

PETROGENESIS OF NATUNA GRANITE AND ITS RELATIONSHIP WITH THE NATUNA TECTONIC ENVIRONMENT OF RIAU PROVINCE

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Abstract

This paper aims to investigate the petrogenesis of Natuna Granite and its relationship with the tectonic environment. The method used in this study is petrographic and geochemical analysis. The results of microscopic observations of 14 rock sections (NRV-1 to NRV-12, NSRV-1 and NSRV-2) showed phaneritic, holocrystalline, and hypidiomorphic textures; composed of k-feldspar phenocrysts, quartz, plagioclase, biotite, with mineral sizes between 1 mm – 4 mm. There are also sericites, carbonates and opaque minerals, in small amounts which are minerals derived from k-feldspar, plagioclase and biotite. Based on potassium content (K₂O) and silica (SiO₂), it shows that the magma that makes up rocks mostly belongs to the group High-K Calc-Alkaline series, with some anomalies included in the group Shoshonitic series and included in the group Calc-Alkaline series. The condition may have been due to the magma differentiation. As the main element, FeO decreases along with the increase in SiO₂, MgO, CaO, Na₂O, K₂O, Al₂O₃, P₂O₅ and TiO₂. Based on content, K₂O, TiO₂, dan P₂O₅ show that rocks in research areas are derived from continental magma. Determination of tectonic environments using trace elements Y and Nb showed that rocks in the research area formed in tectonic environments VAG+syn-COLG (Volcanic Syn Collision Granite). Based on calculations of CIPW, the research area rocks are composed of quartz minerals, plagioclase, orthoclase, corundum, hypersthene, ilmenite, magnetite, apatite and pyrite. Based on the plotting results, it is known that the granite Natuna area belongs to granite type S (peraluminous).

Keywords: Alkaline granite, Granite, Magma continental, Magma tholeiitic, Natuna.

1. Introduction

Bunguran Island is composed of sea sediments from the Jurassic-cretaceous period. Bunguran Formation, which folds strongly and gabbro and serpentinite is remarkably similar to the lake formation in Kalimantan [1]. Bunguran Island comprises Mesozoic granite, sedimentary rocks such as chert, tuff, and metasediment, associated with serpentinite, gabbro, and dolerite rocks. In Bunguran Island, granite occurred as an intrusion rock that formed Mount Ranai. The northern part of Bunguran Island is composed of sandstone which consists of a thick layer of sandstone and a conglomerate covering bunguran sediment. This rock formation is known as Bunguran Formation of the Tertiary age. This formation is younger than Ranai granite [2].

The Bunguran Formation of Bunguran Island intruded by the granite rocks, forming the Gunung Ranai, with an altitude of 1035 masl. In the Natuna Islands, two Tertiary sediment basins contain oil and gas. The basins are the West Natuna Basin and the East Natuna Basin, separated by the north south Natuna Arch. The Raharjapura Formation, which dominates the arrangement of formations on this island and has the lithology of alternating sandstone and repeating limestone, exhibits the new spreading of formation distribution. Another new spreading can be seen in the Eastern Pengadah Formation, which features sandstone aligned with Raharjapura's formation and conglomerate lithology [3].

Globally, it is known that there are three granite provinces found in Southeast Asia that are famous as tin-producing granite belts. This granite province is divided into Eastern, Main Range and Western [4-6]. The Western Province reaches Myanmar from Upper Peninsular Thailand. In the Eastern Province, biotite-hornblende granites of the "I-type" arc, connected with Cu-Au deposits, and subordinate hornblende-barren plutons bearing sparse Sn-W deposits are the dominant geological features. The Late Triassic "S-type" collision-related biotite granites, linked to Sn-W deposits, and subordinate muscovite- and hornblende-bearing granites form the majority of the Main Range Province. Lineaments of serpentinite and deep-marine sediments, collectively regarded as remains of the Paleo-Tethyan suture zone, divide the two granite provinces [5, 7, 8].

Bangka Island is an area in Indonesia that is famous for its granite rocks. Granites found on Bangka Island are geochemically similar to granites found in Malaysia's Main Range [9] However, several studies on granite were undertaken in Southeast Asia, especially in Indonesia, but not many researchers have specifically examined granite on Natuna. Some researchers discuss Natuna granite such as The Natuna Granite is a bedrock for oil and gas-producing basins [10, 11]. In the meantime, these granitoids were described by Darman and Sidi [12] as the Tertiary sediments bedrock. The granite complex found in Natuna, Bangka, Singkep and Sibolga granite systems belongs to the East Asian granite system [13]. The determination of the age of Granit Ranai using K-Ar's staging shows that the granite unit was formed at 71.56 ± 0.32 million years [2]. Natuna granite (Mount Ranai) belongs to the Natuna-Anambas granite zone, and from the determination of the age using K-Ar, the granite of Mount Ranai is 71.56 Ma (Late Cretaceous) [14]. The geochemical characteristic of a major element of granitoid was carried out at Natuna. The SiO_2 contents of the granites are 71.16 to 73.02 wt%, which are classified as acid magma, derived from the plutonic rock types and calc-alkaline magma [13].

Because there have not been many studies that specifically examine Ranai Natuna granite, then the object of the research carried out will (1) classify the characteristics and analyzed the origin of granite rocks in Bunguran Island of Natuna Regency; (2) interpret tectonic activities that are involved in the granite rock formation process; and (3) reconstruct the tectonic model of the Bunguran Island based on new findings from the petrogenesis of granitic rock formation.

2. Research Methods

This research was conducted in three steps, literature study, field observation and laboratory analysis. The first step is a literature review and other research preparations. Library studies are primarily related to previous research around research areas. The instruments were computer, internet, textbook, journal, camera, topographic map, satellite imagery map, printer. The next step is a field survey.

Field survey includes rock mapping, geological structure mapping, rock sampling and geological structure data. Geological mapping was conducted by method of trajectory and tape measuring with the help of GPS. The retrieval of rocks samples is done utilizing grab sampling. The last step is laboratory analysis that includes petrography analysis and geochemical analysis.

3. Result and Discussion

Table 1 shows the summary of petrography analysis results while Tables 2 and 3 shows that of geochemical analysis results.

Table 1. Summary of petrography analysis results.

No.	Sample Code	Composition (%)							Name of Rock
		Kf	Q	Pl	Bio	Cb	Ser	Op	
1	NRV-1	50	25	15	10	5	3	2	Granite
2	NRV-2	55	25	10	10	5	3	2	Granite
3	NRV-3	55	20	15	12	4	3	1	Granite
4	NRV-4	50	20	20	12	3	3	2	Granite
5	NRV-5	50	30	10	10	3	5	2	Granite
6	NRV-6	55	20	15	12	3	3	2	Granite
7	NRV-7	50	25	15	10	5	3	2	Granite
8	NRV-8	50	20	20	12	4	3	1	Granite
9	NRV-9	55	25	10	10	5	3	2	Granite
10	NRV-10	50	25	15	10	5	3	2	Granite
11	NRV-11	50	30	10	10	3	5	2	Granite
12	NRV-12	55	25	10	13	5	2	3	Granite
13	NSRV-1	55	20	15	13	4	3	2	Granite
14	NSRV-2	50	15	25	10	5	3	2	Granodiorite

Kf: K-feldspar, Q: Quartz, Pl: Plagioclase, Bio: Biotite, Cb: Carbonate, Ser: Sericite, Op: Opaque

**Table 2. Summary of the results of
geochemical analysis of major oxide elements.**

	NRV- 1	NRV- 2	NRV- 3	NRV- 4	NRV- 5	NRV- 6	NRV- 7	NRV- 8	NRV- 9	NRV- 10	NRV- 11	NRV- 12	NSRV- 1	NSRV- 2
SiO₂	71,72	71,87	70,26	72,33	68,41	71,17	74,07	70,21	72,11	70,00	70,23	68,58	72,74	67,43
TiO₂	0,26	0,29	0,37	0,29	0,58	0,40	0,16	0,32	0,27	0,23	0,33	0,32	0,27	0,53
Al₂O₃	14,63	14,89	14,68	14,23	15,18	14,41	13,32	15,21	14,29	15,18	14,76	16,75	14,32	15,16
Fe₂O₃	2,57	2,57	3,52	3,09	4,63	3,51	2,47	3,29	2,88	2,69	3,23	3,21	2,36	4,98
MnO	0,04	0,04	0,05	0,05	0,06	0,05	0,04	0,06	0,04	0,04	0,05	0,04	0,04	0,08
MgO	0,72	0,82	1,02	0,77	1,38	1,04	0,72	0,85	0,78	0,72	0,84	1,04	0,64	2,29
CaO	1,46	1,90	1,76	1,64	2,15	1,98	1,09	2,04	1,92	1,55	1,75	3,27	1,37	2,78
Na₂O	2,74	3,01	2,57	2,82	2,58	2,63	2,38	3,04	3,01	3,01	2,95	4,07	3,38	2,81
K₂O	5,28	4,60	4,49	4,48	4,35	3,86	5,02	4,15	3,95	5,44	4,33	2,05	3,71	2,82
P₂O₅	0,140	0,133	0,133	0,137	0,151	0,144	0,083	0,155	0,133	0,169	0,146	0,077	0,110	0,120
S	0,006	0,009	0,013	0,008	0,050	0,022	0,042	0,012	0,010	0,009	0,006	<0,002	0,019	0,033
LOI	0,165	0,174	0,225	0,115	0,424	0,359	0,439	0,23	0,13	0,32	0,409	0,434	0,379	1,238
Total	99,7	100	99,1	100	100	99,6	99,8	99,6	99,5	99,4	99	99,8	99,3	100

Table 3. Summary of the results of geochemical analysis of trace elements.

	NRV- 1	NRV- 2	NRV- 3	NRV- 4	NRV- 5	NRV- 6	NRV- 7	NRV- 8	NRV- 9	NRV- 10	NRV- 11	NRV- 12	NSRV- 1	NSRV- 2
Ce	26,3	30,1	38,5	31,6	47,8	40,4	24,4	40	26,9	27,1	35,7	18	33,6	42,6
Dy	8,7	2,4	3,2	2,6	3	3	1,7	3,7	2,3	2,8	3,1	1	1,9	2,9
Er	3,6	1	1,4	1,1	1,1	1,2	0,7	1,6	1	1,3	1,3	0,4	0,8	1,5
Eu	1,8	0,5	0,7	0,4	0,9	0,5	0,4	0,4	0,4	0,4	0,4	0,5	0,5	0,7
Gd	8,6	2,9	3,8	3,1	4,2	3,8	2,2	4,2	2,6	3	3,5	1,4	2,8	3,5
Ho	1,5	0,4	0,6	0,5	0,5	0,5	0,3	0,7	0,4	0,5	0,5	0,2	0,4	0,6
La	25,2	14,3	19,2	14,8	23,8	19,7	11,5	19,1	12,8	12,8	16,9	8,9	17	21,2
Lu	0,48	0,13	0,16	0,16	0,14	0,14	0,08	0,22	0,15	0,17	0,18	0,07	0,11	0,21
Nd	28	13,7	18,6	15,4	22,4	19	11,6	19,5	12,9	12,8	17,2	8,6	14,3	19,1
Pr	6,19	3,6	4,59	3,7	5,53	4,63	2,96	4,86	3,2	3,26	4,3	2,21	3,72	4,84
Sm	8,1	3,3	4,4	3,5	4,8	4,2	2,7	4,8	3	3,3	4	1,7	3,2	4,1
Tb	1,54	0,43	0,6	0,48	0,58	0,55	0,3	0,64	0,39	0,47	0,58	0,19	0,37	0,53
Tm	0,5	0,1	0,2	0,1	0,1	0,1	<0,1	0,4	0,1	0,2	0,2	<0,1	0,1	0,2
Yb	3,3	0,8	1	0,9	0,9	1,1	0,6	1,4	0,9	1,1	1,2	0,4	0,9	1,4

The main geochemical characteristics of Natuna rocks are alkaline granite rocks and granodiorite rocks. Series of Rock-Forming Magma show that the rock-building magma is rich in alkali, which is quite high with a high enough iron bladder and belongs to magma Tholeiitic. Based on potassium content (K_2O) and silica (SiO_2), it shows that the magma that makes up rocks mostly belongs to the group High-K Calc-Alkaline series, with some anomalies included in the group Shoshonitic series and included in the group Calc-Alkaline series. The condition may have been due to the magma differentiation.

Based on content, K_2O , TiO_2 , and P_2O_5 showed that rocks in research areas were derived from continental magma. Determination of tectonic environments using trace elements Y and Nb showed that rocks in the research area formed in tectonic environments VAG+syn-COLG (Volcanic Syn Collision Granite).

Based on calculations of CIPW, the research area rocks were composed of quartz minerals, plagioclase, orthoclase, corundum, hypersthene, ilmenite, magnetite, apatite and pyrite. Based on the plotting results, it is known that the granite Natuna area belongs to granite type S (peraluminous). The temperature of the magma is expected to range between 793-935°C with a density of 2,72-2,84 gram/cm³.

4. Conclusion

The geochemistry characteristics of Natuna granite rocks include alkaline granite rocks and granodiorite rocks. Series of Rock-Forming Magma show that the rock-building magma is rich in alkali, which is quite high with a high enough iron bladder and belongs to magma Tholeiitic. Based on potassium content (K_2O) and silica (SiO_2), it shows that the magma that makes up rocks mostly belongs to the group High-K Calc-Alkaline series, with some anomalies included in the group Shoshonitic series and included in the group Calc-Alkaline series. The condition may have been due to the magma differentiation. FeO as the main element decreases along with the increase in SiO_2 , MgO, CaO, Na₂O, K_2O , Al_2O_3 , P_2O_5 and TiO_2 oxides.

Based on content, K_2O , TiO_2 , and P_2O_5 show that rocks in research areas are derived from continental magma. Determination of tectonic environments using trace elements Y and Nb, showed that rocks in the research area formed in tectonic environments VAG+syn-COLG (Volcanic Syn Collision Granite).

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References

1. Tanjung, A. (2020). Warisan geologi di ujung utara Indonesia. Retrieved August 12, 2022, from <https://www.metrokepri.com/warisan-geologi-di-ujung-utara-indonesia/>

2. Haile, N.S.; and Bignell, J. (1971). Late cretaceous age based on K/Ar dates of granitic rock from the Tambelan and Bunguran Islands, Sunda Shelf, Indonesia. *Geologie En Mijnbouw*, 50(5), 687-690.
3. Kausarian, H.; Lei, S.; Lai, G.T.; Cui, Y.; and Suryadi, A. (2019). A new geological map of formation distribution on southern part of South China Sea, Natuna Island, Indonesia. *IOP Conference Series: Materials Science and Engineering*, 532(1), 012020.
4. Hutchison, C.S. (1973). Tectonic evolution of Sundaland: A phanerozoic synthesis. *Geological Society of Malaysia*, 6, 61-86.
5. Hutchison, C.S.; and Tan, D.N.K. (2009). *Geology of peninsular Malaysia*. The University of Malaya.
6. Schwartz, M.O.; Rajah, S.S.; Askury, A.K.; Putthapiban, P.; and Djaswadi, S. (1995). The southeast Asian tin belt. *Earth-Science Reviews*, 38(2-4), 95-293.
7. Hutchison, C.S. (1977). Granite emplacement and tectonic subdivision of Peninsular Malaysia. *Geological Society of Malaysia*, 9(1997), 187-207.
8. Cobbing, E.J.; Mallick, D.I.J.; Pitfield, P.E.J.; and Teoh, L.H. (1986). *The granites of the Southeast Asian Tin Belt*. *Journal of the Geological Society*, 143(3), 537-550.
9. Ng, S.W.P.; Whitehouse, M.J.; Roselee, M.H.; Teschner, C.; Murtadha, S.; Oliver, G.J.; and Chang, S.C. (2017). Late triassic granites from Bangka, Indonesia: A continuation of the main range granite province of the South-East Asian tin belt. *Journal of Asian Earth Sciences*, 138, 548-561.
10. Hamilton, W.B. (1979). *Tectonics of the Indonesian region (Vol. 1078)*. US Government Printing Office.
11. Katili, J.A. (1975). Volcanism and plate tectonics in the Indonesian island arcs. *Tectonophysics*, 26(3-4), 165-188.
12. Darman, H. and Sidi, F.H. (2000). *An outline of the geology of Indonesia*. Lereng Nusantara.
13. Usman, E. (2016). The geochemical characteristic of major element of granitoid of Natuna, Singkep, Bangka and Sibolga. *Bulletin of the Marine Geology*, 30(1), 45-53.
14. Hakim, A.S.; and Suryono, N. (1994). Peta geologi lembar teluk butun dan ranai, Sumatera. *Bandung: Pusat Penelitian dan Pengembangan Geologi*.