The Geochemical Characteristic of Major Element of Granitoid of Natuna, Singkep, Bangka and Sibolga

Karakteristik Geokimia Unsur Utama Granitoid Natuna, Singkep, Bangka dan Sibolga

Ediar Usman

Marine Geological Institute of indonesia,

Jl. Dr. Junjunan No. 236, Bandung 40174, Indonesia, Email: ediar.usman@gmail.com

(Received 08 May 2014; in revised form 10 April 2015; accepted 07 May 2015)

ABSTRACT: A study of geochemical characteristic of major elelemnt of granitoid in Western Indonesia Region was carried out at Natuna, Bangka, Singkep and Sibolga. The SiO2 contents of the granites are 71.16 to 73.02 wt%, 71.77 to 75.56wt% and 71.16 to 73.02wt% at Natuna, Bangka, and Singkep respectively, which are classified as acid magma. While in Sibolga the SiO2 content from 60.27 to 71.44wt%, which is classified as intermediate to acid magma. Based on Harker Diagram, the granites from Natuna, Bangka and Singkep as a co-genetic. In other hand the Sibolga Granite show as a scatter pattern.

Granites of Natuna, Bangka and Singkep have the alkaline-total (Na_2O + K_2O) between 6.03 to 8.51 wt% which are classified as granite and alkali granite regime. K_2O content ranges from 3.49 to 5.34 wt% and can be classified as calc-alkaline type. The content of alkaline-total of Sibolga granite between 8.12 to 11.81 wt% and classified as a regime of syenite and granite. The range of K_2O is about 5.36 to 6.94wt%, and assumed derived from high-K magma to ultra-potassic types.

Granites of Natuna, Bangka and Singkep derived from the plutonic rock types and calc-alkaline magma, while Sibolga granite magma derived from K-high to ultra-potassic as a granite of islands arc.

Based on the chemical composition of granite in Western Indonesian Region can be divided into two groups, namely Sibolga granite group is representing the Sumatera Island influenced by tectonic arc system of Sumatera Island. Granites of Bangka and Singkep are representing a granite belt in Western Indonesian Region waters which is influenced by tectonic of back arc.

Keywords: magma, geochemical characteristic, major element and Western Indonesian Region

ABSTRAK: *Kajian karakteristik geokimia dari unsur utama granitoid di Kawasan Barat Indonesia telah dilakukan di daerah Natuna, Bangka, Singkep dan Sibolga. Kandungan SiO_2 granit Natuna antara 71,16 – 73,02%, Bangka antara 71,77 – 75,56%, Singkep antara 72,68 - 76,81% termasuk dalam magma asam. Granit Sibolga memiliki kandungan SiO_2 antara 60,27 - 71,44% termasuk dalam magma menengah - asam. Berdasarkan Diagram Harker, granit Natuna, Bangka dan Singkep mempunyai asal kejadian yang sama (ko-genetik), sedangkan granit Sibolga membentuk pola pencar.*

Granit Natuna, Bangka dan Singkep mengandung total alkalin (K_2O+Na_2O) antara 6,03 - 8,51% termasuk dalam jenis rejim granit dan alkali granit. Berdasarkan kandungan K_2O antara 3,49 - 5,34 %berat, bersifat kalk-alkali. Granit Sibolga mengandung total alkali antara 8,12 - 11,81% termasuk dalam rejim syenit dan granit, dan berdasarkan kandungan K_2O antara 5,36 - 6,94% berasal dari jenis magma K-tinggi sampai ultra-potassik.

Granit Natuna, Bangka dan Singkep berasal dari jenis batuan beku dalam dan magma kalk-alkalin yang berhubungan dengan penunjaman, sedangkan granit Sibolga berasal dari jenis magma K-tinggi - ultra-potassik sebagai granit busur kepulauan.

Berdasarkan komposisi unsur kimia utama, granit di Kawasan Barat Indonesia dapat dibagi dalam dua, yaitu granit Sibolga yang mewakili P. Sumatera, dipengaruhi oleh sistem tektonik busur P. Sumatera. Granit Bangka dan Singkep dapat mewakili suatu jalur granit di perairan Kawasan Barat Indonesia yang dipengaruhi oleh tektonik busur belakang.

Kata kunci: *jenis magma, karakteristik geokimia, unsur utama, dan Kawasan Barat Indonesia*

INTRODUCTION

Survey area is located at some areas, those are: Natuna and Singkep (Riau Islands Province), Bangka (Bangka Belitung Islands Province), and Sibolga (North Sumatera Province). The aim of study is to find out the characteristic and distribution of granite in Western Indonesia (Figure 1).

granite in a variety of places, either as the bedrock of Pre-Tertiary sediments up to Quarternary and intrusion body in the islands, is needs to be studied further, so the real picture and the relationship evolution and tectonic environment in the Western Indonesia Region.

Some of the ridges, the plutonic rocks in the Malacca Strait and Bangka-Belitung Islands, are known

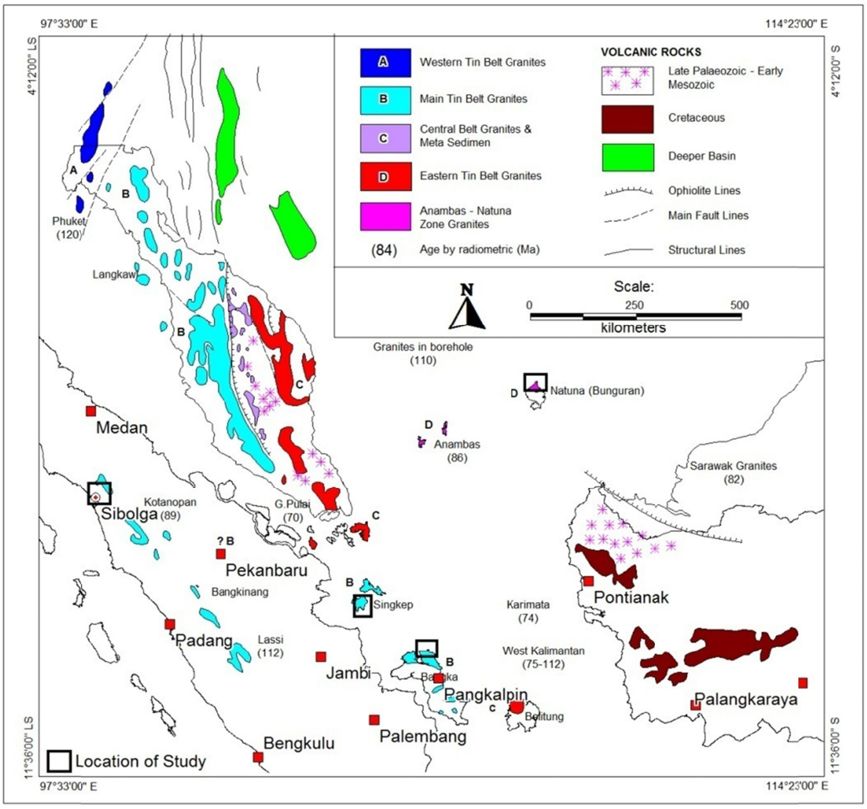

Figure 1. Map of granite samples location at Natuna, Bangka, Singkep, Sibolga, and distribution of Regional granite (Source : Batchelor, 1983).

Whole of these granite has its own characteristics, which was grouped as a granitic belts. According to Batchelor (1983), granite belts in Western Indonesian Region can be divided into five belts, namely: Western Belt Granites, Main Belt Granites, Central Belt Granites and Metasediment, Eastern Belt Granites and Anambas-Natuna Zone Granites (Figure 1).

In addition, the granite rocks in the Western Indonesia Region (WIR) is an interesting geological phenomenon, because it is source of Tertiary to Quaternary Sedimentary Rocks on terrestrial and offshore.

Around the Java and the Natuna Seas, the bedrock is often referred as a granitoid, and according to previous researchers, the granitoid is physically appear in the Bangka Belitung Islands and some results of oil and gas drilling in Java Sea (Hamilton, 1979; Katili, 1980; Darman and Sidi, 2000). Physical appearance of as tin source rocks. In the Java Sea and South China Sea, namely Anambas and Natuna Islands act as bedrock for basins that have been producing oil and gas (Hamilton, 1978 and Katili, 1980). Meanwhile, Darman and Sidi (2000) stated that these granitoids as a bedrock of Tertiary sediments .

Studies on the chemical granite in Natuna, Bangka, Singkep and Sibolga are expected to help in explaining the general description of the type, and magmatic evolution of granite as the bedrock in Western Indonesia Region in connection with the exploration of mineral and energy resources in the future.

Generally, the geological framework of granite Natuna, Bangka, Singkep and Sibolga included in the system granite-East Asia (Batchelor, 1983). Granite is the bedrock in the Western Regions of Indonesia establishing some form of altitude islands and granite intrusions, such as in the waters of the Malacca Strait, Riau Islands. Bangka-Belitung, Anambas, Natuna Islands. Form of intrusion located along Sumatera and West Kalimantan (see Figure 1). This ridge is part of the Tin Granite Belt of Sunda Shelf which extends from the mainland of Thailand, Malaysia Peninsula, Riau Islands, Bangka-Belitung to West Kalimantan (Katili, 1980; Batchelor, 1983).

Based on the position of the Regional spread of granite, granite of Sibolga and Bangka including granite in the western part of the Indonesian system are included in the granite system of Southeast Asia (Main Belt Granites) about 89 million years old (Early Cretaceous). Natuna granite exposed at Mount Ranai (Natuna), and included in the Granite Zone Natuna - Anambas (Natuna - Anambas Granite Zone) , and the dating results by K / Ar is about 71.56 Ma (Late Cretaceous) and in Semiun Island about 100 Ma (Early Cretaceous) - (Hakim and Suryono, 1994). The oldest granites in Indonesia are 180 Ma (Early Jurassic) is older than the granite in the Pacific and mainland Sumatera other Triassic age (Katili, 1980). This condition provides of granite differentiation process in the Western Indonesia Region. According to Ishihara (1977), the S-granites of Bangka-Belitung and Singkep as a source of tin mineral .

Physiographically, study area is located in the waters of the Sunda Shelf which has been tectonically stable since the Early Miocene to form the platform. Coverage of shelf and the ridge began to evolution structurally from the Natuna Sea in the north to the south, and the southern boundary is the Bangka-Billiton Ridge. Bedrock in this shelf area consists of igneous rocks (gabbro, diabase, andesite and granite) about Mesozoic to late Cretaceous age, and Early Miocene is intruded by granite of various types (Ishihara, 1977).

This bedrock morphology to form the shallow marine and covered by thin sediments, characterized by a sharp magnetic anomaly charts and graphs gravity rather smooth (smooth). On this platform, there are two depressed sedimentary basins which have a thickness of more than 800 meters of sediment, namely Bangka Depression that extends to the northwest - southeast (parallel to the coast of Sumatera) and the Pacific Depression trending elongated north - south (parallel to the west coast of Borneo) - (Katili, 1980).

Geologically, the granite Bangka are difference with Sumatera, because the oldest rocks exposed on the Bangka Island is Pemali Complex of metamorphic rocks Permo-Carbon-old. The complex was intruded by diabase Penyabung with Permo - Triassic age. Offshore granite waters around the Malacca Strait, Riau Islands, Bangka-Belitung and Natuna Islands is a continuation of the geological conditions at Thailand and Malaysia (Batchelor, 1983).

Magmatic rock as a bedrock of granite and other igneous rocks, lies on it is Pre-Tertiary sediments, and marine sediments are covered by Tertiary sediments as a hydrocarbon trap. According to Katili (1980), granite and volcanic in Western Indonesian Zone, based on age and tectonic evolution has evolved its own path along the Malaysia Peninsula and Sumatera, towards the northern part of West Kalimantan.

METHODS

Geochemical analysis of Natuna and Bangka-Belitung granites were carried out in the laboratory of Geological Survey Center, Bandung. Geochemical data in Sibolga was obtained from Subandrio and Soeria-Atmadja (1995), while Singkep data was resulted by Marine Geological Institute (Mustafa et al., 2012).

X-Ray Fluorescense Spectrometre Automatic Thermo ARL Advant XP equipment were used to determine major elements concentration and was carried out at the Laboratory of Geological Survey Centre. The results are in percentage weight (%wt) unit of SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5, SO_3 and LOI. Content of FeO_{tot} is calculated based on the number of elements between FeO and Fe_2O_3, where $FeO_{tot} = (FeO + 0.8998\ Fe_2O_3)$ (Rollinson, 1992).

The differentiation of magma and rock based on geochemical data by using the bivariant discriminant Harker's diagrams between various elements (oxides).The SiO_2 with other elements, *either in the form of discriminant two elements or in the form of three elements (triangle diagram).* The next step is to plot the data on the model of Harker diagrams between the SiO_2 vs. other major chemical elements. Another model is the diagram between the SiO2 vs. total alkali ($Na_2O + K_2O$) according to classification of Cox et al. (1979); in Rollinson (1992); and diagrams between elements of SiO_2 vs. K_2O (Peccerillo and Taylor, 1976); Al_2O_3 vs. TiO_2 diagram (Muller et al, 1993; in Muller and Grove, 1997). Diagram model of SiO2 vs. Total Alkali ($Na_2O + K_2O$) to determine the regime of igneous rocks (plutonic rock) based on the total alkali, K_2O vs. SiO_2 diagram models and Al_2O_3 vs. TiO_2 to determine the level of alkalinity rock and its relation to the origin of granitic rocks and tectonic environment for four area studied.

RESULTS

The data used in this study through data collection on rock outcrop in the Bangka and Natuna, plus the results of previous studies in Sibolga by Subandrio et al (2010) and Singkep Island by Mustafa et al (2012) as the Table 1. Subsequently, the analysis of discriminant between elements of SiO_2 vs. total alkali ($Na_2O + K_2O$) to determine the igneous rock regime (plutonic rocks

Table 1. Results of the analysis of the main chemical in granite in Natuna, Bangka, Singkep Island and Sibolga after normalized to 100% without LOI.

No. Sample	% Weight										
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
Natuna Island											
EU.N-1	71.47	0.29	13.19	3.23	2.26	0.04	0.85	1.51	2.59	4.37	0.16
EU.N-2	73.02	0.37	11.70	2.87	2.02	0.09	0.98	1.94	2.39	4.39	0.19
EU.N-3	71.16	0.31	12.80	3.27	2.29	0.03	0.78	1.73	3.08	4.46	0.13
Bangka Island											
GB-1	75.43	1.67	11.51	2.06	2.32	0.05	0.21	0.64	2.54	3.49	0.04
GB-2	75.56	2.09	10.68	2.08	2.39	0.11	0.26	0.67	2.55	3.51	0.05
GB-3	71.77	0.73	9.57	2.16	2.48	0.09	2.32	3.23	3.34	4.18	0.05
Singkep Island											
MC-01	75.56	0.09	13.19	1.47	0.66	0.05	0.17	0.53	3.34	5.07	0.03
MC-02	76.81	0.06	12.63	1.26	0.57	0.12	0.12	0.21	3.11	5.15	0.02
MC-03	72.68	0.12	15.58	1.39	0.63	0.07	0.31	0.40	3.74	4.39	0.04
MC-04	74.79	0.10	13.48	1.69	0.76	0.03	0.21	0.44	3.17	5.34	-
MC-05	74.83	0.11	13.52	1.78	0.80	0.04	0.21	0.36	3.06	5.07	0.03
Sibolga											
BA-18	71.44	0.43	13.55	1.90	2.42	0.10	0.36	1.59	2.76	5.36	0.09
XNBA	66.09	0.53	14.89	2.94	3.06	0.10	0.40	1.83	4.60	5.46	0.10
HBR	60.27	1.16	15.50	4.15	4.49	0.17	0.97	3,14	4.45	5.39	0.31
SI-12	67.35	0.27	18.22	1.20	1.03	0.05	0.14	0.05	4.79	6.85	0.04
SI-12B	66.87	0.15	18.59	1.21	1.06	0.05	0.18	0.04	4.87	6.94	0.04
BA-18	71.44	0.43	13.55	1.90	2.42	0.10	0.36	1.59	2.76	5.36	0.09

type) based on the total alkali elements. Model diagram of the elements of SiO_2 vs. K_2O rocks to determine the level of alkalinity and its relationship to tectonic environment of formation of granite, and TiO_2 vs. Al_2O_3 diagram models to determine the tectonic environment of granite.

Furthermore, based on the chemical data composition can be compiled chemical data to plot on a discriminant between chemical elements of SiO_2 vs. total alkali ($Na_2O + K_2O$) dan SiO_2 vs FeO_{tot}/MgO as in Table 2.

Table 2. Results of calculations for the plots of SiO_2 vs. ($Na_2O + K_2O$) for granite regime types and SiO_2 vs. FeO_{tot} / MgO to determine the type of granite rocks from Natuna, Bangka, Singkep and Sibolga.

No. Sample	% Weight							
	SiO_2	Fe_2O_3	FeO	MgO	FeO_{tot}	K_2O	Na_2O	K_2O+Na_2O
EU.N-1	71.47	3.23	2.26	0.85	5.17	4.37	2.59	6.96
EU.N-2	73.05	2.89	2.02	0.98	4.62	4.39	2.39	6.78
EU.N-3	71.08	3.27	2.29	0.78	5.23	4.46	3.08	7.54
GB-1	75.43	2.06	2.32	0.21	4.17	3.49	2.54	6.03
GB-2	75.56	2.08	2.39	0.26	4.26	3.51	2.55	6.06
GB-3	71.77	2.16	2.48	2.32	4.42	4.18	3.34	7.52
MC-01	75.56	1.47	0.66	0.17	1.98	5.07	3.34	8.41
MC-02	76.81	1.26	0.57	0.12	1.70	5.15	3.11	8.26
MC-03	72.68	1.39	0.63	0.31	1.88	4.39	3.74	8.13
MC-04	74.79	1.69	0.76	0.21	2.28	5.34	3.17	8.51
MC-05	74.83	1.78	0.80	0.21	2.40	5.07	3.06	8.13
BA-18	71.44	1.90	2.42	0.36	4.13	5.36	2.76	8.12
XNBA	66.09	2.94	3.06	0.40	5.71	5.46	4.60	10.06
HBR	60.27	4.15	4.49	0.97	8.22	5.39	4.45	9.84
SI-12	67.35	1.20	1.03	0.14	2.11	6.85	4.79	11.64
SI-12B	66.87	1.21	1.06	0.18	2.15	6.94	4.87	11.81

The results of chemical analysis above shows the content of SiO_2 between 60.27 to 76.81% or in the range of intermediate to acidic magma. The content of SiO_2 at each location shows, the highest SiO_2 contained in the Natuna area between 71.16 to 73.03%, Bangka between 71.77 to 75.56%, Singkep between 72.68 to 76.81% and granite Sibolga between 60.27 to 71.44%.

Results of plot vs. SiO_2 diagram (Na_2O + K_2O) based on the classification of Cox et al (1979); in Rollinson (1992), granite of Natuna, Bangka and Singkep included in the igneous rock types *(plutonic rock)* with granite and alkali granite regime. Granite of Sibolga mostly included in regime syenite and only one sample included in the granite (Figure 2).

Based on the above diagram, the position of Natuna, Bangka and Singkep sample are the alkali granite and granite, while the rock Sibolga mostly located in the middle syenite and syenite acid.

Furthermore, to get the evolution of magma rock and differentiation based on the affinity using the SiO_2 vs other major elements on Harker Diagrams. Generally show a relatively similar patterns which shows a decrease in the content of the major elements in line with the increase in SiO2 (Figure 3).

Based on the diagram, to illustrate that the granites of Natuna, Bangka and Singkep belongs the characteristics and same magma evolution and unidirectional of a pattern formed by co-genetic pattern. The patterns shows the similarity of evolution and development with increase in SiO_2 and decrease of all other major elements, except in the discriminant between SiO_2 vs MnO formed by scatter pattern; meaning that the increase in SiO_2 is not always followed by decrease in MnO element.

Population of samples distribution from granite of Sibolga shows the indications of separation with others granite in all diagrams, are caused by lower SiO_2 content in Sibolga is smaller from SiO_2 in Natuna, Bangka and Singkep. This condition indicates the position or chemically between granites of Natuna, Bangka and Singkep with Sibolga relatively different in evolution.

In the K_2O vs SiO_2 diagram based on classification of Peccerillo and Taylor (1976) to determine the level of alkalinity magma origin and its relation to tectonic environment, showed that the granite from Natuna, Bangka and Singkep included in high alkaline magma types (high-K) - (Figure 4).

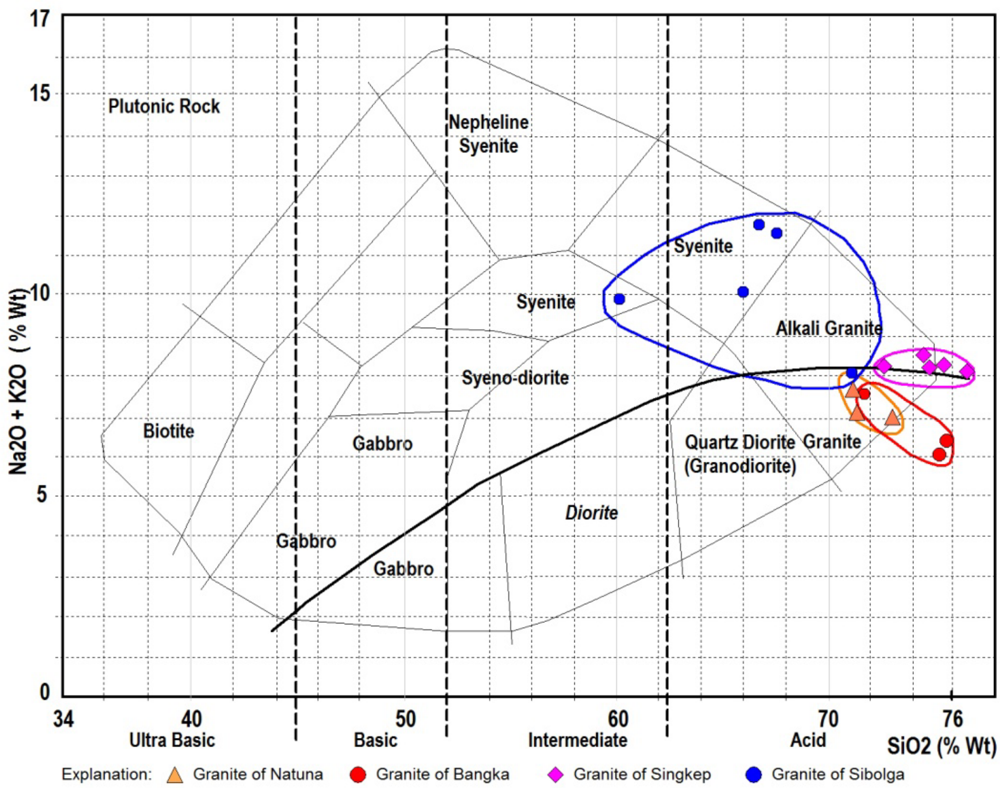

Figure 2. Plot of SiO_2 vs Total Alkali (Na_2O + K_2O) classification according to Cox et al (1979) in Rollinson (1995), to determine the regime of igneous rock based on the total alkali of elements.

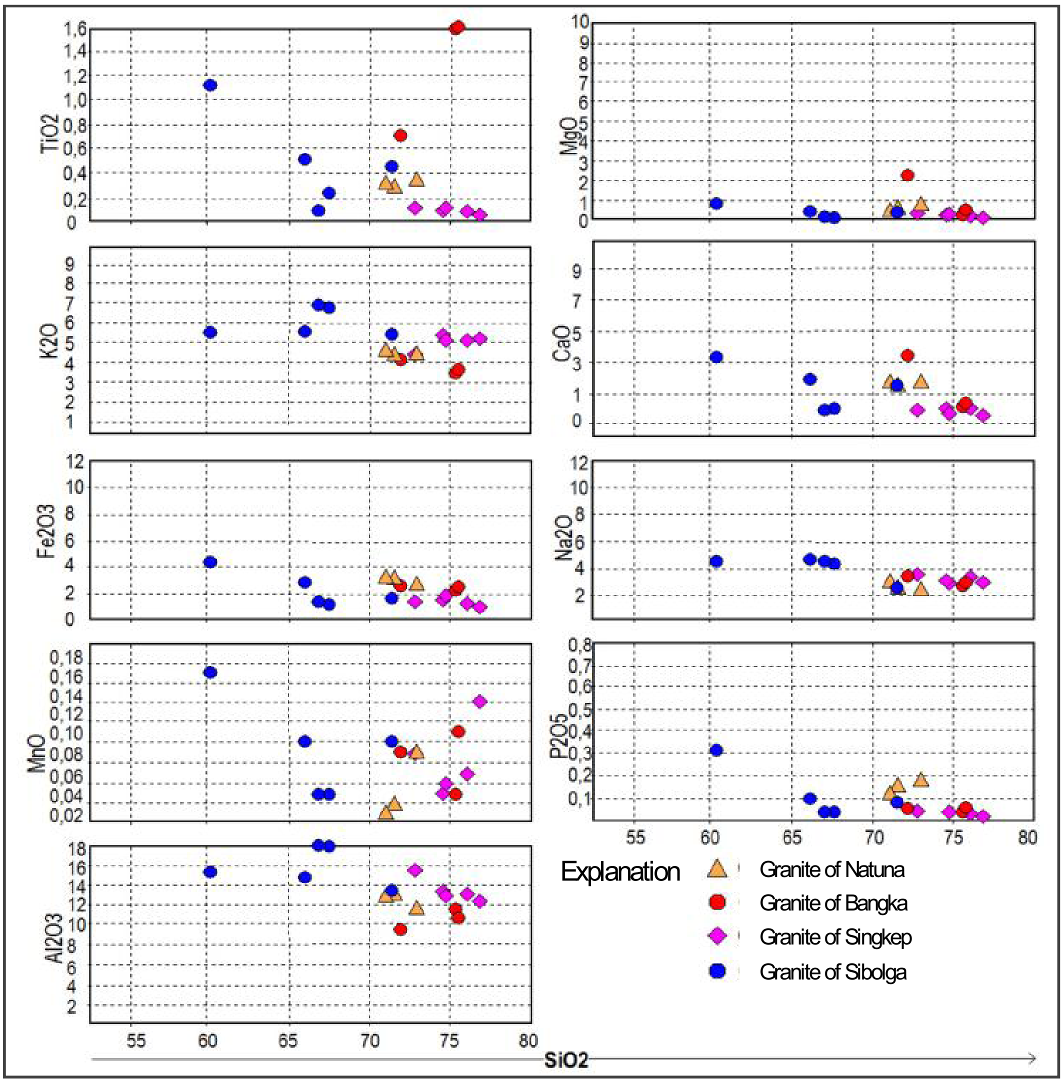

Figure 3. Evolution of magma according to Harker Diagrams between SiO_2 vs other major elements of Natuna, Bangka, Singkep and Sibolga granites.

Third granite above are on the K-high (high alkali) and granite Sibolga included in the K-very high (very alkaline) to ultra-potassic. According to Miyashiro (1974), calc-alkaline magma series (alkaline medium - high) associated with continental arc.

DISCUSSION

The characteristic of geochemical granite from Natuna, Bangka and Singkep, including the granite and alkali granite tipe, while granite from Sibolga, including the syenite type. These results strengthen on the type and spread of granite as the bedrock in the Western Indonesia Region, as the islands in the Malacca Strait, Bangka Belitung, Riau and West Kalimantan as source rocks with continental characteristics type. According to Katili (1980); Batchelor (1983); Hakim and Suryono (1994), the granite in the Western Indonesia Region (180 to 71.56 million years), are the sedimentary source rocks of Tertiary and Quaternary about 5000 meters thickness.

Tertiary sediments containing granules of quartz is known as a reservoir containing the hydrocarbons such as in Central Sumatera, Java Sea and Anambas-Natuna Islands (Darman and Sidi, 2000; PND, 2006). Quaternary sediments around Bangka Belitung Islands is a sediment with content of grains of quartz and tin (Ishihara, 1977; Mustafa and Usman, 2013).

The results of the analysis of the chemical composition and plot the data on the Harker Diagrams, SiO_2 vs total alkali (Na_2O + K_2O) and SiO_2 vs K_2O shows the granite from Natuna, Bangka and Singkep has a unidirectional pattern of evolution, only the MnO vs SiO_2 diagram shows the scatter pattern. The pattern of unidirectional magma evolution are indicated by the

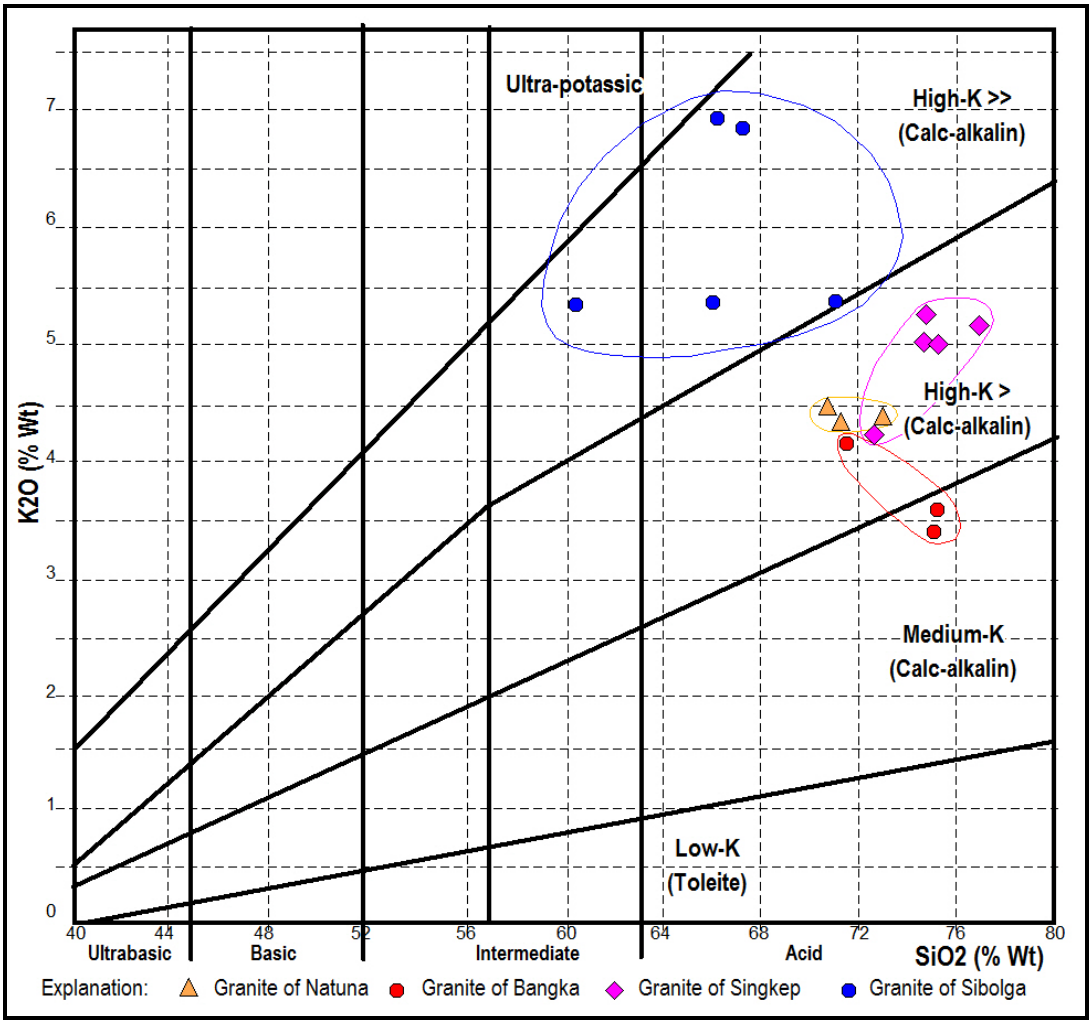

Figure 4. Plot of elements in the K_2O vs SiO_2 diagram according to Peccerillo and Taylor (1976) to determine affinity rocks

increase of SiO2 and decrese of other major chemical elements.

The content of total alkali (Na_2O + K_2O) on granites of Natuna, Bangka and Singkep shows the total alkali content on the three of all granites ranged from 6.06 to 8.51%. The three granites are included in the igneous rock types (plutonic rock) namely regime of granite and alkali granite. The total alkali content on Sibolga granite between 8.12 to 11.81%, including most of the syenite regime and only one sample included in the granite regime. Generally, the total alkali granite of Sibolga is greater than the third others location of granite. This condition is the same with the content of K_2O on the granite of Sibolga with very high-K to ultra-potassic types (see Figure 4). Based on SiO_2 vs K_2O diagram, granite of Natuna, Bangka and Singkep derived from the same magma types are calc-alkaline with K_2O content between 3.49 to 5.36%.

Granite of Sibolga is different with third granite at others location, because coming from high-K magma types to ultra-potassic with content of K_2O between 5.36 to 6.94%. Based on the similarity of the third granites at Natuna, Bangka and Singkep can be concluded that third granites have the same of evolution, igneous rock types (plutonic) and calc-alkaline magma. However, granite of Sibolga different from the third granite above it can be concluded that it has specific characteristics as granite islands.

Based on the distribution of granite by Batchelor (1983), was putting the granites of Bangka, Singkep and Sibolga in one group of Main Belt Granites Zone, and granite of Natuna as Anambas-Natuna Granites Zone. Based on Harker Diagram, the granite of Sibolga is different with the third granite at others location as a separate group are called as Sumatera Arc Granite Belt.

Based on the results of this study, it is chemically, the granite in Western Indonesian Region can be divided into two major groups, namely granite Sibolga that represent the granite type of Sumatera Island. This granite is influenced directly by system of Sumatera Arc Tectonic (see Figure 5). Granites of Natuna, Bangka and Singkep may represent a granite belt in the waters of the Malacca Strait, Riau and Bangka Belitung Islands. This granite is influenced by the back arc tectonic system of Sumatera. However, based on its position and division by Batchelor (1983), the granite of Natuna can be separated and needed the special of chemical study with most sample of granites. According to Batchelor (1983), based on tectonic position, the granites along Sumatera Island, Bangka and Singkep influenced by tectonic of Sumatera Arc and the transition area with Back Arc in Western Indonesian Region, so as became one group, namely the Main Belt Granites.

The results of this study, and based on geochemical and plots in the two charts above provide a new understanding of the distribution of granite in the Western Indonesia Region is not only based on the position and belt, but also the chemical composition.

CONCLUSIONS

The content of SiO_2 in granites of Natuna between 71.16 to 73.02%, Bangka 71.77 to 75.56%, Singkep 72.68 to 76.81% and Sibolga 60.27 to 71.44%. Granites of Natuna, Bangka and Singkep included in the acid magma, whereas granite of Sibolga derived from intermediate - acid magma. Generally, granites of Natuna, Bangka and Singkep have unidirectional evolution pattern, whereas the granite of Sibolga have scatter pattern.

The content of total alkali the granites of Natuna, Bangka and Singkep between 6.06 to 8.51%, including the type of igneous rock in (plutonic rock) with granite and alkali granite regime. The content of total alkali the granite of Sibolga between 8.12 to 11.81% included in syenite and granite regime. The content of K_2O can determine the magma type of Natuna, Bangka and Singkep between 3.49 to 5.36% are calc-alkaline. Granite of Sibolga is different with three granites from the others location above, the K_2O content of between 5.36 to 6.94% derived from high-K magma to ultra-potassic types.

Chemically, granites of Natuna, Bangka and Singkep have the same evolution, igneous rock types and calc-alkaline magma, whereas the granite of Sibolga as a Islands Arc Granite and different from the granites of Natuna, Bangka and Singkep. Based on the chemical conditions, granite Western Indonesian Region (WIR) can be divided into two group, namely granite of Sibolga representing the Sumatera, directly influenced by tectonic system of Sumatera Arc. Granites of Bangka and Singkep represent a granite belt in WIR influenced by the back arc tectonic systems of Sumatera. Based on the current position, granite of Natuna is far to the islands arc and near to Eurasian Continent Arc, so the needed the chemical study separate about the evolution and environment tectonic with others granite in the vicinity of the continental arc .

AKNOWLEDGEMENT

The authors thank to Head of Marine Geological Institute Mr. Susilohadi for his permission and support this paper in the Bulletin of Marine Geological. Also thank to Prof. Dr. Adjat Sudradjat, M.Sc., Prof.. Dr.. Emmy R. Suparka, Prof. Dr. Udi Hartono, Dr. Ildrem Syafri, DEA. and Dr. Dicky Muslims, M.Sc. for discussion.

REFERENCES

[1] 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.

[2] Darman, H. and Sidi, F.H., 2000. *An outline of The Geology of Indonesia.* Indonesian Association of Geologist, Jakarta: 192pp.

[3] Hakim, A.S. and Suryono, N., 1994. *Geological of the Teluk Butun & Ranai Sheet, Sumatera, Scale 1 : 250.000.* Geological Research and Development Centre, Bandung.

[4] Hamilton, W., 1978. *Tectonics Map of the Indonesian Zone.* Prepared on Behalf of The Ministry of Mines, Government of Indonesia and The Agency for International Development US. Department of State. Department of the Interior, United States Geological Survey Pub., Washinton.

[5] Hamilton, W., 1979. *Tectonics of the Indonesian Zone,* United States Geological Surveys Professional Paper 1078. United States Government Printing Office, Washington: 345pp.

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

[7] Katili, J.A., 1980. *Geotectonics of Indonesia, A Modern View.* Directorate General of Mines, Jakarta: 271pp.

[8] Muller, D. and Grove, D.I., 1997. *Potassic Igneous Rocks and Associated Gold-Copper Mineralization.* Second Updated and Enlarged Edition. Springer-Verlag Berlin Heidelberg: 238 pp.

[9] Mustafa, M.A., Kurnio, H., Kamiluddin, U., Harsenanto, C.W., Rachmat, B., Hadi, P.H., Nurdin, N., 2012. Penelitian Keterdapatan

Endapan Plaser Pembawa Timah Perairan Singkep Timur, Provinsi Kepulauan Riau. Pusat Penelitian dan Pengembangan Geologi Kelautan, Laporan Intern, Bandung: 100pp.

[10] Mustafa, A. and Usman, E., 2013. Analisis Perbandingan Geokimia Granit dan Sedimen Dasar Laut di P. Singkep Bagian Timur, Provinsi Kepulauan Riau. *Journal Geologi Kelautan,* 11(3), Pusat Penelitian dan Pengembangan Geologi Kelautan, Bandung: p.131 - 140.

[11] Patra Nusa Data (PND), 2006. *Indonesia Basin Summaries (IBS),* The Gateway to Petroleum Investment in Indonesia, Elnusa Jakarta: 466pp.

[12] Peccerillo, A. and Taylor, S.R., 1976. Geochemistry of Eocene Calc-alkaline Volcanic Rocks from the Kastamonu Area, Northern Turkey. *Contrib. Mineral Petrol* 58: p.63-81.

[13] Subandrio, A.S. and Soeria-Atmadja, R., 1995. Petrography Relationship and Uranium Distribution in the Sibolga Granitoid Complex, North Sumatera. Indonesia. Geosea Eighth Regional Conference on Geology, Mineral and Energy Resources of Southeast Asia. In Koesoemadinata, R.P. and Noeradi, D. (ed)., 2003. *Indonesian Island Arcs: Magmatism, Mineralization and Tectonic Setting*. ITB Press, Bandung: p.194-215.

[14] Rollinson, H., 1995. *Using Geochemical Data: Evaluation, Presentation and Interpretation*. Longman Group Limited, London: 352pp.

[15] Suparka, M.E., Martodjojo, S. and Soeria-Atmadja, R., 1990. Cretaceous-Early Tertiary Magmatic Belt in Java and its Surrounding areas. *Prosiding Persidangan Sains Bumi and Masyarakat,* Universiti Kebangsaan Malaysia, 9-10 Julai 1990, Kuala Lumpur: p.81-91.

[16] Usman, E., 2010. A Comparison of Major Elements Between Marine Sediment and Igneous Rocks: As a Basic Determination of the Sediment Source at Ujung Penyusuk Waters, North Bangka, Bangka-Belitung Islands Province. *Bulletin of The Marine Geology*, 25(1). Marine Geological Institute, Bandung: p.1-12.