A COMPARISON OF MAJOR ELEMENTS BETWEEN MARINE SEDIMENTS AND IGNEOUS ROCKS: AS A BASIC DETERMINATION OF THE SEDIMENT SOURCE AT UJUNG PENYUSUK WATERS, NORTH BANGKA, BANGKA BELITUNG PROVINCE

By:

Ediar Usman [1]

(Manuscript received : 15 November 2009)

ABSTRACT

Three igneous rock samples from the coast and five sediments from the marine of Ujung Penyusuk Waters have been used for chemistry analysis as the basic determination of sediment source. The result of chemistry analysis shows that the major element with relatively same pattern. In the igneous rock samples, the result of chemistry analysis shows the SiO_2 ranges between 72.3 - 76.8%, Al_2O_3 (9.64 - 11.64%), and Fe_2O_3 (2.08 - 2.18%). In the marine sediment, the content of SiO_2 is between 62.2 and 66.5%, Al_2O_3 (2.93 - 3.63%) and Fe_2O_3 (21.19 - 24.40%). Other elements such as CaO, MgO, K_2O, Na_2O and TiO_2 are relatively similar values in all samples.

The difference of element content in marine sediment and coastal igneous rock occurs in Al_2O_3 and Fe_2O_3. The Al_2O_3 is small in marine sediment while the Fe_2O_3 is higher compared to igneous rocks. Decreasing of the Al_2O_3 (kaolinite) in the marine sediment is caused by the character of the Al_2O_3 that was derived from quartz rich of igneous rocks forming kaolinite. It was than deposited in the sea floor. Increasing of the Fe_2O_3 in marine sediment is caused by addition reaction of the Fe from the sea.

Generally, the content of the SiO_2 (quartz) in igneous rock and marine sediment belongs to the same group source that is acid igneous rock. The SiO_2 in the sediment belongs to a group of granitoid.

Keywords: major elements, marine sediment, igneous rock, Ujung Penyusuk waters

1. Marine Geological Institute of Indonesia
   Jl. Dr. Junjunan No. 236 Bandung 40174, email: ediar.usman@gmail.com

SARI

Tiga contoh batuan dari pantai dan lima contoh sedimen dari dasar laut di perairan Ujung Penyusuk, Bangka Utara telah digunakan untuk analisis kimia sebagai dasar dalam penentuan sumber sedimen. Hasil analisis kimia menunjukkan kandungan unsur utama dengan pola yang relatif sama. Pada contoh batuan beku, hasil analisis kimia memperlihatkan kandungan SiO_2 antara 72,3 - 76,8%, Al_2O_3 (9,64 – 11,64%) dan Fe_2O_3 (2,08 - 2,18%). Pada sedimen dasar laut memperlihatkan kandungan SiO_2 antara 62,2 – 66,5%, Al_2O_3 (2,93 – 3,63%) dan Fe_2O_3 (21,19 - 24,40%). Unsur lainnya seperti CaO, MgO, K_2O, Na_2O dan TiO_2 yang relatif sama pada seluruh contoh.

Perbedaan kandungan pada sedimen dasar laut dan batuan beku di pantai terjadi pada unsur Al_2O_3 dan Fe_2O_3. Kandungan Al_2O_3 pada sedimen dasar laut lebih kecil dan Fe_2O_3 lebih besar dibandingkan pada batuan beku. Berkurangnya Al_2O_3 (kaolin) pada sedimen dasar laut disebabkan oleh sifat Al_2O_3 yang berasal dari rombakan batuan beku yang kaya kuarsa (SiO_2) membentuk kaolin. Unsur tersebut kemudian diendapkan di dasar laut. Peningkatan Fe_2O_3 pada sedimen dasar laut disebabkan oleh penambahan unsur Fe_2O_3 yang mengikat unsur Fe dari berbagai mineral di laut.

Secara umum, kandungan SiO_2 (kuarsa) dalam batuan beku dan sedimen dasar laut termasuk dalam kelompok yang relatif sama yaitu batuan beku asam. SiO_2 dalam sedimen termasuk kelompok granitoid.

Kata kunci: senyawa utama, sedimen dasar laut, batuan beku, Perairan Ujung Penyusuk.

INTRODUCTION

Study area is located in Ujung Penyusuk waters, North Bangka, Bangka Belitung Province. Geographically, the location is in coordinates between 105°42'40"E-105°46'16"E and 01°23'35"S - 01°28’07"S (Figure 1).

Geologically, the Ujung Penyusuk offshore, is part of SE Asia granite known as a tin belt enriched in tin concentrates (Cobing, 1992). As the tin belt region, the study area could be found valleys and ancient rivers (paleo-channel) as the place of sand accumulation that contains tin concentrates (Ishihara, 1977).

The tin concentrated sediments derived from granite rocks of Late Cenozoic, distributed along coastline and offshore of western Malaysia and Indonesia. It was important rock unit that exposed along the coastline and offshore of Malacca Strait. The tin sediment found in Quaternary sediment that produces the tin concentrate as an important mining commodity in this area (Batchelor, 1983).

The frame of regional geology of Bangka Belitung and the islands belongs to Bangka-Billiton ridge. This region is high bedrock resides in eastern of South Sumatra Basin and Northern of Sunda Basin (Katili, 1980). The high of hills consist of granite belt from Sunda Craton along the coast of Thailand, Malaysia peninsula, Riau Islands, Bangka-Belitung up to West Kalimantan (Batchelor, 1983). This granite bedrock appears along the tin belt of the Bangka Island insert in Main Tin Belt Granite and Belitung Island is belongs to Western Tin Belt Granite Group (Figure 2).

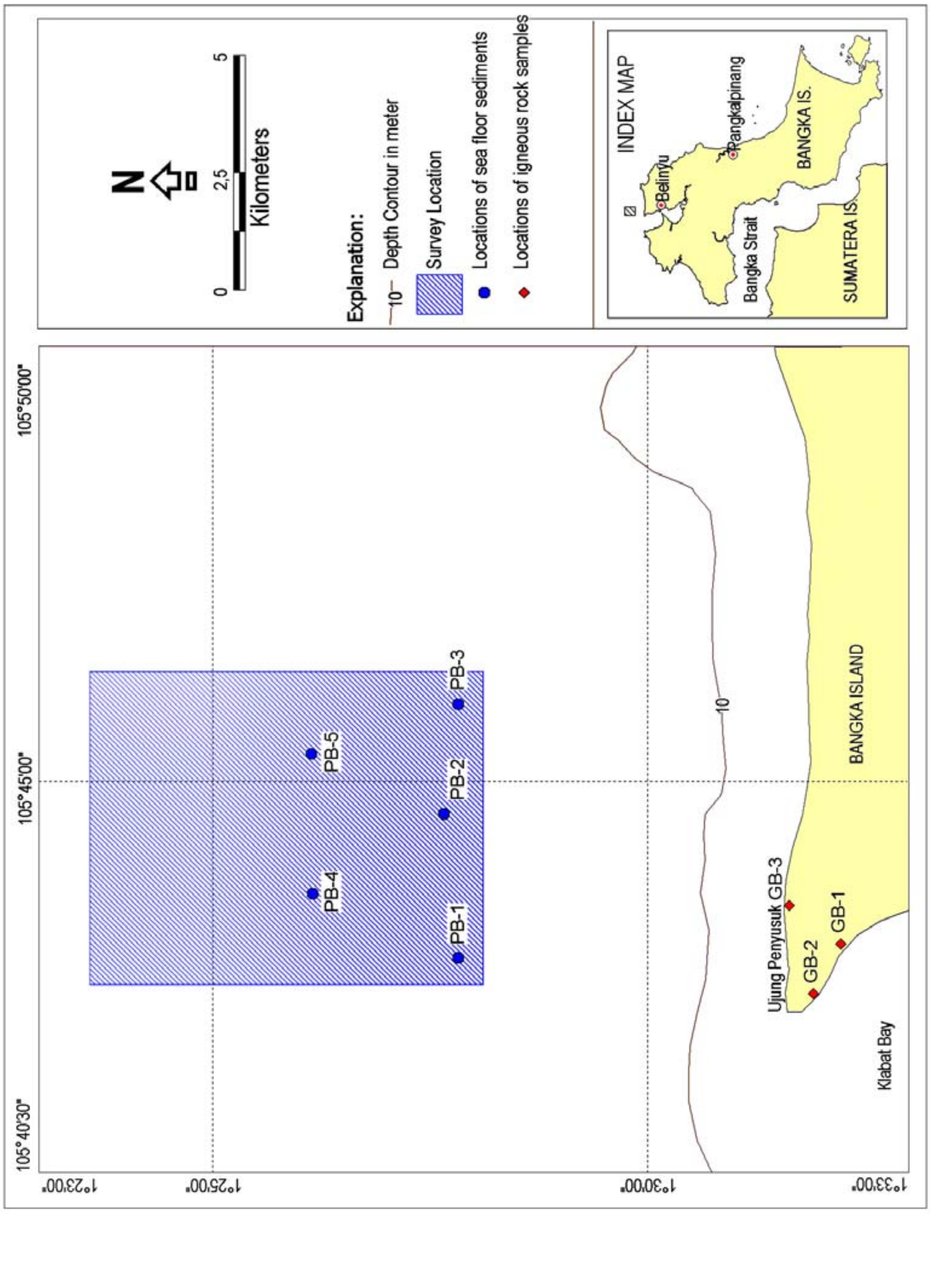

Figure 1. Map of study area

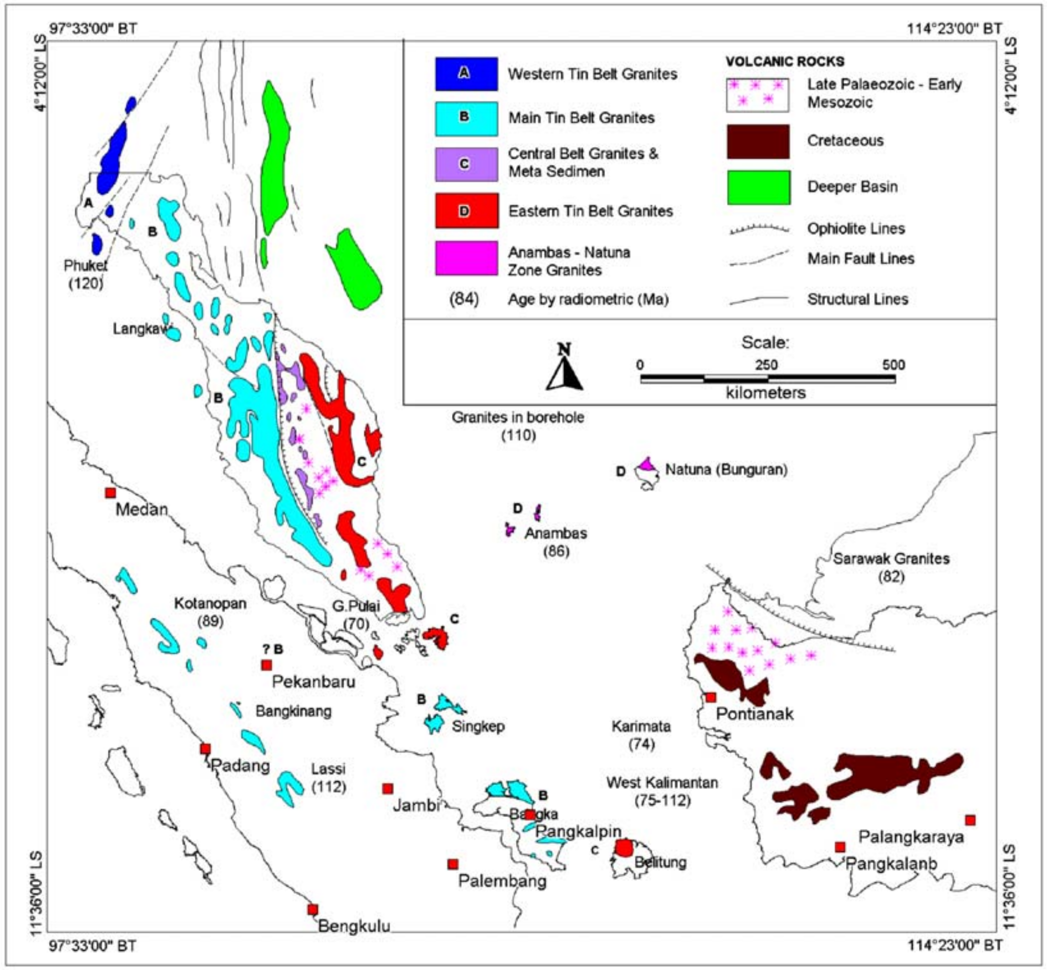

Figure 2. Map of the regional granite belt of SE Asia (Batchelor, 1983).

Based on volcanic development of Sumatra, it shows that the granite in the Belitung is older (Permian to Jurassic), than the granite in Bangka and Sumatra Island (Triassic). This matter, to give an information that erosion process of granite in Belitung region was also developing in advanced. Consequently, the results was alluvial sediment along the coast and sea that has developed intensively compared with Bangka and Sumatra regions.

Physiographically, the study area is located in Sunda Shelf, and according to tectonic stable since Miocene. Based on tectonic setting (Tjia, 1970), Sunda Shelf can be devided into three parts: (1) Part of Northern Sunda, (2) Singapore Shelf, (3) Part of Southern Sunda (Java Sea). Singapore Shelf is the separation between Northern Sunda and part of Southern Sunda.

The basement of this shelf consists of igneous rock (gabro, diabase, andesite and granite) with having Mesozoic to late Carboniferous age. In the Early Miocene was intruded by granite. The Cenozoic sediment in this shelf was only achieved to be around 500 meters in thickness.

The Bangka Island is a part of flat Sunda Shelf, but especially Bangka-Belitung is characterized by hilly region. Geologically, Bangka Island is part of Sunda Land that was up-raised over the sea level. The oldest rock (Permian to Triassic) is represented by quartzite and phyllite, cerisite that is found in SW Bangka. The series of this rock is covered by layers of sandstone and shale, and several chert, conglomerate and volcanic rock, diabase, sometimes fusulinides limestone and lava. The majority of rock layer has dip between 70° and 90°.

In some places, the granite can not be assumed as an intrusion rock, but as a basement of the sediment rock. Therefore, the age of granite at some places are older (Late Triassic). The biggest part of sediment layer in Bangka Island is covered by alluvial and underlain by Pre-Tertiary sediments. The alluvials in physiographical basinal in Bangka and Belitung, are areas of open mining activity of the local peoples. The basinal area is filled by alluvial which consists of swamp and clay deposit, and have swamp vegetations in some places.

The Sibolga Granitoid Complex conforms to the mineralogical and geochemical profile of a typical A-Type granite (Subandrio et. al., 2007). Its emplacement was presumably in the Late Paleozoic. This age presumably post dated the weakening stages of the Sunda Land orogeny and the inception of regionally developed extension in the upper crust, some of which are of sub-alcaline affinity. The net veined intrusion and xenolith swarms of this district could be suggested, that the veining was the result of intrusion granitic magma along cracks propagated during cooling of the host granodioritic or rhyolitic rocks. Marshall and Sparks (1984) believed that pillow-shaped enclave and net veining could be promoted by subsidence of a central crustal block above a zoned magma chamber and thought these features.

The main intrusive body is a megacrystic coarse grained biotite granite containing abundant xenolites of amphibolite, and is crossed cut by medium grained hornblende syenite (Haporas Granitoid Pluton). The geochemical signatures suggest that the granitoid belong to transitional environment between late orogenic and non orogenic as well as within plate environment.

The stratigraphy of Bangka Island are Pemali group, Klabat Granite, Tanjung Genting Formation, Ranggam Formation, Quatenary Sediment (alluvium). The Pemali group (Permo-Carbon) consists of phyllite, schist, quartz and limestone.

The Klabat granite (Late Triassic – Early Jurassics) consists of granite, granodiorit, adamelit, diorite, quartz diorite, and locally consists of apalite and pegmatite dyke. The Tanjung Genting Formation is probably Triassic, and was formed in a shallow sea environment consisting of sandstone, siltstone and limestone layers. The Ranggam Formation (Early Pleistocene) consists of quartz sandstone formed as a consolidated sediment. The Quaternary sediment consists of mud, clay, sand, gravel and boulder as the river, swamp and coastal deposits.

METHODS

Five marine sediments were carried out by using a grab sampler and three granite samples from the coastal area were collected by hand sampling. The geochemical contents on marine sediment and igneous rocks samples are then analyzed in Quaternary Laboratory, Geologycal Research and Development Centre, by using Atomic Absorption Spectrometry (AAS). This analyzed data is then plotted by some models, such as classification of SiO_2 versus Na_2O + K_2O by Cox and Pankhurst (1979). This classification is conducted to get the magma type and the name of igneous rock as well as the source rocks of marine sediments. Other plotted data of Fe_{tot}/MgO vs SiO_2 is to know the granite type (Whalen et al. 1987 and Eby, 1990); and Sumatra granite group (Subandrio et al., 2007) as a source of sediments.

RESULTS

The major element on marine sediments (PB/sample code) and coastal igneous rocks (GB/sample code) in Ujung Penyusuk area shows a similar pattern of element composition, except the element of Fe_2O_3 both in the igneous rock group and marine sediments.

In marine sediment samples, it shows that the content of SiO_2 is between 62.2 and 66.5%, Al_2O_3 (2.93 - 3.63%), and Fe_2O_3 (21.19 - 24.40%) as seen in Table 1. In the igneous rock samples, the content of SiO_2 is between 72.3 – 76.8%, Al_2O_3 (9.64 - 11.64%), and Fe_2O_3 (2.08 - 2.18%) as shown in Table 2. The elements of CaO, MgO, K_2O, Na_2O and TiO_2 are relatively similar in entire samples, as well as in the marine sediments.

The large difference of chemical content between marine sediment and igneous rock samples is the element of Al_2O_3 and Fe_2O_3, while on the element of SiO_2 is still exist same as source rock i.e., between 63 and 76% (Cox and Pankhurst, 1979). In the igneous rock, the content of Al_2O_3 is higher and Fe_2O_3 is smaller than in marine sediments. This condition is seen in Figure 3; where the element of Al_2O_3 is higher in igneous rock and smaller in marine sediments, but the element

Table 1. Percentage of major element composition in marine sediments off North Bangka Island

No	Sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2
1	PB-1	62.2	3.22	24.20	0.76	0.39	2.75	2.2	0.43
2	PB-2	63.9	2.98	24.40	0.59	0.41	2.12	2.12	0.24
3	PB-3	64.5	2.93	23.90	0.68	0.31	2.11	2.13	0.12
4	PB-4	65.2	3.63	21.39	1.61	0.13	2.31	1.91	0.22
5	PB-5	66.5	2.93	21.19	0.78	0.81	2.61	1.41	0.65

Table 2. Percentage of major elements on granite in the coastal area of Ujung Penyusuk

No	Sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2
1	GB-1	76.3	11.64	2.08	0.65	0.21	3.53	2.57	1.69
2	GB-2	76.8	10.85	2.11	0.68	0.26	3.57	2.59	2.12
3	GB-3	72.3	9.64	2.18	3.25	2.34	4.21	3.36	0.74

of Fe_2O_3 increases in the marine sediment and smaller in igneous rock.

The decreasing of Al_2O_3 element in marine sediment is caused by the character of Al_2O_3 as it was weathered mineral to form kaolinite with it's chemical composition is hydrate silicate alluminium (Al_2O_3 $2SiO_2$ $2H_2O$) and other element non-metal (Rahmawati, 2009). Therefore, Al_2O_3 is chemically easy to reduction during decay process and transportation from land to the sea.

The increasing of Fe_2O_3 in marine sediment is caused by the element character of Fe_2O_3 where Fe is from various mineral in the sea, especially metal or mineral oxide, like magnetite, titaniferous magnetite (weathered from magnetite and ilmenite), ilmenite, limonite and hematite (Sutisna, 2006).

Furthermore, to have the description of igneous rock, it is referred to Cox, et al. (1979), determinable based on ploting of chemical element in diagram SiO_2 vs Na_2O + K_2O (Cox, et al., 1979) as seen in Figure 4.

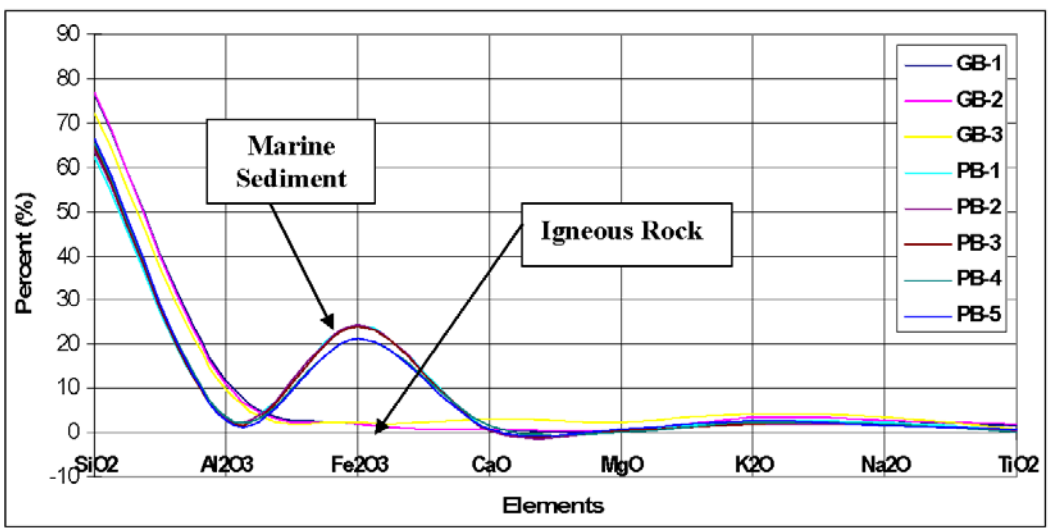

Figure 3. Percentages of the major element content on marine sediment (PB) and coastal igneous rock (GB) in Ujung Penyusuk area.

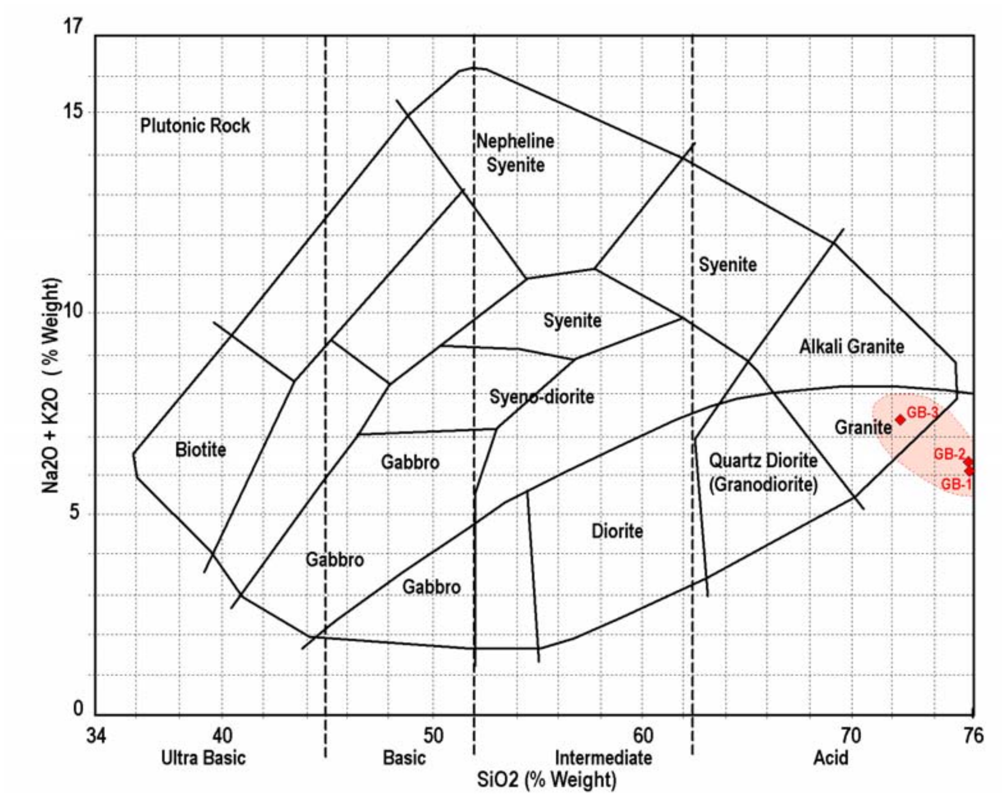

Figure 4. Classification diagram of the SiO_2 vs $Na_2O + K_2O$ from Cox, et al. (1979), that shows the plutonic rock nomenclatures.

In diagram of plot the SiO_2 vs Na_2O + K_2O of igneous rock, the content of SiO_2 is between 72.3 and 76.8%. That is situated in granite group and the sediment of chemical element with having content of SiO_2 is between 62.2 and 66.5% belonging to diorite group and quartz diorite (granodiorite). For rock type of both groups does not shows difference. Therefore, this result can give explanation that marine sediment from granite as a sources in the coast of Ujung Penyusuk. It is difference contents of SiO_2, Al_2O_3 and Fe_2O_3 in marine sediments and igneous rock is not obviated factor as a consequence of weathering and transportation process at the coast and under the sea.

DISCUSSIONS

The complex of Bangka granite and Sibolga granite in West Sumatra have been studied by Subandrio, et al. (2007). Based on plot of the chemical element in diagram of FeO_{tot}/MgO vs SiO_2 region, the second granite samples are found two granite groups: granite group of Sibolga as type granite A (Eby, 1990) and Bangka Granite as I and S types (Whalen, et al., 1987). I and S types of granites, then called as the Bangka Tin Granite, due to rich in tin concentrate (Subandrio, et al., 2007; Subandrio and Usman, 2008). In this study, the analyzed data in igneous rock shows that samples of GB-2 and GB-3 belong to I and S types of granite, and GB-1 sample belongs to A type of granite (Figure 5).

The inclination result of study shows that the granite at coastal of the Ujung Penyusuk as a source of sediment and tin concentrates belongs to I and S Types (Whalen, et al. , 1987) and belongs to Tin Granite Bangka (Subandrio, et al., 2007) like showed by GB-2 and GB-3. The Bangka Granite belongs to SEA granite group as a tin concentrate rich (Cobing, 1992). This condition can assist on tin exploration in North Bangka waters. The area around coast as a source rock of sediment and tin concentrate are high possibility area to get the tin concentrates.

As mentioned above, transportation process from weathering quartz (SiO_2) is kaolinite (Al_2O_3 $2SiO_2$ $2H_2O$) that causes the reduction of Al_2O_3 in marine sediment (Rahmawati, 2009). This reduction as consequence of kaolinite as a light mineral that was transported by current sea waters. Hence, it could not accumulation with other materials in sediments. The transportation of sediment through the sub-marine channels caused the increasing of Fe_2O_3 in marine sediment. The increasing of Fe is derived from granite on land and Fe from other oxides mineral during transportation process. The Fe from other oxides is magnetite, titaniferous magnetite (weathering from magnetite and ilmenite), ilmenite, limonite and hematite (Anonymous, 2010).

Medium transportation of granite weathering in study area can be seen from the

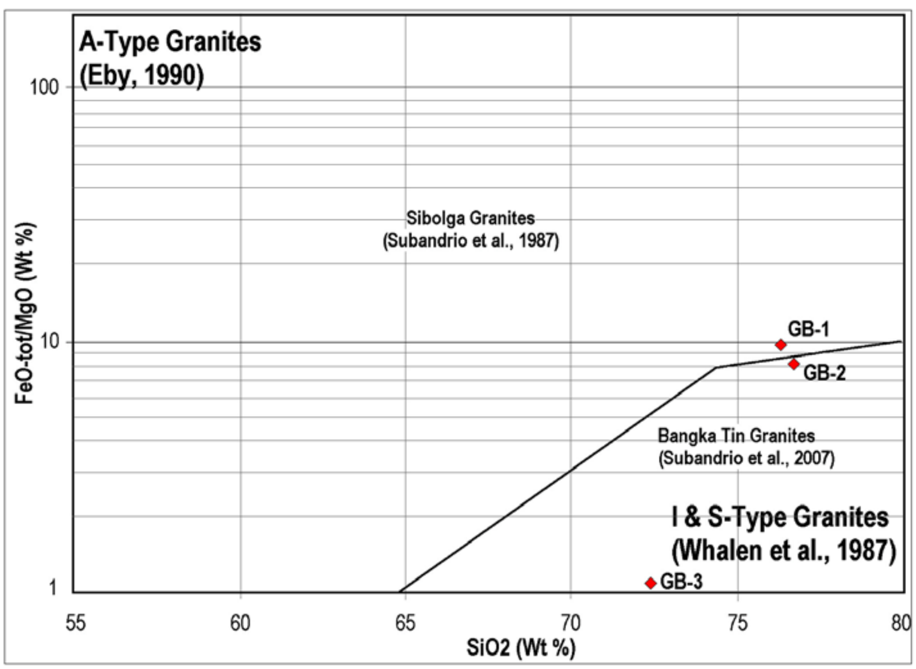

Figure 5. Plot of FeO_{tot}/MgO vs SiO_2 from coastal igneous rock indicates two samples (GB-2 and GB-3) on I and S type Granites (according to Whalen, et al., 1987), and Bangka Tin Granites (according to Subandrio, et al., 2007); and one sample (GB-1) on A Type Granite (according to Eby, 1990) and Sibolga Granite (according to Subandrio, et al., 2007).

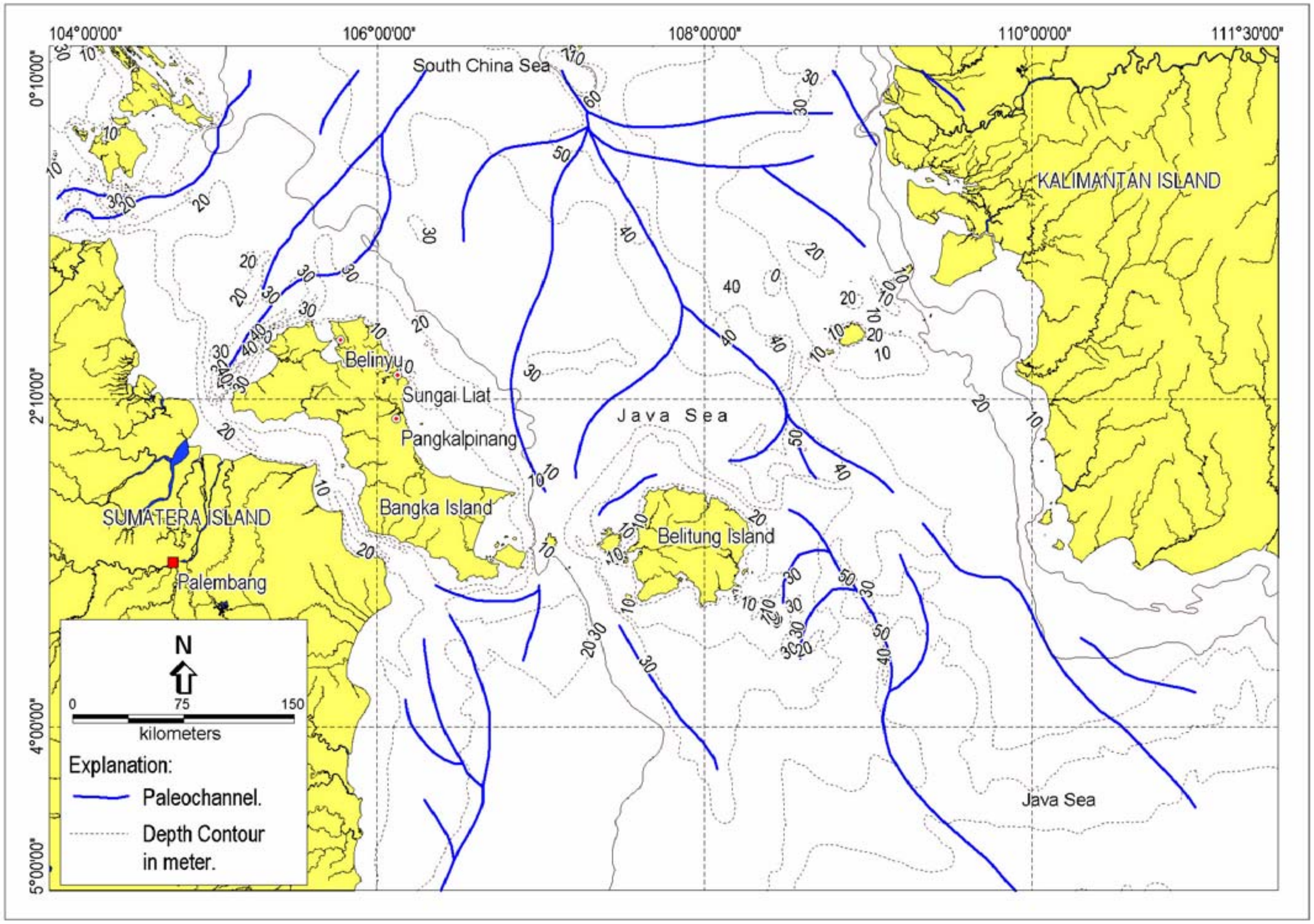

Figure 6. Map of paleochannel distribution in Bangka Waters as the drainage pattern (modified from Emery and Aubrey, 1972).

distribution of rivers (paleo-channel) in the Bangka Waters (Figure 6).

Based on paleo-channel distribution map, it could be predicted some sources and direction of sediment transport at North Bangka waters. The sediment was transported from coast to waters and deposited in paleo-channels, and may be predicted as a progradated process.

CONCLUSIONS

The present study shows that the content of major element of the igneous rock both from the coast and marine sediment of Ujung Penyusuk, North Bangka based on diagram of SiO_2 vs $Na_2O + K_2O$ and FeO_{tot}/MgO vs SiO_2 indicated relativelly in the same group.

The plotting in the diagram of SiO_2 vs $Na_2O + K_2O$ of the major element from igneous rock with content of SiO_2 (72.3-76.8%) classified as granite. The content SiO_2 (62.2-66.5%) in sediment, it is probably derived from diorite group and quartz diorite (granodiorite). While, plotted data on FeO_{tot}/ MgO vs SiO_2 from coastal igneous rock represented by two samples (GB-2 and GB-3) and interpreted as I and S Type Granites. Bangka Tin Granites which is represented by one sample (GB-1) and interpreted as A Type Granite and Sibolga Granites.

Based on diagram above, it can be concluded that the marine sediment off Ujung Penyusuk composed by SiO_2 as a stable element in the granite. It could be assumed that SiO_2 in marine sediments derived from SiO_2 in granite from coast of Ujung Penyusuk.

ACKNOWLEDGEMENTS

The authors would like to thank to Mr. Subaktian Lubis, Head of the Marine Geological Institute. Thanks are due to the survey team members: Andri S. Subandrio, Deny Setiady, Agus Setyanto, Tarsono, Agus Sutarto and Sadjuri Latif for their participation and cooperation in collecting data during the survey.

REFERENCES

Anonymous, 2010. Pasir Besi, in www.tekmira.esdm.go.id/data/pasirbesi/ulasan. Access on July 3th, 2010.

Batchelor, B.C., 1983. *Late Cenozoic Coastal and Offshore Stratigraphy in Western Malaysia and Indonesia*, Thesis Ph.D., Dept. Of Geology, University Malaya, Kuala Lumpur.

Cobing, E.J., 1992. *The Granite of the South-East Asian Tin Belt*, British Geological Survey, London.

Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1979. *The Interpretation of Igneous Rock.* Allen and Uwin, London: 450p.

Eby, G.N., 1990. The A-type Granitoids: A Review of their Occurrence and Chemical Characteristics and Speculations on their Petrogenesis. *Lithos* 26: 115-134.

Emery, K.O. and Aubrey, D.G., 1972. *Sea Levels, Land Levels, and Tide Gauges*. Springer-Verlag Pub.: 237p.

Ishihara, S., 1977. The Magnetit-series and Ilmenite-series Granitic Rocks. *Mining Geol*., 27: 293-305.

Katili, J.A., 1980. *Geotectonics of Indonesia, A Modern View.* Directorate General of Mines, Jakarta: 271p.

Marshall, L.A. and Sparks, R.S.J., 1984. Origin of Some Net Veined Ring Intrusions. *Journal Geol. Soc. London*, 141: 171-182.

Rahmawati, R., 2009. Kaolin dalam Industri, in www.docs/google.com. Access on October 27th, 2009.

Subandrio, A.S.. Gatzweiler, R. and G. Friedrich, G., 2007. Relationship Between Magnetite-Ilmenite Series and Porphyry Copper Tin Metallogenic Province of Sumatera Island with Special Aspects of Sibolga and Bangka Granitoid Complex. *Proceedings of The 36st Annual convention of Geologist, Denpasar.*

Subandrio, A.S. and Usman, E., 2008. Shallow Seismic Imaging for Paleo-Channel Mapping related to Tin Prospecting on Tanjung Penyusuk Offshore, Northern Bangka Island. *Asia Pacific Resources Investment (Ltd)*, Jakarta (Internal Report, unpublished).

Sutisna, D.T., 2006a. Tinjauan Umum Potensi dan Pemanfaatan Cebakan Bijih Besi di Indonesia, *Bulletin Sumber Daya Geologi*, 1(2). Pusat Survei Sumber Daya Geologi, Bandung : 10 – 15.

Sutisna, 2006. http: /www. tekmira. esdm.go.id/data/pasirbesi).

Tjia, H.D., 1970. Quaternary Shorelines of the Sunda Land, South East Asia, *Geol. Mijnbouw*, 49(2) : 35-144.

Whalen, J.B., Currie, K.L., and Champpell, B.W., 1987. A-Type Granites: Chemical Characteristics, Discrimination and Petrogenesis. *Contrib. Mineral. Petrol*. 95 : 407-419.