Kelatakan, Merbuk and Patas Mounts (the eastern part of Gilimanuk). Then deposited the Palasari Formation (QTsp) is composed by conglomerate and reef limestone. Palasari Formation is Middle Pleistocene age. Unit alluvium (Qa) is located about Gilimanuk bay to the east, composed by gravel, sand, silt and clay; as lacustrine and beach deposits.

The geological structure of the survey location on the Regional Geology Map of Bali (Purbo-Hadiwidjojo et al, 1998) is a lineament with east – west direction, which has been covered by alluvium sediment. The straightness of a subsurface fault structures formed when the tectonic activity followed by volcanic activity of Merbuk and Banyuwedang Sangiang Mounts in the eastern part of the bay of Gilimanuk. In the late Miocene to early Late Pleistocene age, the tectonic and volcanism activity to produce the Parapatagung formations at the end of Late Pliocene.

Merapi Volcano rocks (Qvm) consists of breccia-volcanic, lava, lava and tuff are source of sediment around the coast. This condition is seen from the condition of coastal sediments are dominated by iron sand and slightly limestone fractions and coral reefs. Iron sand is also expected to come from andesitic-basaltic lava, porphyritic, structured local scoria and phenocrysts of plagioclase, pyroxene and mafic minerals in base mass of volcanic glass.

METHODS

The core drilling are conducted to obtain the data of vertical sediment under the surface of the seabottom. In this drilling depth reaching an average of 20 meters under seabottom. Drilling location that is used to represent the two regions, namely Bor-1 in Gilimanuk (Bali) and Bor-2 in Ketapang (Java). At the time of drilling, the location of Bor-1 in Gilimanuk carried out at the sea with 0.5 meters water depth at the lowest tide, but this time the location of Bore-1 at the coastal land of Gilimanuk is influenced by the high sedimentation process from coastal land.

Result of core profile analysis is taken to the laboratory for analysis the grain size by triangle Folk (1980). Comparison of grain size in the phi to the Wentworth Scale refers to Boggs (2006) which divides the grain size: -2 to -1 phi as coarse gravel (granule), -1 to 0 phi as very coarse sand, 0 - 1 phi as coarse sand, 1-2 phi as medium sand, and 2-3 phi as fine sand, 3-4 phi as very fine sand and more 4 phi as fine sand to clay. To obtain the deposition process and transport medium of sediment are using the depositional model (Friedman and Johnson, 1982; in Usman and Silalahi, 2009) based on the relationship of grain size (phi) and the percentage of frequency cumulative (Visher, 1965; in Usman and Kusnida, 2009).

This methods can determine a regime that movement of sediment grain and the percentage of the cumulative frequency of each quantity of grains. Based on this process can be seen the depositional regimes that form the river sand or beach sand. Furthermore, based on the model according Visher (1969) can determine the movement and distribution patterns of depositional sediment that are grouped in the some model such as rolling and sliding, saltation and suspension.

RESULT AND ANALYSIS

The results of sediment grain size analysis in the laboratory are obtained the composition of grain size ranging from -2 phi as coarse gravel to 4 phi as very fine sand (Table 1). These data become the basic for further calculations, such as naming the texture of the sediment by Folk (1980). Grain size data will also shows the percentage frequency of grain size on bore data as well as the influences that are caused by transport and deposition of sediments.

Result of grain size analysis as a basic in determining the sediment texture. Based on triangle model by Folk (1980) obtained some sediment texture. At the location of Bor-1 in the area of Gilimanuk (Jembrana, Bali) gained 5 units of texture sediments consist of sand (S), sandy gravel (sG), gravelly sand (gS), muddy gravel (mG) and slightly gravelly mud (g)M. At the location of Bor-2 in area of Ketapang (Banyuwangi, East Java) devided into 5 units of texture sediments consist of sandy muddy Gravel (msG), muddy gravel (mG), sandy gravel (sG), gravelly mud (gM) and muddy gravelly sand (gmS) - (Table 2).

Results of the grain size shows that the sediment texture on the bore profile consist of gravel and sand. The content of the average grain at Bore-1 are: gravel 21.3%, sand 60.2%, silt 5% and clay 0.4%, while Bore-2 are gravel 44.3%, sand 26.8%, silt 24.6% and clay 0.6%. This result indicates that the Bore-1 is dominated by sand and in Bore-2 is dominated by gravel. These results can illustrate that in Bore-2 as the influence the srong current because it is able transports the gravel

Table 1. Percentages of grain size of the 16 samples per-thickness from sea-bottom in two core drilling locations in the Bali Strait (Usman et al, 2003).

No	Core Thickness (meter)	Percentages of Grain Size												
		-2 phi	-1.5 phi	-1 phi	-0.5 phi	0 phi	0.5 phi	1 phi	1.5 phi	2 phi	2.5 phi	3 phi	3.5 phi	4 phi
	Bore-1													
1	B1 (0- 3)	0	0	0	0	0	0	1.01	6.90	28.32	34.62	16.00	11.15	0.93
2	B1 (3- 4)	23.13	3.16	3.26	2.94	3.83	5.05	6.31	6.33	7.60	11.64	9.28	11.18	2.17
3	B1 (5- 6)	6.47	2.68	4.37	4.88	6.22	7.46	8.34	8.12	10.61	16.27	10.36	9.21	1.79
4	B1 (9-10)	3.99	5.51	7.82	6.68	7.45	7.65	12.28	13.67	5.13	11.49	10.10	2.25	3.74
5	B1 (10-11)	35.88	1.90	1.99	2.19	2.20	2.22	2.53	3.10	4.06	4.02	2.86	6.00	3.50
6	B1 (17-18)	30.66	8.19	6.47	6.22	5.89	5.19	5.25	5.04	5.54	5.03	2.29	5.46	3.58
7	B1 (19-20)	0	18.00	3.24	3.79	4.65	11.61	7.62	7.06	7.61	5.74	2.78	5.08	2.58
	Bore-2													
8	B2 (0-1,5)	61.11	5.97	4.23	3.99	3.52	3.37	3.88	4.65	10.80	14.03	7.94	13.24	5.83
9	B2 (2-3)	45.36	5.51	4.18	3.30	2.68	2.22	1.66	1.69	2.00	1.31	0.75	2.31	4.63
10	B2 (4-5)	6.86	12.80	18.22	19.62	16.29	8.39	4.87	2.63	2.23	1.59	0.71	1.74	1.23
11	B2 (7-8)	50.99	3.53	3.24	2.66	3.06	2.87	3.21	2.91	3.31	2.45	1.23	3.15	2.29
12	B2 (10-11)	56.55	3.14	3.12	2.24	2.27	2.10	1.75	1.64	2.07	1.68	1.05	2.54	18.34
13	B2 (13-14)	52.92	4.17	3.62	3.19	2.54	2.30	2.04	1.77	2.05	1.70	1.11	2.71	2.07
14	B2 (14-15)	20.07	4.29	4.09	3.67	3.21	3.25	3.01	2.91	3.48	3.72	2.81	7.93	3.38
15	B2 (17-18)	22.63	5.02	3.53	3.75	4.25	5.75	6.15	6.48	7.30	5.53	2.90	4.38	0.30
16	B2 (19-20)	44.01	3.95	3.62	2.73	2.14	1.89	1.74	1.68	2.08	2.04	1.23	2.67	1.25

Table 2. Results of grain size analysis based on triangular model by Folk (1980) to get the sediment texture on profile of Bore-1 and 2 (Usman et al, 2003).

No	Symbol of Samples	X (Phi)	Sort	Skew.	Kurt.	Composition (%)				Classification of Folk (1980)	
						Gravel	Sand	Silt	Clay	Name of Texture	Symbol
	Bore-1 (Gilimanuk, Jembrana)										
1	B1 (0 - 3)	2.2	0.7	0.2	2.5	0	100	0	0	Sand	S
2	B1 (3 - 4)	0.6	2.2	-0.2	1.6	30.8	69.2	0	0	Sandy Gravel	sG
3	B1 (5 - 6)	1.1	1.7	-0.6	2.4	14	86	0	0	Gravelly Sand	gS
4	B1 (9 - 10)	0.8	1.6	-0.2	2.1	17.7	82.3	0	0	Gravelly Sand	gS
5	B1 (10 - 11)	1.4	3.3	0	1.5	36.5	30	33	0.5	Muddy Gravel	mG
6	B1 (17 - 18)	-0.4	2.1	0.5	2	47.8	52.2	0	0	Sandy Gravel	sG
7	B1 (19 - 20)	4.2	1.2	-3.6	16.7	2	5.5	92.4	0.1	Sligthty gravelly Mud	(g)M
	Bore-2 (Ketapang, Banyuwangi)										
8	B2 (0 - 1,5)	0.8	3.1	0.5	2.1	44.3	26.8	24.6	0.6	Muddy Sandy Grvel	msG
9	B2 (2 - 3)	0.8	3.6	0.5	1.7	50.1	20.5	28.2	1.3	Muddy Gravel	mG
10	B2 (4 - 5)	-0.5	1.3	1.1	4.6	39	61	0	0	Sandy Gravel	sG
11	B2 (7 - 8)	0.1	3.1	0.9	2.3	55.2	26	18	0.8	Muddy Sandy Gravel	msG
12	B2 (10 - 11)	0.2	3.3	0.8	2	56.4	19	24.1	0.5	Muddy Gravel	mG
13	B2 (13 - 14)	0.4	3.4	0.6	1.8	54	19.1	25.7	1.2	Muddy Gravel	mG
14	B2 (14 - 15)	2.2	3.3	-0.1	1.7	26.3	34.5	39.1	0.1	Gravelly Mud	gM
15	B2 (17 - 18)	1.6	3.1	0.1	1.6	28.7	17.6	33.6	0.2	Gravelly Muddy Sand	gmS
16	B2 (18 - 19)	1.3	3.5	0.2	1.4	44.6	16.8	28.1	0.5	Muddy Gravel	mG

grains in an amount greater than the Bor-2 which is dominated by sand shows the moderate currents (Krestenitis et al, 2007). The results of megascopic description shows the grains are dominated by black mineral (magnetite, ilmenite and hematite) and little quartz is generally sub-angular to angular with colour greyish white and unconsolidated sediment type.

To get the pattern of sediment movement and media sedimentation in two locations are Gilimanuk (Jembrana, Bali) and Ketapang (Banyuwangi, East Java), the data used is to construct cumulative frequency percentage of grain of sediment (Table 3).

The data of percentage of cumulative grain size can provide a picture of the pattern of depositional frequency and media transport of sediment. To determine the frequency of grain size in each layer as the result of drilling using the data in Table 1. Furthermore, to obtain the pattern of diposition using the data connection between grain size (phi) and the percentage of cumulative frequency of grain size (%) of each samples as in the Table 3.

Furthermore, based on the frequency of sediment grains in each layer of bore profile as Table 1, it is known the patterns of uniformity of grain content of each layer drilling. The uniformity of the frequency content of sample the grains sediment for each depth at each bore can be seen in the relationship between grain size (phi) and frequency details (%) in Bor-1 and-2. At Bor-1, generally, shows a pattern uniformity, represented by the parallel pattern of line curves. On the grain size of -2 phi (coarse gravel) between 6.47 to 35.88% grain, while the sample of Bor-2 on the size of -2 phi between 6.86 to 61.11% grain.

The unconformity is occurs in two samples, namely in the B1 (0-3) and B1 (19-20). In the sample of B1 (0-3) in sample thickness between 0 to 3 meters under the sea floor, especially on grain size between 1.5 to 3 phi as medium to very fine sand with the highest content reached 34.62% grain (Figure 3). Furthermore, in the sample B1 (19-20) in the sample thickness between 19 to 20 meters under sea floor, in the initial conditions on the grain size of -2 phi there is no grain content, the grain size of -1.5 phi as coarse gravel to coarse sand indicates the content of grains reaches 18% then subsequently varies with frequency fluctuations are not too large.

At Bor-2, the uniformity of the frequency content of each samples of sediment grains, can also be seen in the relationship between grain size (phi) and frequency grain size. Generally, it shows the uniformity pattern, just one sample as an unconformity as in the sample of B2 (4-5) at a sample thickness between 4 to 5 meters under the sea floor. The differences of uniformity on the grain size between -2 to 0.5 phi as medium gravel to coarse sand. The peak of uniformity is at -0.5 phi of grain content 19.62% (Figure 4).

The results of the relationship of frequency grains and grain size, generally indicates uniformity so that it

Table 3. Percentage of cumulative grain size of the 16 samples on two core drilling locations in the Bali Strait.

No.	Core Thickness (meter)	Percentages of Grain Size												
		-2 phi	-1.5 phi	-1 phi	-0.5 phi	0 phi	0.5 phi	1 phi	1.5 phi	2 phi	2.5 phi	3 phi	3.5 phi	4 phi
	Bore-1													
1	B1 (0-3)	0	0	0	0	0	0	1.01	7.91	36.23	70.85	86.85	97.99	98.92
2	B1 (3-4)	23.13	26.29	29.55	32.50	36.32	41.37	47.69	54.02	61.62	73.26	82.54	93.71	95.88
3	B1 (5-6)	6.46	9.14	13.51	18.38	24.61	32.07	40.40	48.52	59.13	75.40	85.75	94.96	96.75
4	B1 (9-10)	3.99	9.51	17.32	24.00	31.45	39.10	51.38	65.05	70.18	81.66	91.76	94.01	97.75
5	B1 (10-11)	35.88	37.78	39.77	41.95	44.15	46.37	48.91	52.00	56.06	60.08	62.95	68.95	72.45
6	B1 (17-18)	30.66	38.84	45.31	51.54	57.43	62.62	67.87	72.91	78.45	83.48	85.77	91.23	94.81
7	B1 (19-20)	0.00	18.00	21.24	25.03	29.68	41.29	48.91	55.97	63.58	69.33	72.11	77.19	79.76
	Bore-2													
8	B2 (0-1.5)	42.86	47.05	50.01	52.81	55.28	57.64	60.37	63.63	71.21	81.04	86.62	95.90	99.99
9	B2 (2-3)	45.36	50.87	55.06	58.35	61.03	63.25	64.91	66.60	68.60	69.90	70.65	72.96	77.59
10	B2 (4-5)	6.86	19.66	37.89	57.51	73.80	82.19	87.06	89.69	91.92	93.51	94.23	95.96	97.19
11	B2 (7-8)	50.99	54.51	57.75	60.41	63.47	66.34	69.55	72.46	75.77	78.22	79.45	82.60	84.89
12	B2 (10-11)	56.55	59.68	62.80	65.04	67.32	69.41	71.16	72.80	74.86	76.55	77.60	80.14	98.47
13	B2 (13-14)	52.92	57.08	60.71	63.90	66.44	68.74	70.78	72.55	74.60	76.30	77.41	80.12	82.18
14	B2 (14-15)	20.07	24.35	28.44	32.11	35.32	38.57	41.57	44.48	47.95	51.67	54.48	62.41	65.79
15	B2 (17-18)	22.63	27.65	31.18	34.93	39.18	44.93	51.08	57.56	64.86	70.38	73.28	77.65	77.95
16	B2 (19-20)	44.01	47.96	51.58	54.31	56.46	58.35	60.09	61.76	63.84	65.87	67.09	69.76	71.01

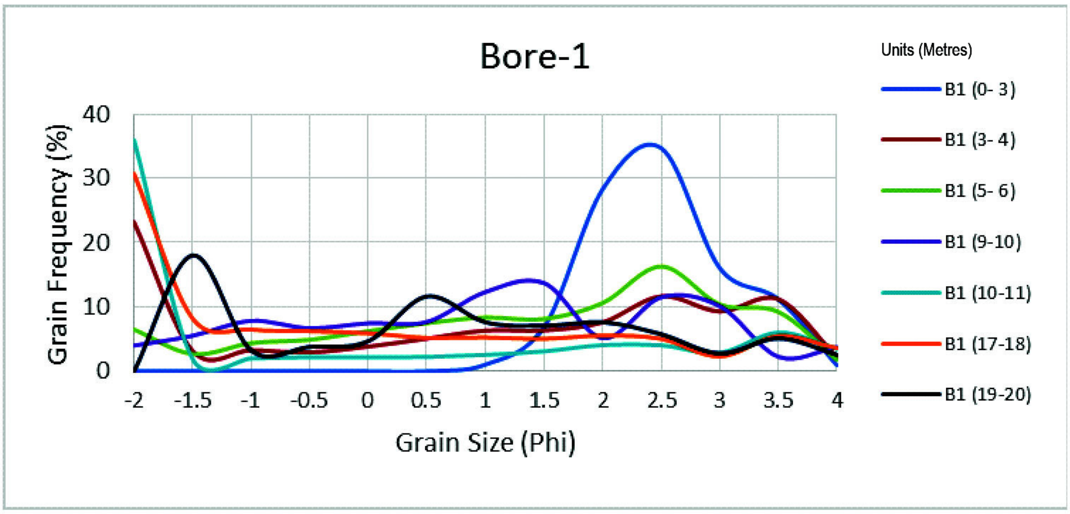

Figure 3. The pattern of uniformity frequency percentage of grains based on the relationship between grain size (phi) and the percentage of grains (%) in the sediment sample of Bor-1.

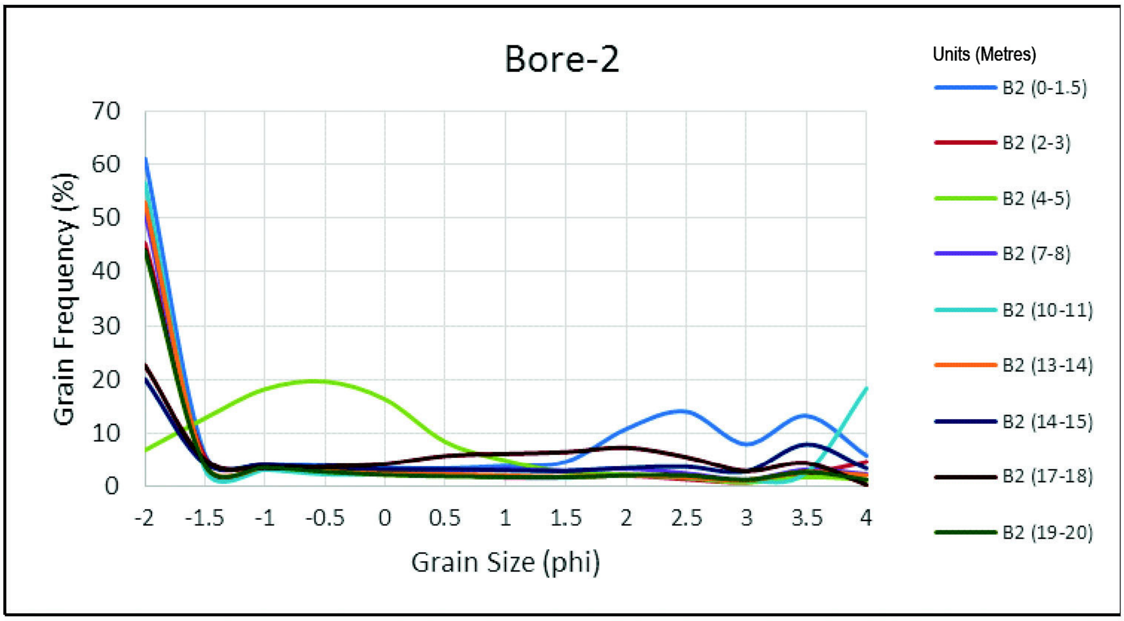

Figure 4. The pattern of uniformity frequency percentage of grains based on the relationship between grain size (phi) and the percentage of grains (%) in the sediment sample of Bor-2.

can give an idea that the supply of sediment to the sea have a uniform for each depth of the sea. Total coarse and fine grain sediments tend to be uniform as shown in the two curves.

Furthermore, to get the cumulative pattern about increase in the cumulative for each of sediment sample can be drawn on the relationship between grain size (phi) for each sample and the cumulative number of grains (%). The cumulative curve depicts the number of grains at the beginning of transport until the end of the depositional process. Generally, the pattern of cumulative frequency Bore-1 and 2, are relatively the same. Only two samples show the difference. This condition is caused by differences in the volume of increase in sediment source and condition of current patterns, so that the supply of sediment is slightly disturbed. In the sample of B1 (0-3), on the grain size up from -2 to 1 phi there are no grains. Sharp differences is seen on the grain size of 1.5 phi with a cumulative value of 7.91%, grain size 2 phi with a cumulative 36.23% and 2.5 phi with a cumulative 70.85%, so that happened the surge on size of 1.5 to 2.5 phi from 7.91 to 70.85% (Figure 5).

The another sample is B2 (4-5m), on the size of -2 to -1 phi, in the beginning of -2 phi size is only 6.86% is the smallest grain among other samples in Bore-2, then the it will be increase slowly and cross the another sample of the curve lines (Figure 6).

The pattern of grain and cumulative frequency of each sample at Bore-1 and 2 can provide a picture of the domination of grains during transportation and deposition time. The pattern of cumulative curves on Bore-1 and 2 are relatively similar, except each has one sample that does not follow the pattern of the curve in general. In the area of ??Gilimanuk (Bore-1) in the sample of B1 (10-11m) shows the dominance of coarse grains, particularly grain size of -2 to -1 phi frequency content of grains reached 35.88%, while in the Ketapang (Bore-2) on sample of B2 (0 - 1.5m) the cumulative frequency content of the grain reached 61.11%. These results illustrate the current patterns that occur on the surface of the sediment layers at Bore-2 stronger then Bore-1 because it can move the sediment grain size of coarse (Clarke, 2011). This can be seen in all the samples analyzed from sea floor up to a total

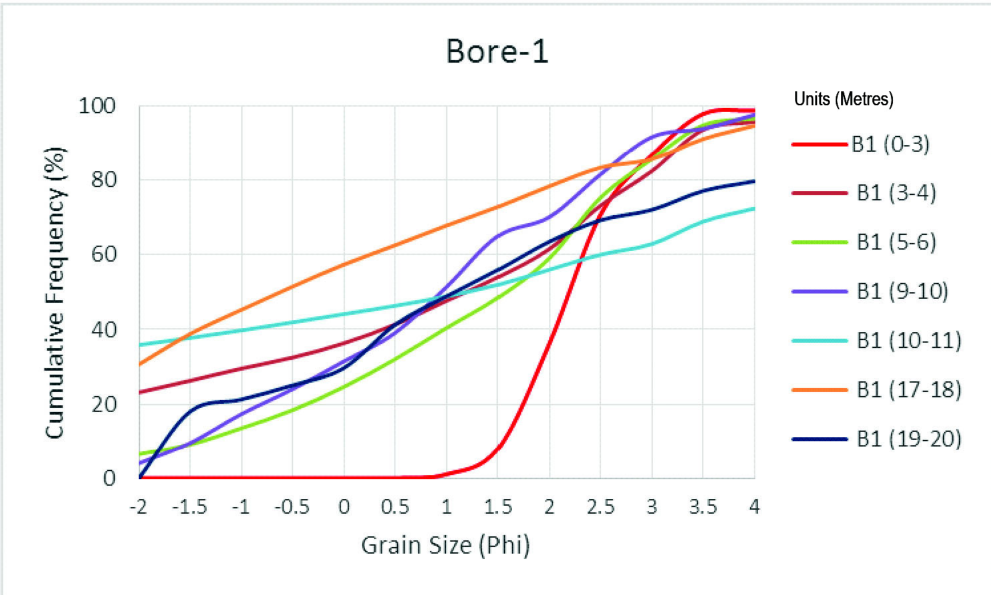

Figure 5. The relationship pattern between grain size (phi) and cumulative frequency (%) in Bore-1.

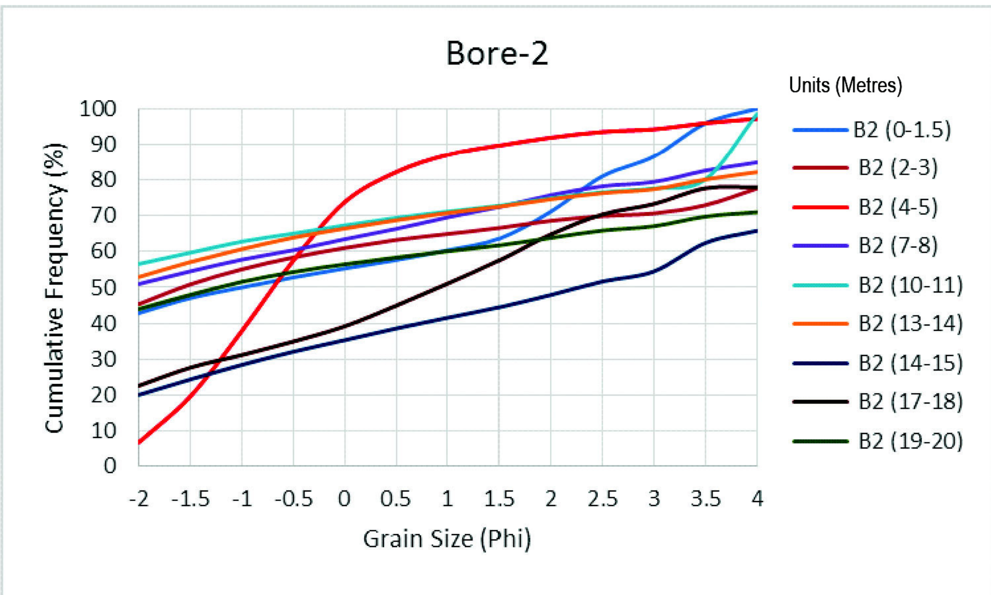

Figure 6. The relationship pattern between grain size (phi) and cumulative frequency (%) in Bore-2.

depth of bore profile (20 meter under sea floor) in Ketapang area shows the pattern of dominance frequency coarse grains, so as to describe the current pattern and grain deposition of sediments in relatively the similar on all samples.

Analysis of grain movement patterns and media deposition refers to the statistical calculation frequency and cumulative percentage of sediment grain size. This calculation refers to the statistical model according to Visher (1965 and 1969) and has been tried in several places to get an overview of the process of sediments deposition by the rivers that forms the river sand pattern and around the coastline that forms a beach sand pattern to the marine sand pattern in the offshore (Usman and Kusnida, 2009; Usman and Silalahi, 2009).

In the survey location, based on a plot of grain size versus frequency cumulative of sediment grain size (Visher, 1969; in Usman and Kusnida, 2009) can be known pattern of sediment movement. The data used describe the pattern of development of vertically, using two bore hole profile (Bore-1 and 2) with a sediment thickness about 20 meters under the sea floor. The results shows the movement patterns at the time of sediment transport and sedimentation. At Bore-1 of seven samples with grain size between -2 to 2 phi as medium gravel to medium sand, early in the process of transport and deposition between 20 to 35.88% grain sediment, then continued to increase until 80% shows the rolling and sliding pattern, while the remaining approximately 20% from fine to very fine sand formed the saltation and suspension pattern (Figure 7). In the sample of B1 (0-3), in contrast to other samples and almost saltation pattern, and only a portion of the suspension.

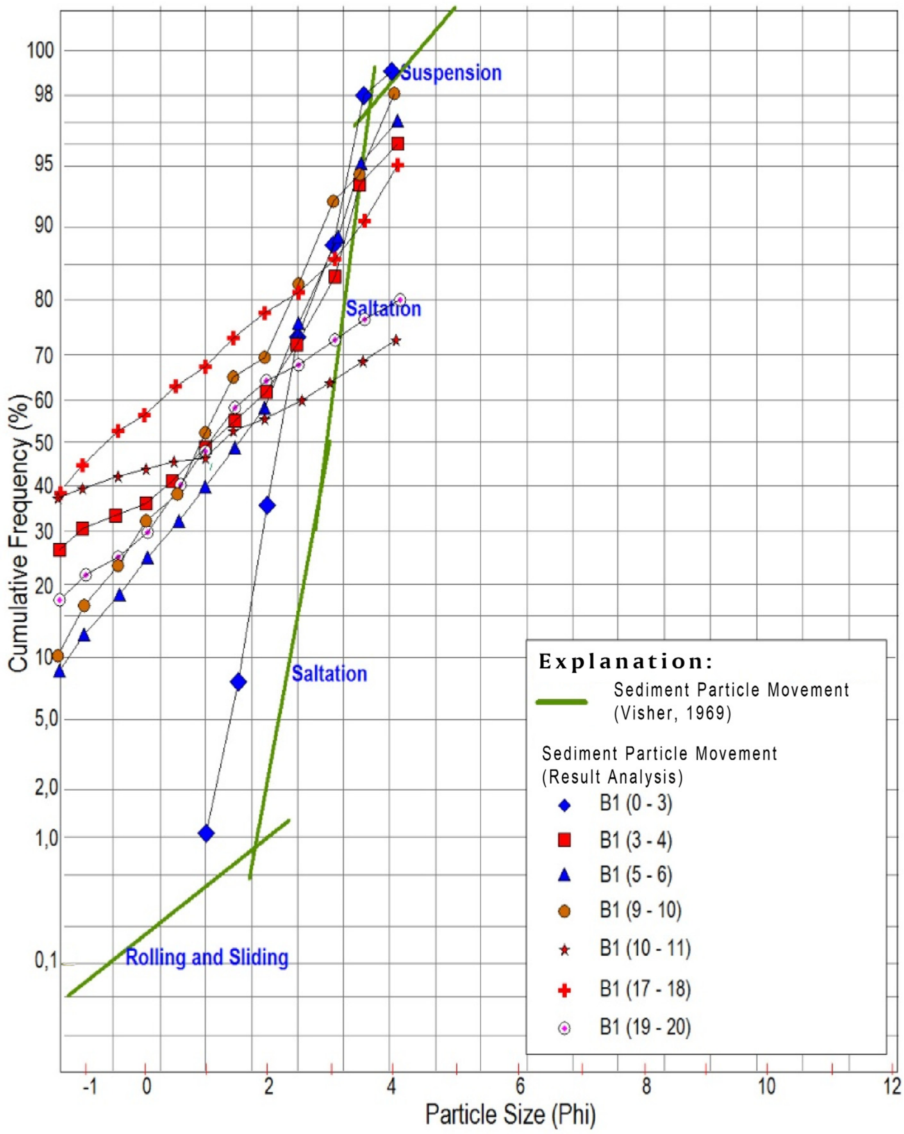

Figure 7. Analysis model of sediment movement on seven samples of Bore-1 (Visher, 1969; in Usman and Silalahi, 2009).

At Bore-2 consist of nine samples with grain size between -2 to 2 phi (medium gravel to fine sand) at the early transportation process is characterized by 20 to 61.11% of coarse grain sediment, then continued to increase until 90% forms the rolling and sliding pattern, while the remaining approximately 10% as fine to very fine to form saltation and suspension patterns (Figure 8).

At the sample of B2 (4-5), early is only 6.86% as very coarse grain, but increasing until 90% from coarse to fine sand shows the rolling and sliding patterns of sediment movement.

Generally, the results of the analysis of the relationship between grain size and frequency cumulative shows the similar of movement patterns are dominated by patterns of rolling and sliding. This pattern generally occurs in sea floor with a coarse grain size and strong energy (Clarke, 2011). These results can describe the condition of the Gilimanuk and Ketapang Port, especially on two bore site, from sea floor sediment to bottom of sample thickness up to 20 meters are formed by sediment with very coarse grained to coarse, and driven by strong currents. This conditions, then the next to determine the media of sediment transport can be determined by using a model of the relationship between grain size and frequency cumulative (Visher, 1965; in Usman and Silalahi, 2009).

At Bore-1, generally shows the domination of pattern as beach sand, only one sample shows the river

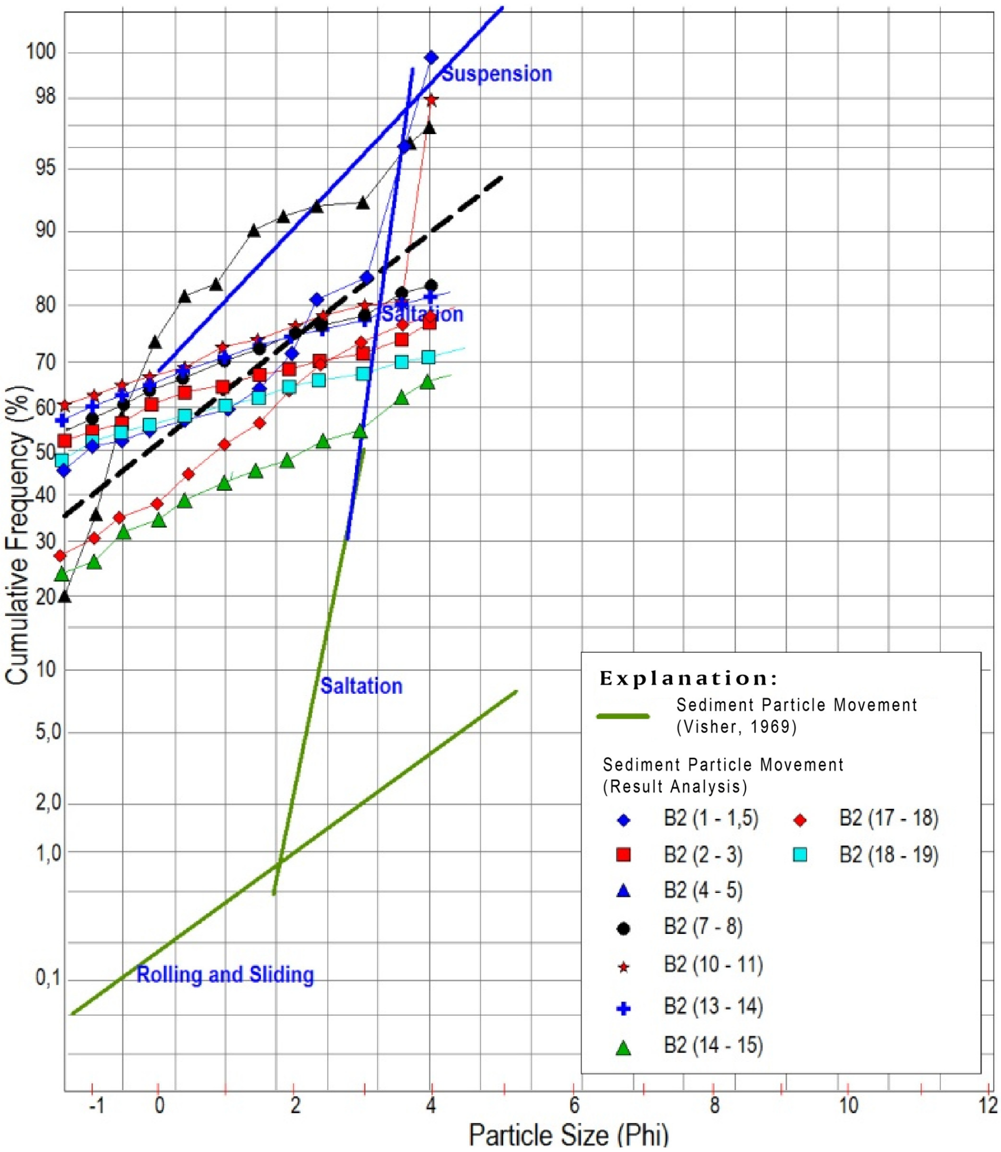

Figure 8. Analysis model of sediment movement on nine samples of Bore-2 (Visher, 1969; in Usman and Silalahi, 2009).

sand, which is a sample of B1 (0-3). This sample is the top of sediment (recent sediment), and sediment thickness from 3 to 20 meters entirely a coastal sediment (Figure 9). At the Bore-2, generally shows the domination of pattern as beach sand, only one sample shows the combination of river sand, which is a sample of B2 (4-5). In this sample, the grains of coarse to fine sand are depotioned by the beach process, and the fine size with a percentage about 10% is the river process. The aamples of river deposits on B2 (4-5) as small layer because only one is formed by combination of beaches and rivers of the whole samples of Bore-2 (Figure 10).

Based on the model, at the Bore-2 almost dominated by coastal sediment, especially the size of very coarse to coarse. The river sediment deposits only on one sample of the sediment thickness between 4 to 5 meters thickness sub-seafloor.

DISCUSSION

Generally, the location of Bore-1 and 2 are characterized by coarse grained sediments (gravel - sand). While, in reality the condition of core sediment profiles are difference. At Bore-1 located at Gilimanuk, the frequency of grain sizes more various compared with Bore-2 which is located at Ketapang. Geologically, the sediment supply in Gilimanuk higher than Ketapang, because location of Bore-1 at coastal land while Bore-2 in the Ketapang as a foot of volcanic

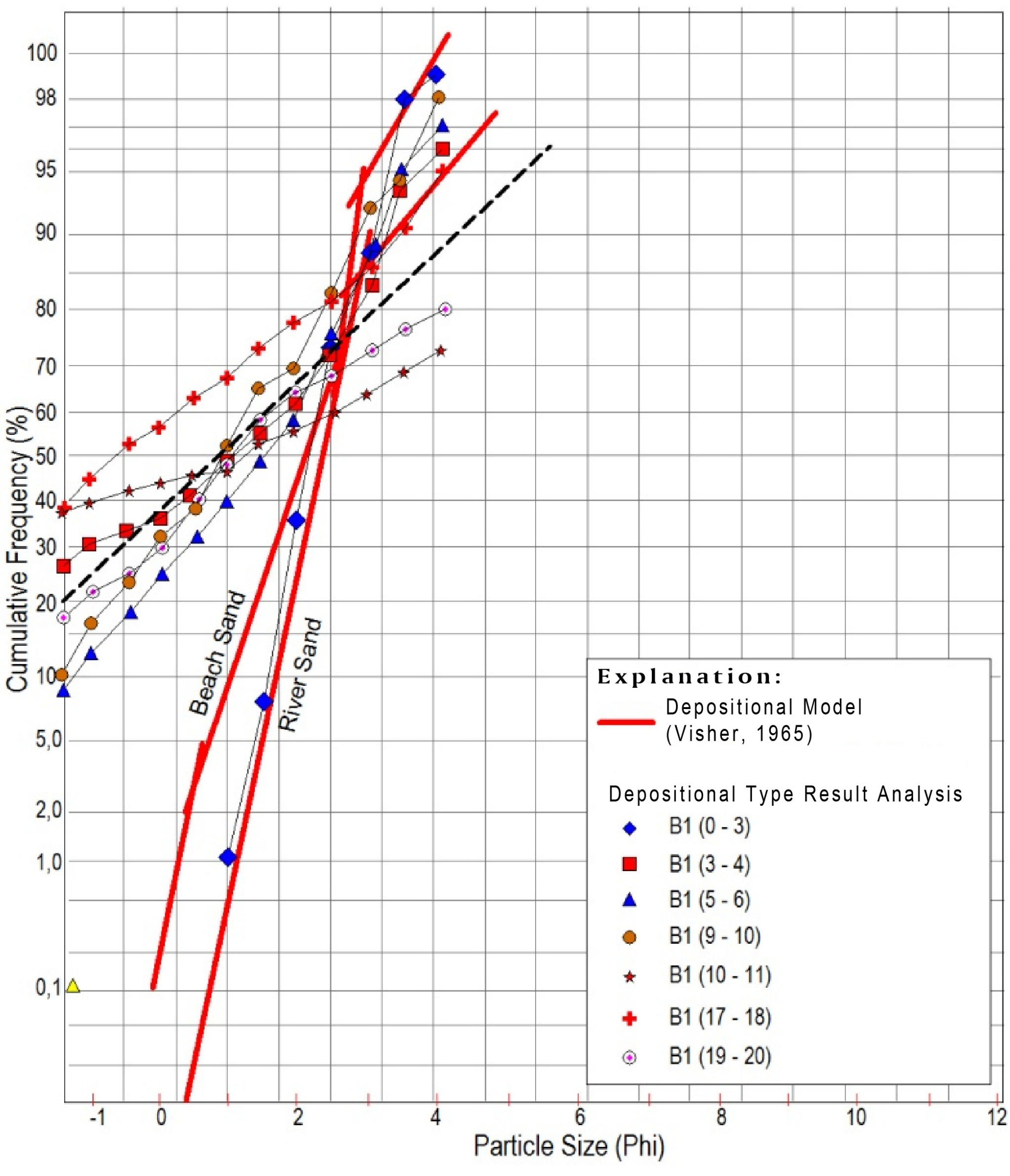

Figure 9. The model of depositional environment of sediment at Bore-1 according to Visher, 1965; in Usman and Silalahi, 2009.

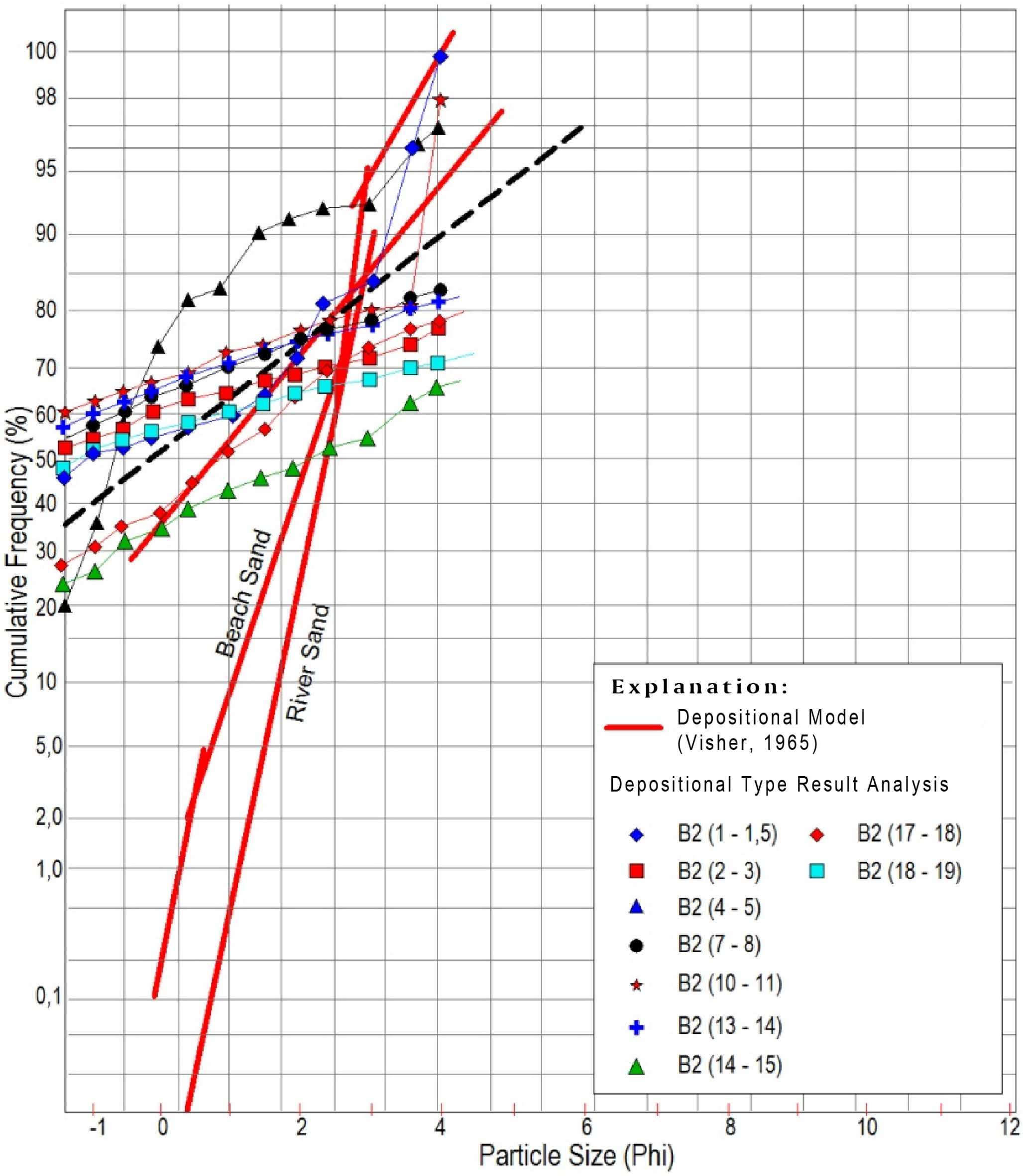

Figure 10. The model of depositional environment of sediment at Bore-2 according Visher, 1965; in Usman and Silalahi, 2009.

mountain. The main grain sediments are derived from volcanic unit which is of iron sand and volcanic igneous rock fragments.

The whole of the data and models on the Bore-2, showing the content of uniformity of the frequency and content of grains larger if compared to Bore -1. This indicates that in Ketapang area are dominated by gravel to sand grained. It shows that the Bore-2 is dominated by very strong currents, being able to transport the sediment in size and larger quantities compared in Gilimanuk area. While in the area with fine size shows the medium to low currents force (Krestenitis et al, 2007). These results will help reconstruct past conditions associated with the deposition process and the relationship with the marine currents (medium - strong) in the survey location.

CONCLUSION

Result of analysis shows that the general grain sediments on bore hole in the Gilimanuk (Bore-1) is dominated by medium grain size and gravel, while in the Ketapang (Bore-2) by gravel to medium sand. Generaly in both areas, the frequency content of grains shows the pattern of uniformity frequency, represented by the similar curve pattern. On the size of -2 phi as gravel medium between 6.47 to 35.88%, while the

Bore-2 on the size of -2 phi between 6.86 to 61.11% grain.

The content of the average grains at Bore-1 are gravel 21.3%, sand 60.2%, silt 5% and clay 0.4%, while Bore-2 are gravel 44.3%, sand 26.8%, silt 24.6% and clay 0.6%. These results indicate that the Bore-1 is dominated by sand and in Bore-2 is dominated by gravel. These results can illustrate that in Bore-2 is moved by the strong of marine current because it can transport the gravel grains more then Bore-1, which is dominated by sand.

Generally, the Bore-1 and Bore-2 show the beach sand environment, and only one sample in Bore-1 showing as the river sand environment, especially at 0-3 m core depth; while at the Bor-2, only one sample shows the combination of beach and the river in the sample of B2 (4-5 m). In this sample, the grains of coarse to fine are deposited by the beach, and the fine to medium grained with a percentage about 10% by river sediment.

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