PETROGENESIS OF PASIR CUPU DIORITE, PLERED DISTRICT, PURWAKARTA, WEST JAVA

Kurnia Arfiansyah F[1], Hana Nur Aini[1], Ildrem Syafri[1], Ahmad Lutfi[1], Bunga Amitama[1]
[1] Faculty of Geological Engineering, Universitas Padjadjaran
Correspondence e-mail: k.arfiansyah@unpad.ac.id

ABSTRACT

Pasir Cupu located in the area of Plered and Sukatani, Purwakarta, West Java. It is geographically on 107º 26 '25.2' - 107º 27 '16.8' Easternmost and 6º 37 '22.8' - 6º 37 '03 "Southtermost. The Pasir Cupu is a formally formed intrusion, and classified into diorite (Streckeisen, 1978 in Gillespic and Styles, 1999). The method used is petroloogy, petrographic, and geochemical analysis using the XRF and CIPW methods. The megascopic appearance shows gray-colored rocks - in fresh, black-brown gray - in weathered ones; masive; very hard; fanheritic porphyritic textures; contains dark and bright minerals, dark minerals estimated to be amphibol, and pyroxene, and minerals that are bright feldspar; and masasaras are gray. Microscopic observations of 3 thin section of rock samples (CP 1, CP2 and CP3), showed porphyritic-afanitic texture, hypocrystalline, hypidiomorphic; composed of phenocryst plagioclase, amphibol, pyroxene, biotite, with mineral sizes between 0.1 mm - 4 mm; there are also small amounts of opaque, K-feldspar, quartz and carbonate minerals; with medium-coarse-grained bottom, consisting of plagioclase microlite, amphibole microlite, pyroxene and biotite microlite, carbonate minerals, chlorite and clay minerals. Based on geochemical analysis, Pasir Cupu is composed by diorite according to the Total Alkali Silica diagram. The magmatic series is included in the Calc-Alkaline and Thoeliitic series, the types of magma include the High-K and Medium-K (Calc-Alkaline Series) groups, as long as magma interacts with continental crust (continent), as long as the magma is based on the Island Arc Calc -Alkaline Basalt, the origin of magma origin ranged ± 140 Km - ± 185 Km in the Benioff zone and formed at temperatures of 1016 ˚– 1062 ˚C with rock specific gravity of 2.82 - 2.89 gram / cm3.

Keywords : Diorite, geochemistry, pasir cupu, petrographic, purwakarta.

INTRODUCTION

Regional Geology

Pasir Cupu is administratively located in Plered District, Purwakarta, West Java Province. Its geographical boundary is located at 107º 26 East Longitude '25.2' - 107º 27 '16.8' and South Latitude 6º 37 '22.8' - 6º 37 '03'.

Physiographically, Pasir Cupu is located in the Bogor Zone. The Bogor Zone is a complicated and convex anticlonirum line to the north. It extends extensively from the western part of Rangkasbitung, to the eastern part of Bumiayu, passing through Bogor, Purwakarta, Subang and Sumedang (van Bemmelen, 1949). The stratigraphy of this zone consists of a sequence of Neogene layers that are very thick and unknown. In general, the Bogor lithology zone consists mainly of clastic rocks, namely conglomerates, sandstones, claystone and marl, with strong volcanic activities. In addition there are also limestone lenses and reef limestones. Depositional environment ranges from litoral to neritic, as seen in the lithology arrangement and its fossil content, while terrestrial precipitation is characterized by lignite and mammalian fossils. In addition, volcanic results are often found as both inserts and main rocks. Facies changes take place quickly from north - south and west - east. The depositional age - Neogen deposition ranges from Early Miocene to Resen.

The Bogor Stratigraphy Zone, especially in the Purwakarta area, was first compiled by Ludwig (1933), in eight rock units, from Neogene to Holocene deposits. The eight rock units from old to young are as follows:

1. Neogen Sedimentary Rocks:
   a. Annulatus zone
   b. Cidadap formation (*Cidadap Beds*),
   c. Claystone dan Marine tuff,
   d. Citalang Formation (*Citalang Beds*), dan
   e. Kaliwangu formation (*Kaliwangu Beds*).
2. Quartenary

E-ISSN : 2579 – 3136

a. Old lahar materials and accompanying river deposits,
b. Pleistocene river deposits,
c. Holocene deposits.

The results of Ludwig's research above were then used by van Bemmelen (1949) to compile the middle and east Bogor regional Zone stratigraphy.

Sudjatmiko (1972), in the Geological Map of Cianjur that has been published, composes the stratigraphy of the area from old to young as follows:

1. Rajamandala Formation
2. Jatiluhur Formation
3. Klapanunggal Formation
4. Cantayan Formation
5. Subang Formation
6. Aluvium dan volcanic deposit.

Igenous Rock Petrology

Igneous rocks are formed by crystallizing magma at the time of their journey to the surface of the earth.

Magma is an incandescent thick silicate liquid, naturally formed with a high temperature of around 1500^o -2500^o C and is plastic. Found at the bottom of the earth's crust. The composition of the magma consists of 8 main elements namely O, Si, Al, Fe, Ca, Mg, Na, K and also contains H_2O and CO_2 compounds as well as several components of H_2S, HCl, CH_4 and CO. When the temperature of the magma drops to its saturation point, the magma begins to crystallize.

Hard-soluble elements will crystallize first, for example mineral accessories (apatite, zircon, ilmenite, magnetite, rutile, titanite, chromite, etc.) Soluble elements will crystallize most recently and will be trapped around the crystals that have been formed first.

Magma divided into 3 type (Raymond, 2002), that is:

1. Primitive Magma is a magma that has not been modified, is in the mantle of the earth and is not the result of pulverizing rocks in the lithosphere. This magma has not experienced changes in its composition since the time it was formed.
2. Primary magma is magma which based on its chemical constituent has not changed, but has undergone differentiation as a result of pulverization of rocks that have formed in the listosphere. Primitive magma is primary magma, but most primary magmas are not primitive magmas.
3. The main magma is magma which in the liquid phase has produced another magma.

Primary magma and primitive magma can be the parent magma if in the process of fractionation or other processes produce new magma from existing magma. Primary magma that experiences various kinds of modifications that cause changes in composition. This change causes the formation of various types of igneous rocks.

In general there are three types of modifications that occur in magma, namely differentiation, assimilation, and mixing of magma (Williams et. Al, 1955).

a. Magma differentiation is a process that covers all activities which results in a type of parent homogeneous which is relatively homogeneous fragmented into several parts or fractions with different compositions. This is due to the migration of ions or molecules in the magma solution due to changes in temperature and pressure. Which in the end will form various types of igneous rocks with different compositions.
b. Assimilation is the process by which magma is in contact with side rock (country rock) which results in

E-ISSN : 2579 – 3136

changes in the composition of magma as a result of reacting with side rocks.

c. The process of mixing magma is a process where 2 different types of magma with different compositions undergo mixing. Mixing between magma with the composition of basalt and magma with acid composition will produce magma with intermediate composition.

Shape and Presence of igneous rock

Igneous rocks based on genesis or their formation can be divided into 2 groups:

1. Intrusion igneous rock: igneous rock crystallize inside the earth, which produces 2 types of igneous rocks :
   a. Hypabisal rocks: igneous rocks that crystallize in the earth at shallow depths to produce medium-textured igneous rocks or coarse-fine mixing,
   b. Plutonic rock: igneous rock that crystallize deep within the earth to produce coarse-textured coarse igneous rocks.
2. Extrusion crystallize rock: crystallize of this rock on the surface of the earth, which produces fine-textured volcanic igneous rocks that are very fine.

RESEARCH AND METHDOLOGY

Data collection was carried out at Pasir Cupu, Purwakarta. Samples taken were 3 pieces from 3 observation points.

The data obtained were analyzed through handheld samples, thin incisions and rock geochemical analysis based on the XRF (X-Ray Fluorescent) method.

Petrographic analysis aims to determine the texture, fabric, rock composition, types of minerals contained, and rock structures. This analysis is carried out on 3 selected handheld samples that have been megascopic described. Then 3 thin section were made to be analyzed microscopically.

Geochemical analysis (XRF) produces percent chemical elements of oxides such as SiO_2, TiO_2. Al_2O_3, Fe_2O_3, MnO_3, CaO, MgO, Na_2O, K_2O and P2O_5 Then the element values are processed using "CIPW Norm Calculator"

RESULT AND DISCUSSION

Petrology and Petrographic Analysis

The Ignenous rock of Pasir Cupu is a boss-shaped intrusive rock. The megaskopis appearance shows gray-colored rocks - in fresh, black-brown gray - in weathered ones; masiv; very hard ; fanheritic porphyritic textures; contains mafic and felsic minerals, mafic minerals estimated to be amphibol, and pyroxene, and minerals that are bright feldspar; and groundmass is gray (Figure 1).

Microscopic observations of 3 rock thin sections (CP 1, CP2 and CP3), showed porphyritic-phaneritic texture, hypo-crystalline, hypidiomorph ; composed of phenocryst plagioclase, amphibol, pyroxene, biotite, with mineral sizes between 0.1 mm - 4 mm ; there are also small amounts of opaque, K-feldspar, quartz and carbonate minerals ; with medium-coarse-grained groundmass, consisting of plagioclase microlite, amphibol microlite, pyroxene and biotite microlite, carbonate minerals, chlorite and clay minerals.

E-ISSN : 2579 – 3136

Figure 1 Pasir Cupu Intrusion Outcrop

The mineral composition contained in thin section of rocks in general is:

1. Plagioclase (44-46%), colorless, euhedral-subhedral, sometimes anhedral, low relief, refractive index higher than balm (n> balm), do not have pleocroism, cleavage in one direction, albit, karlsbad, and albit - karlsbad twins, sometimes has a strong zoning. Opaque mineral inclusion, amphibol and pyroxene. 24^o extiction angle, andesine (An 44). Some have been altered into carbonate minerals and clay minerals. Size ranges from 0.2 mm - 3 mm, as phenocrysts and groundmass, and as inclusions in amphibol.
2. Amphibole (25-28%), in the form of anhedral - subhedral, long prismatic, hexagon, brown to greenish brown, yellowish brown interference color - greenish brown chocolate strong pleochroism, high relief, cleavage in one direction {010} and two direction (perpendicular to the axis C {110}) forms an angle of 56^o - 124^o, sometimes zonal texture, simple and plural twins, some of which have been altered to opaque minerals, clay minerals and biotite. Measuring 1 mm - 3 mm as a phenocrysts, and 0.1 mm - 0.5 mm on amphibol microlites as groundmass
3. Pyroxene (2-3%), clear - greenish, subhedral - anhedral, pleocroism absent - weak pleocroism, cleavage in one direction, sometimes two direction, blue, green, yellow, interference, refractive index greater than balm (n> balm). Size ranges from 0.2 mm to 3 mm, spread as phenocrysts and groundmass.

E-ISSN : 2579 – 3136

Table 1 Summary of Petrographic Analysis.

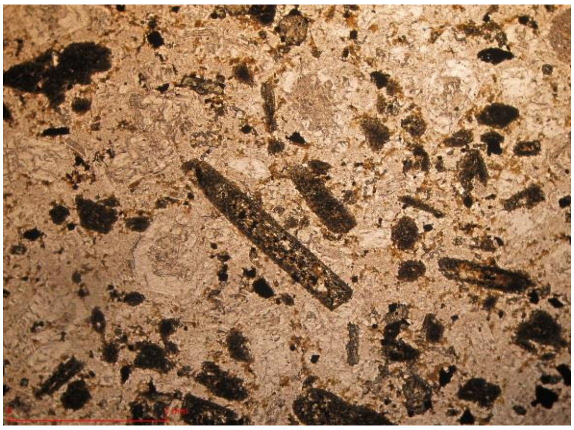
No.	Sample code	Composition (%)											Name of the rock
		Pl	Am	Px	Bi	Kf	Q	Op	Cb	Cm	Kl	Gm	
1	CP 1	44	28	2	1	1	0	2	1	1	1	18	Diorite
2	CP 2	46	25	2	0	1	1	2	1	1	1	20	Diorite
3	CP 3	45	27	2	1	1	1	2	1	1	0	19	Diorite

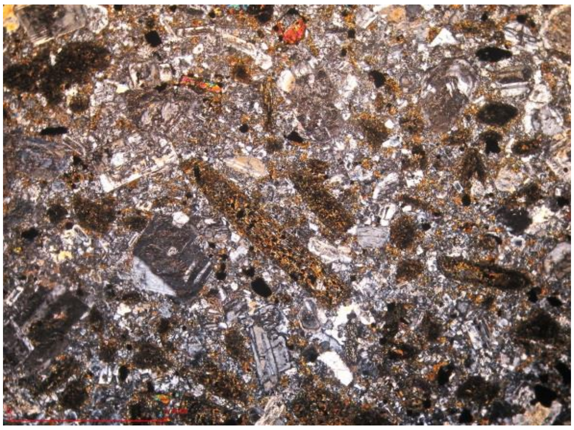
Information : Pl : Plagioclase, Am : Amphibole, Px : Piroxene, Bi : Biotite, Kf : K-feldspar, Q : Quartz, Op : Opaque, Cb : Carbonate, Kl : Chlorite, Cm : Clay mineral, Gm : Groundmass

4. Biotite (1%), greenish-brown, strong pleocroism, anhedral, birds eyes texture, mineral refractive index greater than balm (n> balm), 0^{o} extinction angle, microlite and altered mineral from amphibole.
5. K-feldspar (1%), colorless, sometimes cloudly, anhedral, refractive index less than balm (n <balm). white-gray cloudly interference color, as phenocryst.
6. Quartz (1%), colorless (clear), anhedral, cleavage absent, coroded texture.
7. Opaque minerals (2%), black, anhedral form, high relative, isotropic, as phenocrysts and groundmass. Available as primary and secondary minerals. As primary minerals, inclusions in plagioclase and amphibole, and as a secondary mineral alteration from amphibole.
8. Carbonate mineral (1%), colored white - brownish, medium relative, is a secondary mineral - altered from plagioclase, filling fractures between minerals, if as an alteration takes place plagioclase in the form of patches.
9. Clay minerals (1%), yellowish brown in color, scattered rarely, some scattered along with ore minerals, as groundmass, altered mineral from plagioclase and amphibol.
10. Chlorite (1%), brownish green, fibrous, anhedral, altered mineral from amphibol.
11. Groundmass (19-20%), consisting of microlite plagioclase, amphibol, pyroxene, biotite, k-feldspar, quartz, opaque minerals, carbonate minerals, chlorite and clay minerals, medium-coarse grained.

The type of rock is Diorite (Streckeisen, 1978, in Gillespic and Styles, 1999). A summary of petrographic analysis can be seen in Table 1, while photographs of thin section can be seen in Figures 2, 3 and 4.

E-ISSN : 2579 – 3136

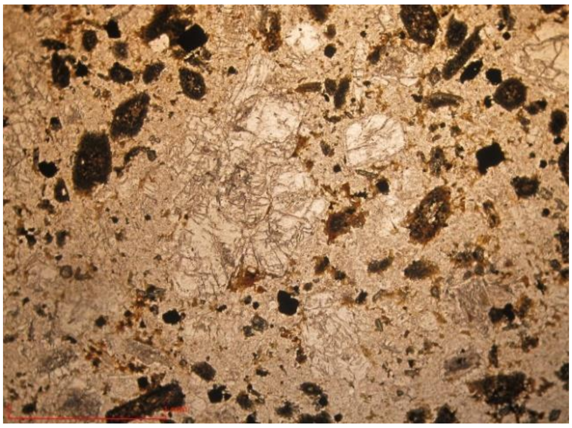


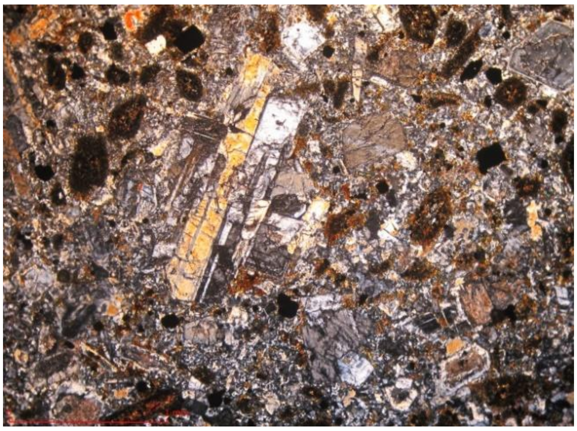


//-nicol ; 40 x

x-nicol ; 40 x

Figure 2 Thin section of CP 1 rock sample, type of this rock is diorite (Streckeisen, 1978)

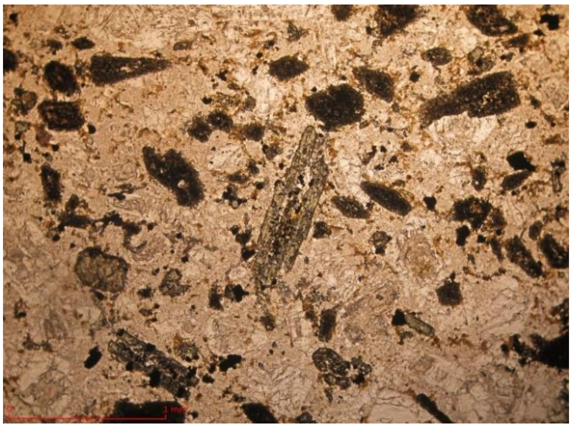




//-nicol ; 40 x

x-nicol ; 40 x

Figure 3 Thin section of CP 2 rock sample, type of this rock is diorite (Streckeisen, 1978)



//-nicol ; 40 x

x-nicol ; 40 x

Figure 4 Thin Section of CP 3 rock sample, type of this sample is Diorite (Streckeisen, 1978)

E-ISSN : 2579 – 3136

Table 2 Result of XRF Method (X-Ray Fluorescene).

CHEMICAL ELEMENTS (%)	SAMPLE CODE		
	CP 1	CP2	CP3
SiO_2	58,31	57,26	56,55
Al_2O_3	17,82	18,73	17,92
Fe_2O_3	4,01	3,82	5,92
FeO	3,77	3,76	5,328
CaO	4,87	5,42	6,97
MgO	1,75	1,79	0,868
Na_2O	2,23	2,71	2,02
K_2O	2,47	2,91	1,04
TiO_2	0,52	0,42	0,429
MnO	0,2	0,18	0,127
P_2O_5	0,13	0,16	0,1

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.

Types of Rock Based on Content of Alkali Total and Silica Content

Wilson (1989) divides igneous rock types using a diagram of Total Alkali Silica (TAS), which is one of the classifications that are mostly used for plutonic rocks. Chemical data used is the amount of Na_2O + K_2O (Alkali Total) and SiO_2 (Silica) to be plotted into the Wilson diagram (1989).

Based on the plotting of the values of Na_2O + K_2O and SiO_2 on the binary diagram, the Pasir Cupu intrusive rock has a type of Diorite (Figure 5).

Magmatic Series of Stone Formation Magma

To determine the magma series from which rocks form the Pasir Cupu Intrusion, comparisons in triangular and binary diagrams are used. Irvine Baragar (1971), dividing the rock series into tholeiitic series and calc-alkaline series using AFM triangular diagrams. A is Alkali content (K_2O + Na_2O), F is iron oxide (FeO + Fe_2O_3) and M is magnesium (MgO). Pasir Cupu intrusion rocks have cacl-alkaline and thoileiitic magma series. (Figure 6).

The magma series is also classified by Peccerillo and Taylor (1976) based on the content of potassium or potassium (K_2O) and silica (SiO_2). Based on this classification, Pasir Cupu intrusive rocks are included in the High-K and Medium-K series (Calc-Alkaline Series) (Figure 7).

Determination of the Origin of Magma

Determination of the origin of magma can be seen from the nature of magma. These properties can be divided into two based on the origin of rocks that interact with magma, namely continents or oceans. Pearce (1977) determines the origin of magma from the content of K_2O, TiO_2, and P_2O_5.

Based on the plotting of K_2O, TiO_2, and P_2O_5 value on the triangle diagram of Pearce (1977), Pasir Cupu intrusive rocks originated from continental / continental crust (Figure 8).

E-ISSN : 2579 – 3136

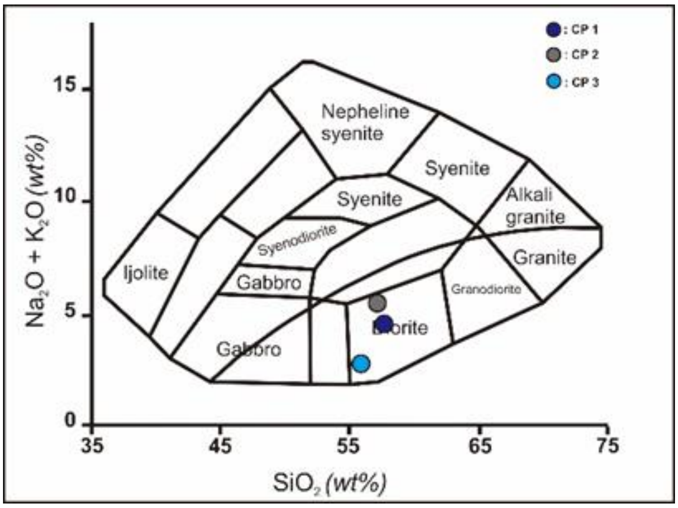


Figure 5 Type of Igneous rock in Pasir Cupu Intrusion Based on Wilson Classification (1989)

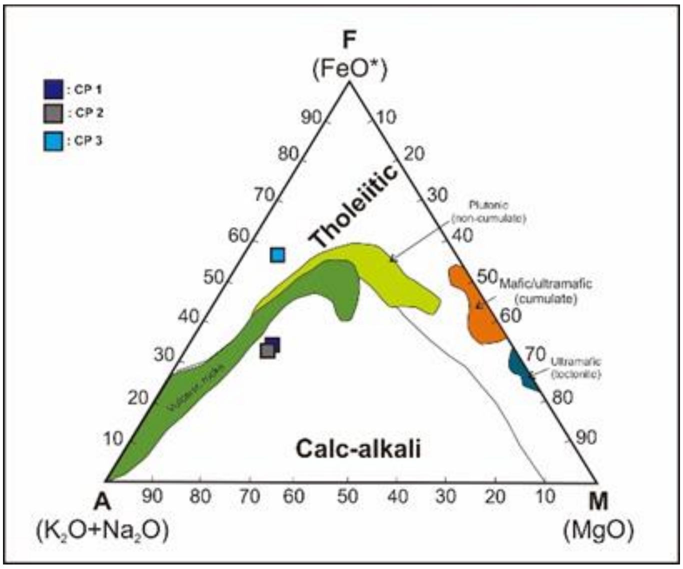


Figure 6 Thin Section of CP 3, type of this rock is Diorite (Streckeisen, 1978)

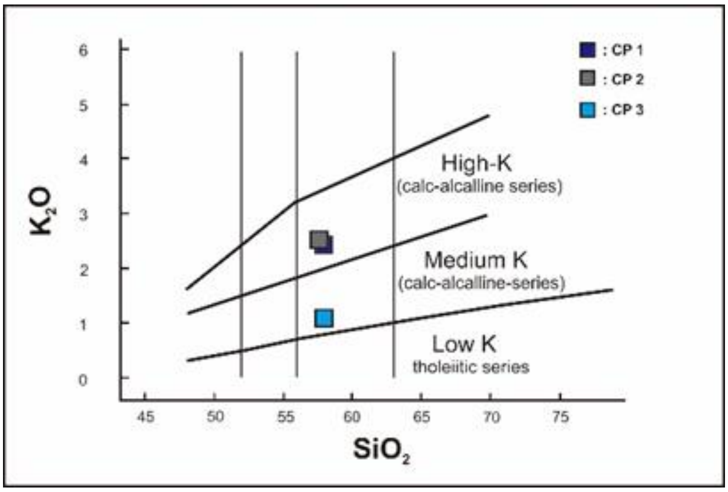


Figure 7 Magma Series of Pasir Cupu Intrusion rock based on Peccerillo & Taylor (1976)

E-ISSN : 2579 – 3136

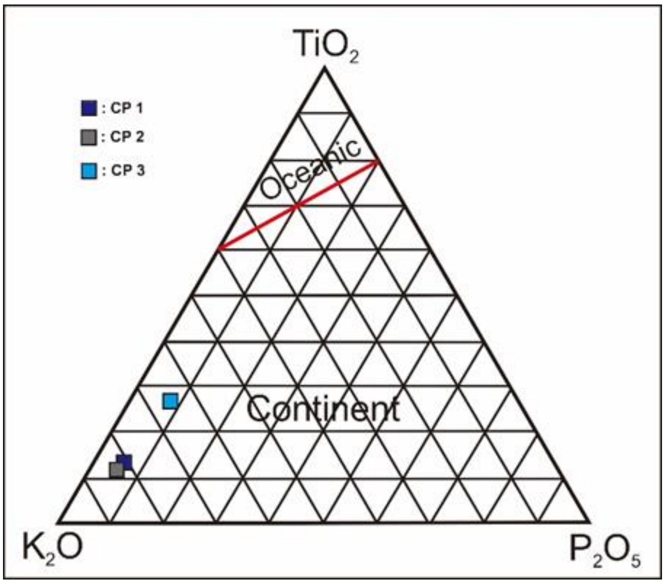


Figure 8 Rock Origin of Pasir Cupu Intrusion Based on Pearce (1977)

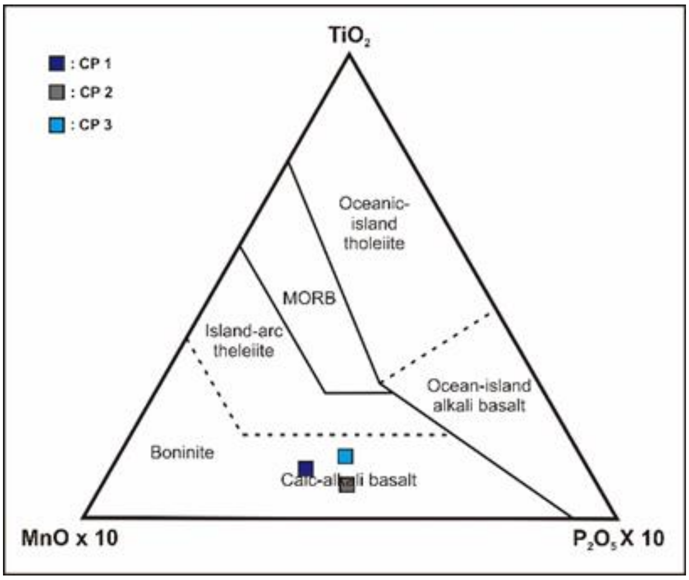


Figure 9 Tectonic Setting of Rock Origin in Pasir Cupu Intrusion Based on Mullen (1983)

The source of magma is divided into 5 tectonic environments based on Mullen (1983), dividec into Mid Oceanic Ridge Basalt, Thoeliite Island Arc, Island Arc Calc-Alkaline Basalt, Oceanic Island Thoeliite, and Oceanic Island Alkaline Basalt. Determination of the origin of this magma is based on the percentage of TiO_2, 10 x MnO, and 10 x P_2O_5 which are plotted in a triangle diagram.

Based on Mullen's triangle diagram, it can be seen that the origin of the magma that forms the Cupu Sandstone is the Island Arc Calc-Alkaline Basalt (Figure 9).

Origin 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

E-ISSN : 2579 – 3136

formed in the depth of the Benioff zone. The original magma depth can be obtained using the percentage data of SiO_2 and K_2O included in the formula as follows:

$$h = [320 - (3.65 \text{ x } \%SiO2)] + (25.52 \text{ x } \%K2O)$$

Based on calculations using this formula, it is known that the original magma depth is estimated to form in the range between ± 140 km - ± 185 km in the Benioff zone.

Estimation of Magma Temperature and Rock Specific Gravity Based on the Results of Calculation of Density and Temperature calculation

Estimation of the temperature of the magma is associated when crystals begin to form first in equilibrium conditions. Rock specific gravity is obtained from the measurement of the mass of each mineral making up rocks against the volume of rock. Based on the calculation of density and temperature calculation, it is known that the diorite rocks of Pasir Cupu are formed at temperatures of 1016° – 1062° C with rock specific gravity of 2.82 - 2.89 gram /cm^3.

CONCLUSION

Based on petrology and petrographic analysis in megascopic and microscopic dimension, Pasir Cupu intrusion is composed of diorite igneous rocks. Based on the geochemical analysis, arranged by diorite based on the total alkali silica diagram, the magmatic series is included in the Calc-Alkaline and Thoeliitic series, the types of magma include High-K and Medium-K (Calc-Alkaline Series) groups, as long as 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 ranges from ± 140 km - ± 185 km in the Benioff zone, and the Pasir Cupu intrusive rocks are formed at temperatures of 1016°-1062° C with rock density 2, 82 - 2.89 gram / cm^3.

REFERENCE

Bowen, N. L. 1956. The Evolution of The Igneous Rocks. Canada : dover. Pp. 60-62.

Cross, W, Iddings J,P, Pirson L.V, and Washington H,S. 1930. Quantitative classification of igneous rock. Univ. Chicago Press.

Gillespic, M.R., and Styles, M.T. 1999. Classification of igneous rocks. Dalam : BGS Rock Classification Scheme, Volume I, British Geological Survey Research Report (2nd edition), British Geological Survey, Keyworth, Nottingham NG12, 5GG, UK, h.1-52.

Hutchison, C. S. 1983. Economic Deposits and Their Tectonic Setting. London : Macmillan.

Irvine, T. N. & W. R. A. Baragar 1971. A guide to the chemical classification of the common volcanic rocks. Can. J. Earth Sci. 8, 523-48.

Kerr, Paul F. 1959. Optical Mineralogy. McGraw-Hill Book Company, Inc., New York, Toronto, London. Kogakusha Company, Ltd., Tokyo, 442 h.

Le Bas, M. J., R. W. Le Maitre, A. Streckeisen & B. Zanettin (1986). A chemical classification of volcanic rocks based on the total alkali-silica diagram. J. Petrology 27

Ludwig, O. 1933. Toelichting bij Blad 30 (Purwakarta). Geol. Kaart van Java, Schaal 1 : 100.000. Dienst Mijb. Ned. Indie.

Martodjojo, S. 2003, Evolusi Cekungan Bogor Jawa Barat, Tesis Doktor Pasca Sarjana. ITB Bandung

Mullen, E. D. 1983. MnO/TiO2/P2O5: a minor element discriminant for

E-ISSN : 2579 – 3136

basaltic rocks of oceanic environments and its implications for petrogenesis. Earth Planet. Sci. Lett. 62, 53-62.

Pearce, T. H., Gorman, B. E. & Birkett, T. C. 1977. The Relationship Between Major Element Geochemistry and Tectonic Environment of Basic and Intermediate Volcanic Rocks. *Earth and Planetary Science Letters* 36, 121–132.

Peccerillo, A. & Taylor, S. R. 1976. Geochemistry of Eocene CalcAlkaline Volcanic Rocks From the Kastamonu Area, Northern Turkey. Contributions to Mineralogy and Petrology 58, 63–81.

Raymond, Loren A.. 2000. Petrology: The Study of Igneous Sedimentary and Metamorphic Rocks Second Edition. New York : McGraw-Hill Higher Education.

Streckeisen, A. & Lemaitre, R. W. 1979. A chemical approximation to the modal QAPF classification of the igneous rocks. Neues Jahrbuch fur Mineralogie, Abhandlungen 136, 169-206.

Sudjatmiko. 1972. Peta Geologi Lembar Cianjur, Jawa. Skala 1 : 100.000. Departemen Pertambangan, Direktorat Geologi, Bandung.

Van Bemmelen, R.W. 1949. The Geology of Indonesia. Volume IA. General geology of Indonesia and adjacent archipelagoes. The Hague Martinus Nijhoff, Nederland, 732 h.

Wahlstrom, Ernest E. 1958. Introduction To Theoretical Igneous Petrology. John Wiley & Sons, Inc., New York ; Chapman & Hall, Limited, London, 365 h.

Williams, Howel, Turner, Francis J., dan Gilbert, Charles M. 1955. Petrography An Introduction to the Study of Rocks in Thin Sections. W.H. Freeman and Company, San Francisco, 403 h.

Whitford. 1979. Classification of Igneous Rock by Silica. Dalam Rollinson, H. R. 1993. Using Geochemical Data. John Willey & Sons Inc : New York

Wilson, M. 1989. Igneous Petrogenesis Global Tectonic Approaach, Dordrecht: Springer

Yuwono, Yustinus Suyatno. 2004. Diktat Kuliah Pengantar Petrogenesis. Bandung : Penerbit ITB.

E-ISSN : 2579 – 3136