PETROGENESIS OF ANDESITE IN BUKITCULA, BALEENDAH DISTRICT, SOUTHERN BANDUNG, WEST JAVA

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ABSTRACT

Administratively, Bukitcula Lava located in the area of Baleendah, Southern Bandung, West Java . Geographically located at Longitude 107°36'00" to 107°39'00" and Latitude 7°00'00" to 7°02'42". Baleendah Lava Complex consisted of steeply hill composed by andesite. Petrology, petrography and geochemical studies (XRF analysis) were used to understand the detail of rock characteristics. Petrological analysis studies shows mineral abundances of feldspar, amphiboles, pyroxenes and opaque mineral. Petrographical analysis show abundances of plagioclase, pyroxene, hornblende, and groundmass composed by plagioclase microlites, volcanic glass, and opaque mineral. Texture found in petrography analysis shows glomeroporphyritic, sieve, pyroxene penetration twin, zoning, and trachytic. Based on geochemical analysis, Bukitcula Lava composed by basaltic andesite and andesite according to TAS diagram. The magmatic series of rocks is Calc-Alkali and Tholeiitic series, with High-K and Medium-K (Calc-Alkaline Series) magma group. Magma interract with continental crust, with tectonical setting related on Island Arc Calc-Alkaline Basalt, and origin of magma ranged ranged from ± 139 km - ± 148 km in the Benioff zone. We conclude that the forming of Baleendah Lava Complex was influenced by fractional crystalization and slightly magma mixing.

Keyword: Andesite, Petrography, Geochemical, Baleendah

Introduction

Bukitcula is administratively located in Baleendah District, Southern Bandung, West Java Province and geographically located at Longitude 107°36'00" to 107°39'00" and Latitude 7°00'00" to 7°02'42".

Bukitcula composed by quaternary volcanic complex located in Southern Bandung, West Java, Indonesia. Although much data from previous studies has been reported, their detailed magma evolutions are still unclear. Combining petrology, petrography and geochemical analysis gave us information the origin of magma and its processes that formed andesite rock in Bukitcula Lava.

Regional Geology

Southern Bandung consists of mountains, hills, Pangalengan plateau, and Bandung plateau. Stratigraphically, volcanic rock in Southern Bandung can be divided by source of the eruption ranged from Pliocene (5,332 to 1,806 million years ago) until the Quaternary. Volcanic rocks can be divided into nine units:

1. Soreang Volcanic Unit (SV),
2. Baleendah Volcanic Unit (BV),
3. Pangalengan Volcanic Unit (PV),
4. Tanjaknangsi Volcanic Unit (TV),
5. Kuda Volcanic Unit (KV),
6. Kendang Volcanic Unit (KdV),
7. Dogdog Volcanic Unit (DV),
8. Wayang Windu Volcanic Unit (WV), and
9. Malabar Volcanic Unit (MV).

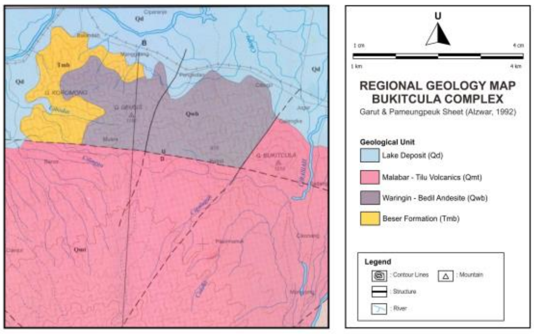

Figure 1 Regional geology map of Bukitcula Area

Research area composed by Baleendah Volcanic Unit (BV). Based on regional geology map (Lembar Garut - Pamungpeuk) by Alzwar et al (1992), Research area composed by 3 main unit such as lacustrine deposite (Qd) composed by clay, silt, fine-grained sand and tuffaceous materials, Waringin – Bedil Old Malabar Andesite (Qwb) composed by alternations of lavas, breccia and tuffs, and pyroxene- hornblende andesite composition, and Beser Formation (Tmb) composed by Andesitic volcanic breccia, lahar breccia, tuff, pumiceous tuff with intercalation of tuffaceous sandstone, tuffaceous claystone and conglomerate.

Methods

Four (4) rock samples were used for petrographic and geochemical analysis done by Laboratorium Pusat Sumber Daya Geologi using X-ray Fluorescent (XRF) analysis.

Petrographic analysis aims to determine the texture, fabric, rock composition, types of minerals contained, and rock structures. XRF analysis yielded percentages of oxide compounds that usually common in rocks, such as SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO_3, CaO, MgO, Na_2O, K_2O and P_2O_5. Then, all the element values are processed using several diagrams and "CIPW Norm Calculator".

Result and Discussion

Petrology and Petrographic Analysis

Generally, rocks in Bukitcula characterized by grey to reddish to brownish grey coloured, mesocratic color index, porphyritic to aphanitic texture, with feldspar, pyroxene and amphibole as phenocryst. Structure mostly massive, sheeting joint and vesicular texture.

Based on petrographic analysis, rocks in Bukitcula generally by transparent to brownish grey colored, composed by phenocryst of plagioclase, pyroxene, and hornblende, aphanitic groundmass composed by plagioclase microlites, volcanic glass, and opaque mineral. Texture shown in thin section is porphyritic (glomeroporphyritic), sieve, penetration twinning in pyroxenes, trachytic and zoning. Plagioclase is main constituent minerals in thin section, generally sized 0,2 mm to 2 mm and shaped euhedral to anhedral

The mineral composition contained in thin section of rocks in general (percentages form each rock compiled in Table 1) is:

Plagioclase (21 – 25%): colorless, euhedral to subhedral, low relief, non pleochroic, 1 direction cleavages, karlsbad, albit-karlsbad twinning, zoning, opaque and amphibole inclusion, sieve texture, size ranges from 0.2 – 2 mm. Type of plagioclase is Andesine (An31)

Pyroxene (7-10%) : colorless to greenish, subhedral to anhedral, high relief, weak pleochroism, cleavage in 1 direction, penetration twinning, blue to green 2nd order birefrengences, size ranges from 0.3 – 1.6 mm

Amphibole (3 – 5%): brown to green, subhedral to anhedral, long prismatic, high relief, strong pleochroism, cleavage in 2 direction at 120°, simple twinning, green 2nd orded birefrengences, size ranges from 0.2 – 0.8 mm.

K-feldspar (1%): colorless, sometimes cloudly, anhedral, white-gray cloudly interference color, as phenocryst.

Quartz (1-2%): colorless (clear), anhedral, cleavage absent.

Opaque minerals (3-7%): black, anhedral form, high relative, isotropic, as phenocrysts and groundmass.

Clay minerals (1%): yellowish brown in color, isotropic, found scattered rarely as groundmass and alteration product from plagioclase and amphibole.

Chlorite (1%): deep green, cumulate texture, anhedral, form as alteration product of amphibole.

Groundmass (53 - 60%): consists of microlite plagioclase, opaque minerals, and clay minerals.

Texture found in thin section of Bukitcula consist of **Glomeroporpyritic**, a texture which phenocrysts are clustered into aggregates called glomerocrysts or crystal clots. Glomeroporphyritic textures are common and often included plagioclase, pyroxenes and hornblende. Glomerocrysts are an important consideration in crystal fractionation by crystal settling since the density of the glomerocryst is an average of that of its constituent phases (Cox, 1979). **Sieve texture** in plagioclase may indicate the occurrence of magma mixing process. Sieve texture formed when plagioclase crystal is placed into magma which it is not in equilibrium, it will become corroded. Furthermore, new plagioclase of a different composition will precipitate from the magma and form a rim around the corroded core (Cox et al, 1979). **Trachytic** is a texture of extrusive rocks in which the groundmass contains plagioclase microlites that are parallel, forming flow lines along the directions of lava flow and around inclusions. This indicates rocks were formed as lava flow (figure 2)

Table 1 Summary of petrography analysis

No	Sample Code	Composition (%)									Name of the rock (Streickeisen, 1976)
		Pl	Px	Amf	Kf	Q	Op	Cl	Cm	Gm	
1	JLG-001	25	8	3	0	1	7	0	1	55	Andesite
2	JLG-002	21	9	4	1	1	4	0	0	60	Andesite
3	JLG-003	26	7	5	1	2	5	0	0	54	Andesite
4	JLG-004	25	10	5	1	1	3	1	1	53	Andesite

Information: **Pl**: Plagioclase ; **Px**: Pyroxene ; **Amf**: Amphibole ; **Kf**: K-feldspar ; **Q**: Quartz ; **Op**: Opaque ; **Cl**: Chlorite ; **Cm**: Clay mineral ; **Gm**: Groundmass

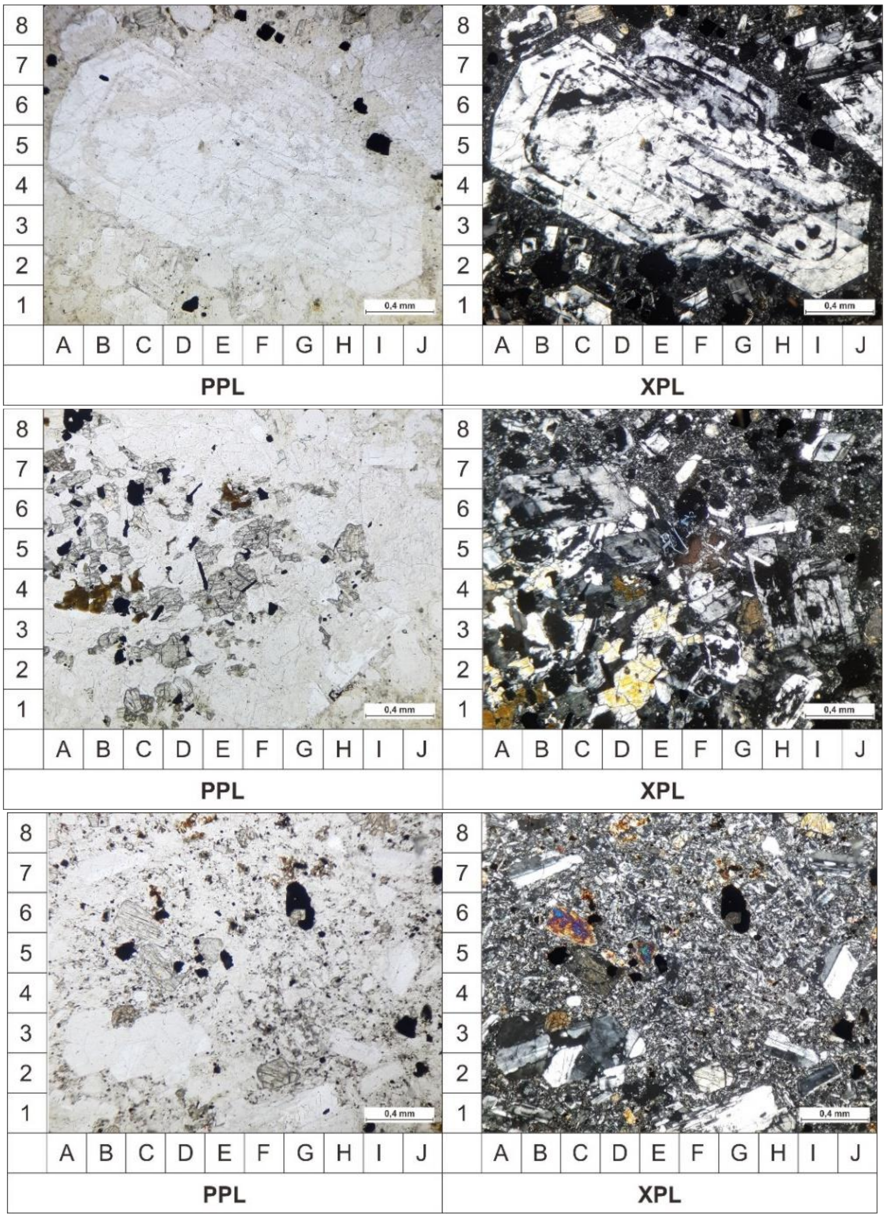

Figure 2 Photomicrograph showing microtexture (in order): sieve, glomeroporphyritic, and trachytic texture in Bukitcula

Table 2 Result of XRF Analysis (%)

Sample Code	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	K_2O	MgO	TiO_2	P_2O_5	MnO	LOI
JLG001	56.86	18.41	9.71	3.12	1.75	0.983	0.635	0.5142	0.1647	0.1402	2.41
JLG002	61.35	17.17	7.39	4.77	3.16	1.983	0.541	0.9163	0.2374	0.1227	2.09
JLG003	61.95	15.72	8.31	3.43	4.03	2.395	0.759	0.9464	0.2511	0.2038	1.68
JLG004	61.6	16.69	8.12	4.83	3.46	2.149	0.593	0.9031	0.2198	0.1148	1.22

Geochemical Analysis

Based on the chemical data of rocks obtained from the results of XRF (X-Ray Fluorescent) test (Table 2) can be determined the type of rock, the original magma, and the depth of magma.

Type of Rocks Based on Silica & Total Alkali Content

Type of rock based on Peccerillo and Taylor (1976) and Whitford (1979) divided rock based on silica content. From table concluded that Lava Jelekong composed by Andesite.

Total Alkali vs Silica (TAS) Diagram

Total alkali vs Silica (Le bass, 1985) divided the igneous rocks based on total alkali content (Na-K) compared to silica content (Si). From the geochemical analysis, total alkali content expressed by K2O and Na2O, and silica expressed by SiO2 (in wt%). Using TAS Diagram, Jelekong Lava Complex composed by Andesite and Basaltic andesite (figure 3).

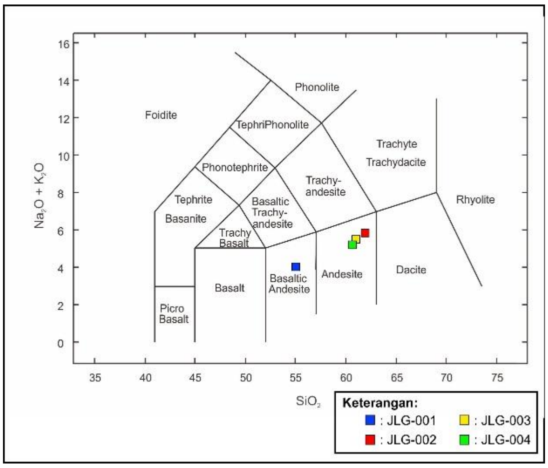

Figure 3 TAS Diagram (Le Bass, 1985)

Magmatic Series

Irvine-Baragar Discriminant Diagram (1971) used for determine series of magma that formed Lava Jelekong. Irvine-Baragar Diagram (figure 4) discriminate magma series between tholeiitic & calc-alkaline series. Geochemical compound that used in this diagram is total FeO (Fe2O3 + FeO), Na2O +K2O, and MgO (in wt%). This diagram concluded that Lava Jelekong composed by Calc-Alkaline Series (JLG-002, JLG-003, JLG-004) and Tholeiitic Series (JLG-001).

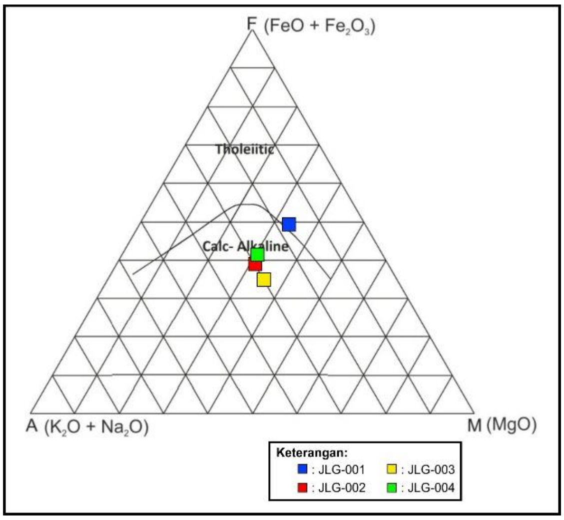

Figure 4 Magmatic Origin based on Irvine-Baragar Discriminant (1971)

Series of magma also classified by Peccerillo and Taylor (1976) based on K2O and SiO2 content. Based on diagram (figure 5), samples JLG-002 composed by High-K Calc Alkaline Series and JLG-001, JLG-003, and JLG-004 composed by Calc-Alkaline Series

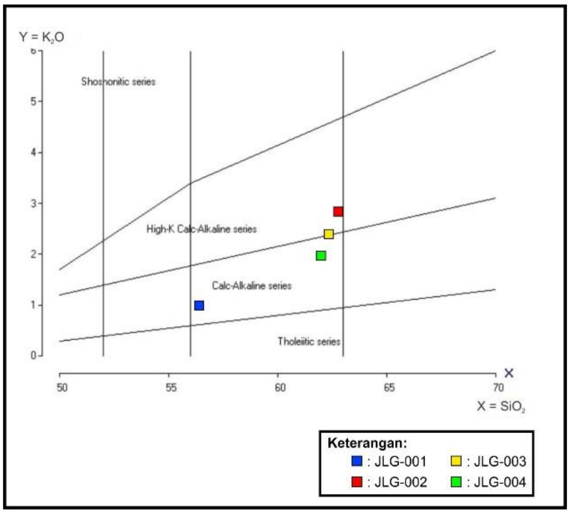

Figure 5 Magmatic Series of Bukitcula rocks based on Peccerillo & Taylor Diagram (1976)

Origin of Magma

Pearce (1977) detemined the origin of igneous rock magma based on a comparison of the percentage weight value of compounds K_2O, TiO_2, and P_2O_5. Based on diagram, it can be seen the origin of the rock-forming magma of Lava Jelekong, whether interacting with continental crust or oceanic crust.

Based on K_2O, TiO_2, and P_2O_5, origin of Lava Jelekong related to continental crust (figure 6). Mullen (1983) diagram of the origin of magma is based on consideration of the weight percentage value of compounds TiO_2, 10XMnO, and $10XP_2O_5$. Based on this analysis it can be seen the origin of magma of a basaltic material, whether it comes from mid oceanic ridge, island arc or oceanic crust. Island arc itself can be divided by thoiileite, alkaline and boninite type. Oceanic crust can be divided by tholeilite and alkaline type. Based on diagram, rocks from Lava Jelekong related to Island Arc –Calc Alkaline Series (Figure 7).

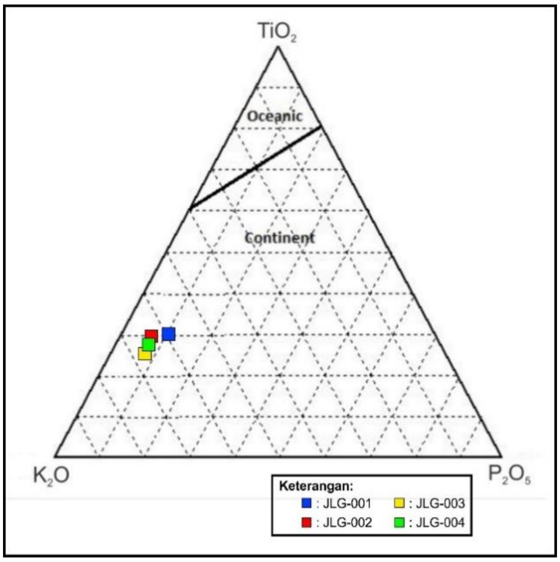

Figure 6 Magmatic Series of Bukitcula rocks based on Irvine Baragar Diagram (1971)

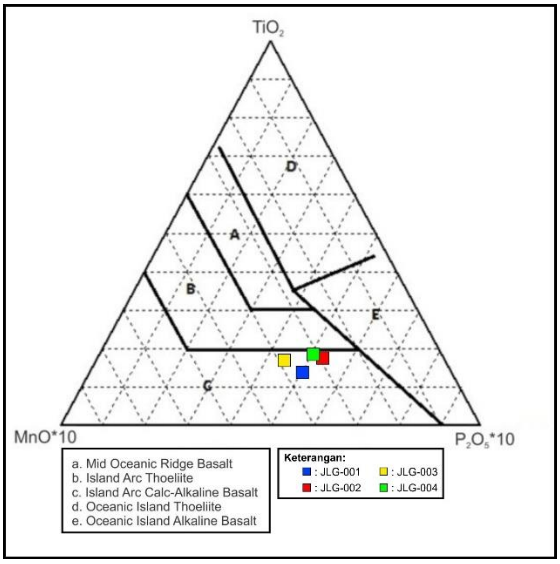

Figure 7 Origin of Magma in Bukitcula rocks based on Pearce (1977) and Mullen (1983)

Origin (Depth) of Magma

Using geochemical data which is then calculated using a formula made by Hutchinson (1975) these results can determine the depth of the place where the magma originated from rocks. The original magma depth can be obtained using the percentage data of SiO2 and K2O included in the formula as follows:

$$h = [320-(3.65 \times \%SiO_2)] + (25.52 \times \%K_2O)$$

Based on calculation using this formula, the original magma that composed Bukitcula estimated to form in range between +/- 139 - +/- 148 km beneath the Benioff zone.

Discussion

Petrography analysis showed several texture such as glomeroporphyritic, trachytic, and sieve that indicates how the magma evolves in Bukitcula. Trachytic texture confirms that rocks in Bukitcula formed as lava flow, glomeroporphyritic indicates crystal fractionation by crystal settling since the density of the glomerocryst is an average of that of its constituent phase, and sieve texture indicates magma mixing between two different magma composition. Geochemical anomalies in SiO_2 at JLG-001 shows 56%, while the other samples at 60-62%. This could indicates that rocks at JLG-001 more basic than other samples, as one of evidence of fractional crystalization process.

Conclusion

Based on petrology and petrography analysis, Bukitcula composed by andesite. Based on geochemical (XRF) analysis composed by andesite and basaltic andesite in TAS diagram, with magmatic series in the Calc-Alkaline and Tholeiitic magma, composed by High-K and Medium-K (Calc-Alkaline Series) group magma, magma interacts with continental crust (continent), as long as the magma based on the tectonic setting is on the Island Arc Calc-Alkaline Basalt, the origin of the original magma ranged from ± 139 km - ± 148 km in the Benioff zone.

Andesite in Bukitcula confirmed that rocks formed as lava flow with evidence of trachytic texture in thin section. Also, andesite in Bukitcula Lava was influenced by fractional crystalization process with evidence of glomeroporphyritic texture and rock composition by geochemical analysis composed by basaltic andesite to andesite. Thus, Bukitcula Lava was slightly influenced by magma mixing by evidence of sieve texture in plagioclase.

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