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Petrographic Characteristic of Pyroxene Andesite Lava in Kalibawang Area, Kulon Progo, D. I. Yogyakarta: a preliminary petrogenetic study of Old Andesite Formation in South of Central Java

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Abstract

Andesitic lavas in Kalibawang area are part of Old Andesite Formation (OAF). These lavas represent the first cycle of volcanism in Sunda arc, which marked the earliest development of Sunda arc.

The samples were collected from three locations in the east of Kulon Progo mountains. Detailed petrographic observation is used to characterize the samples.

The result of petrographic observation shows that two of the three collected samples have similar phenocryst assemblages, composed of clinopyroxene and andesine and texture. Cryptocrystalline plagioclase is present as the main component in the ground mass, showing trachytic texture. Hornblende appears only as oxidized xenocryst. The third sample is collected from a possible dike remnant, exposed in the south of the two andesitic lavas, and composed of equigranular plagioclase laths and remnant of olivine replaced by iddingsite.

The petrographic analysis suggests that the two pyroxene-andesite lavas might have resulted from the same magmatic system. However, it has not been fully understood whether or not they are coming from the same source. The third sample, the diabasic dyke, is not cut through the andesitic lavas. It may represent the sub-volcanic part either of the same system which erupted prior to the two andesitic lavas or the whole different system which presumably is older or younger (?) than the andesitic lava group.

Key Words: Andesite lava, Old Andesite Formation, Sunda arc, Magmatic system.

Introduction

Pre-Quaternary magmatic activity in Java island started from approximately 40-19 Mya (late Eocene - Early Miocene) and generates an arc trail from west to east of Indonesia islands, which its products have andesitic properties, while, the Second Magmatism activity occurred 11-2 million years ago (Miocene - Pliocene) and also producing andesitic product (Soeria Atmadja, et al., 1991; Harjanto, 2015).

One of the important magmatism activity event in The Indonesia is the occurrence of movement and contact subduction of tectonic plates that form a magmatic arc from the northwestern island of Weh in Sumatra to Banda Api in the eastern part of the Banda Islands (Whitford, 1975). This Magmatic arc is known by the name Sunda – Banda Arc. In Sunda - Banda Arc, There are approximately 102 active volcanic mountain because of the subduction activity of the tectonic plates (Padang, 1951).

One of the results of the Pre-Quaternary magmatic activity can be observed in the Kalibawang Region, Kulon Progo Regency, Yogyakarta. From observations on the photo image and on the field, there are various rocks as the past products of volcanism activity in the Kalibawang area, such as Andesite Breccia, Tuff, lapilli tuff, lava flows, dike remnants and others. In the studied area, we found various rocks that characterize proximal volcanic facies, they are association between the lava, volcanic breccias and agglomerates (Bronto , 2006). These Rocks are expected as products of three ancient volcanoes developed in Kulon Progo area, they are Mount Gajah in the center, Mount Ijo in the south, and Mount Menoreh in the north (Bronto 2010 in Wijaya, 2015). For now, these three volcanoes have undergone an intensive erosion process.

One of the lithology that has interest for further investigation in the focus area is the presence of lava in the study area , where there are few lava outcrops that show the differences in petrological appearance. From the three analyzed samples, those are CCI - L01, CCI-L02 and CCI - L03, it can be seen that the first two lava samples have the same texture that is phorphyroaphanitic with a texture that shows the direction of flow and a specific orientation that different from sample CCI-L03.

The differences in Petrological may represent the different magma properties or different process that form the lava in focus Study area. One of the previous research said that volcanism of Mount Gajah produced basaltic andesite lavas that is rich in Pyroxene, and side basalt intrusion (Ichsyansyah, 2015). Volcanism of Mount Menoreh generated lava flows which are initially rich in Pyroxene and changed into hornblende because of differentiation process (Ichsyansyah, 2015).

From the analysis, the difference in characteristic such as phenocryst assemblage in these lavas can be used as a key to understand the characteristics of old magmatic system in Kulonprogo area. The same data can also be used to interpret the magmatic evolution in Kalibawang area, which represent the first cycle of volcanism and also the earliest development of Sunda arc.

Geological Setting

Tectonic development of Java changes magmatic arc turned from south to the north. (Hamilton, 1979) said that tectonic evolution of Java island during Paleogen shows continuous subduction of Hindia-Australian plate that slipped under Java. Sribudiyani, et al, (2003) said that based on the new seismic and drilling data in East Java to interpret the presence of fragments continent (called microplate of East Java) as the cause changing lanes subduction southwest-northeastern direction (pattern of Meratus) into east-west (pattern of Java). Another development is the lane tectonic subduction Karangsambung-Meratus become inactive due to clogged by the presence of continental material.

Kulon Progo area is formed by the more or less independent dome of the Kulon Progo mountains between Purworedjo and the Progo river. Kulon Progo mountains is a dome that is separate from South Serayu mountains. The dome formed by major tectonic force that is process of uplift. The northern and eastern parts of West Progo is bounded by the valley of Progo river and the southern part of the coastal plain bounded by ocean of Indonesia, while the northwestern part of dealing with the mountains of South Serayu (Bemmelen, 1949).

During paleogen era, Kulon Progo experienced at least twice period of tectonic phase which first happened in the Late Oligocene - Early Miocene and the second occurred in the Middle Miocene - Late Miocene which produces magmatic arc. Magmatism activities in the area of Kulon Progo occurred in the Oligocene - Miocene with the spread of volcanic rocks is west – east (Bemmelen, 1949). Stratigraphy of West Progo mountains from the oldest to the young is Nanggulan Formation, Old Andesite Formation, Jonggrangan Formation, Sentolo Formation, and Quaternary Deposit (based on Juhri et al., 1977) in Subiyanto (1989).

Data and Method

The samples were collected from three locations in the east of Kulon Progo mountains (**Fig. 1**). The samples were taken at the upper and lower part of the outcrop, except in the third location. The dyke remnant in third location have homogenous texture and composition. The thin section preparation is conducted at Central Laboratory at Geological Engineering Department of Gadjah Mada University. Petrographic analysis of the samples were carried out at Optical Geology Laboratory of the same institution. Detailed petrographic observation using point counting method is used to determine the mineral assemblages and microtextures of the samples. The percentage of phenocryst assemblages as determined using 1000 observation points.

Result and Discussion

1. The Geology and Petrology of the Outcrops

The study area consists of several lithologies such as andesitic breccia, agglomerate, andesitic lava, and basaltic dyke. The stratigraphic relation show that the lava is deposited either below the breccia or the basaltic dyke. The relation between the lava and the basaltic dyke is difficult to determine because the location is too far, but probably it is older than the lava. There is no major structure observed in this area.

The outcrop of sample CCI-L01 and CCI-L02 show a weathered condition. The upper part is more weathered than the lower part shown by the presence of soil and clay also the color of plagioclase which is brighter. The outcrop has been deformed showing by the sheeting joint along the outcrop caused by the exhumation process (**Fig. 2**). The sample CCI-L03 show grayish-black color and aphanitic textures and there are some vesicles. This outcrop also has deformed showed by columnar joint caused by rapid cooling process (**Fig. 3**). The morphology of columnar joint is colonnade type where the dip slope about 5-75^0 in variated direction. The diameter is about 15 centimeters to 1 meters while the length is about 4-25 meters.

2. Petrographic Analysis

Petrographic analysis show that sample CCI-L01 and CCI-L02 have similar minerals assemblages and textures (**Fig. 4**). The main textures of these samples are porphyroaphanitic holocrystalline. The phenocryst mineral phases show a compositionally zoned as the characteristic of volcanic rocks (Schmincke, 2005). The groundmass is showing trachytic texture which caused by the crystallization of lava flow that create flows line that is a perpendicular orientation of minerals commonly composed by feldspar microlite. Another texture that can be observed is intergranular between plagioclase and pyroxene. The phenocryst phase mainly composed by andesine and clinopyroxene group that is diopside in detail. Some opaque minerals which is probably Fe-Oxide also appears in these samples as the phenocryst or inclusion. Hornblende appears only as xenocryst that showing compositionally zoned where the translucent greenish clinopyroxene cores are overgrown by iron-rich opaque mineral rims. The diopside assemblage decrease from sample CCI-L01 to sample CCI-L02, in other hand andesine and oxy-hornblende assemblage increase. The sample CCI-L01 has fewer matrix assemblages than sample CCI-L02 as shown in the table below.

Composition	**CCI-L01**	**CCI-L02**
Matrix	54.4%	57.6%
Andesine	27.5%	25.1%
Diopside	10.0%	11.7%
Oxy-Hornblende	7.2%	4.5%
Opaque	0.9%	1.1%
Total	**100.0%**	**100.0%**

The sample CCI-L03 generally has different texture, where it mainly composed by intergrowth of equigranular crystal (**Fig. 5**). It has similar texture with diabasic rock that is sub ophitic texture where the pseudomorph crystal grow in the interstitial space of plagioclase laths. This sample has the different composition with those sample above. It mainly composed by plagioclase, labradorite in detail and olivine which has pseudomorphed by iddingsite which replaces most of the olivine phenocrysts and microphenocrysts. Some opaque minerals also appear as inclusion, there is no any clinopyroxene observed in this sample. Labradorite as the main composition with 63.40% assemblage followd by iddingsite 32.90% and opaque minerals with 3.70%.

3. Petrographic Comparison with First Cycle Volcanism Sunda Arc Rocks

The evolution of Indonesian island arc has been dominated since late Paleozoic (Katili, 1975). It was marked by several linear volcano-magmatic complexes associated with sedimentary rock (Whitford, 1975). The "first cycle volcanism" is correspond to the volcanic activity at the south and south-west of Sunda arc during the Paleogene period which culminating in lower Miocene and resulting the Old Andesite Formation (van Bemmelen., 1949).

Petrographic characteristic of some lavas which represent the first cycle volcanism are very similar with many of Quaternary lavas. They have porphyritic textures with abundant assemblages of plagioclase either as phenocryst phase and/or groundmass (Whitford, 1975). Both clinopyroxene and othopyroxene can be found associated with Fe-Ti-Oxide, amphibole, and olivine either as phenocryst or microphenocryst (Whitford, 1975).

The intrusive part is characterized with coarse plagioclase dominated and calcic-clinopyroxene with a sub-ophitic texture and minor Fe-Ti-oxide, where most of the primary olivine has replaced by green-brown (Whitford, 1975).

All the description above show a similarity with the petrographic characteristic of all samples from studied area. The sample CCI-L01 and CCI-L02 has very similar texture with the "first cycle volcanism" lava. The mineral assemblages also show a similarity, although there is no any olivine and orthopyroxene observed. Hornblende only appears in some parts, while Fe-Ti-oxide is probably represent by the opaque minerals. The sample CCI-L03 that is the basaltic dyke also has similar characteristic with intrusive part of first cycle volcanism where plagioclase laths still dominated the rock composition. Clinopyroxene is not well observed in this thin section. While the description above said that olivine has replaced possibly by chlorite, in this sample most olivine was replaced by iddingsite that is the clay minerals members which mostly alteration result of olivine.

Generally, the rock petrogenesis can be interpreted from its textural characteristic and mineral assemblages. The sampled lavas are composed by andesitic magma where the sample CCI-L02 is more primitive than sample CCI-L01. The phenocryst phase of sample CCI-L01 and CCI-L02 show a compositionaly zone which is probably caused by a new mafic magma mixed with the resident magma (Schmincke, 2005). This oscillatory zoning also can be caused by volatile release during the magma eruption that changes the solubility of the liquid (Fenner, 1926 in Johannsen, 1933). The intergranular texture indicate that the nucleation ratio of pyroxene is relatively high so the pyroxene crystal will concentrated in between of plagioclase crystal (Hibbard, 1995). The zoning in oxy-hornblende mainly caused by devolatilization process the greenish cores may represent early crystallization process of the magma at high pressure (probably boundary crust-mantle) (Schimncke, 2005). The sample CCI-L01 has lower matrix assemblages than sample CCI-L02 which indicate that sample CCI-L01 is crystallized slower than sample CCI-L02. The abundant assemblages of labradorite and pseudomorphed olivine in sample CCI-L03 indicate that it has more mafic magma source which represent the sub-volcanic part of the magmatic system.

Based on the petrographic comparison above, the petrogenetic model may have quite similarity with the model proposed by Whitford (1975). The petrogenetic model suggests that the magma generate from partial melting of modified mantle which has added by water and melt component from the slab (Whitford, 1975), but it still need advance study, especially in geochemistry to determine the more accurate petrogenetic model in this area.

Conclusions

The lavas from studied area is the part of Old Andesite Formation (OAF) which represent the first cycle of volcanism. The diabasic dyke is the subvolcanic part of this system which erupted prior to the two andesitic lavas or the whole different system which presumably is older or younger. It also need further research especially in geochemistry to determine the petrogenetic model of this system.

References

Schmincke, H., 2005, Volcanism, Springer.
Katili, J. A., 1975, Tectonophysics, **26,** 195-212
Whitford, D. J, 1975, Geochemistry and Petrology of Volcanic Rocks from the Sunda Arc Indonesia, Australian National University.
Van Bemmelen, R. W. The Geology of Indonesia, **1**, 732.
Johannsen, A. 1939, A Descriptive Petrography of the Igneous Rocks, **1**, University of Chicago.
Hibbard, M. J., 1995, Petrography to Petrogenesis, Prentice Hall, Inc., New Jersey.

Harjanto, Agus, 2011, Jurnal Ilmiah Magister Teknik Geologi, **4**.

Wijaya, Devy Rizky Panji dan Agus Hendratno. 2015. Petrogenesis Andesit Basaltik di Daerah Kali Wader dan sekitarnya, Kecamatan Bener, Kabupaten Purworejo, Provinsi Jawa Tengah. Yogyakarta : Universitas Gadjah Mada

Ichsyansyah, Ade Budhi. 2015. Studi Fasies Gunung Api Purba Daerah Banyuasin Separe dan Sekitarnya, Kecamatan Loano, Kabupaten Purworejo, Provinsi Jawa Tengah. Yogyakarta : Universitas Gadjah Mada

Attachment

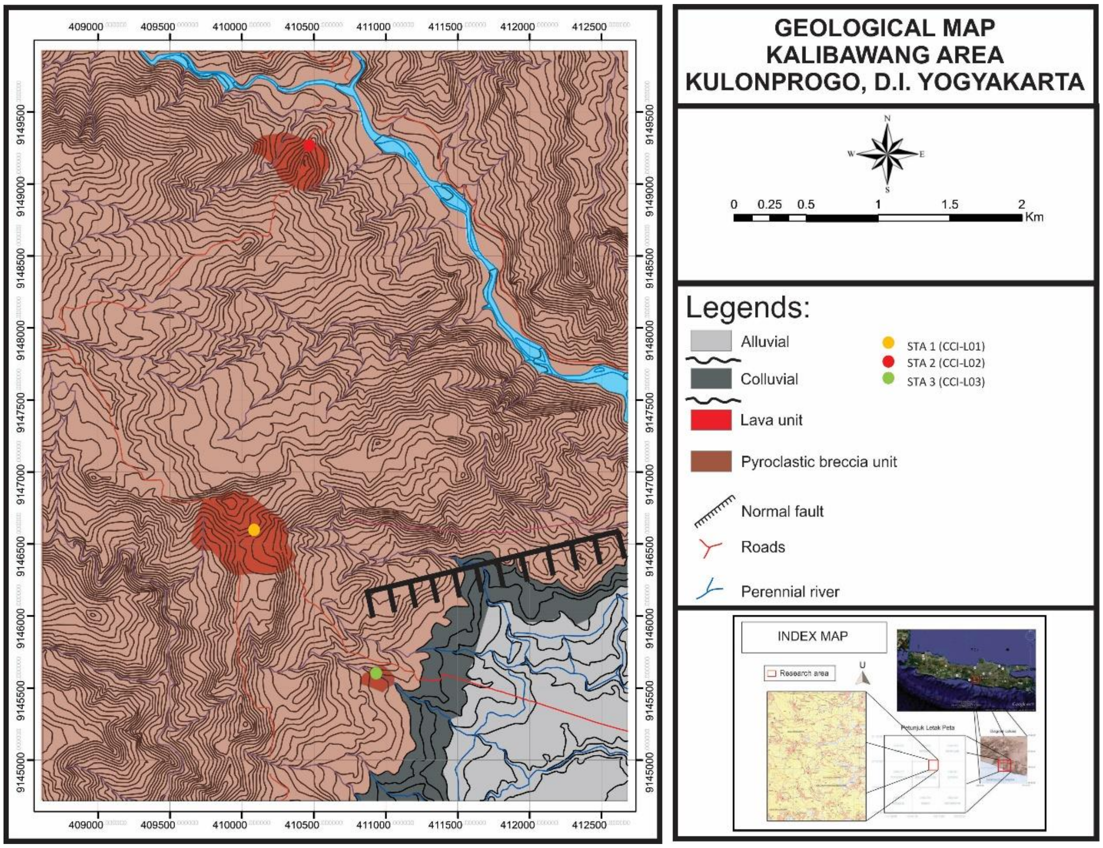

Fig. 1. The geological map of studied area showing the lava unit distribution and sampling location.

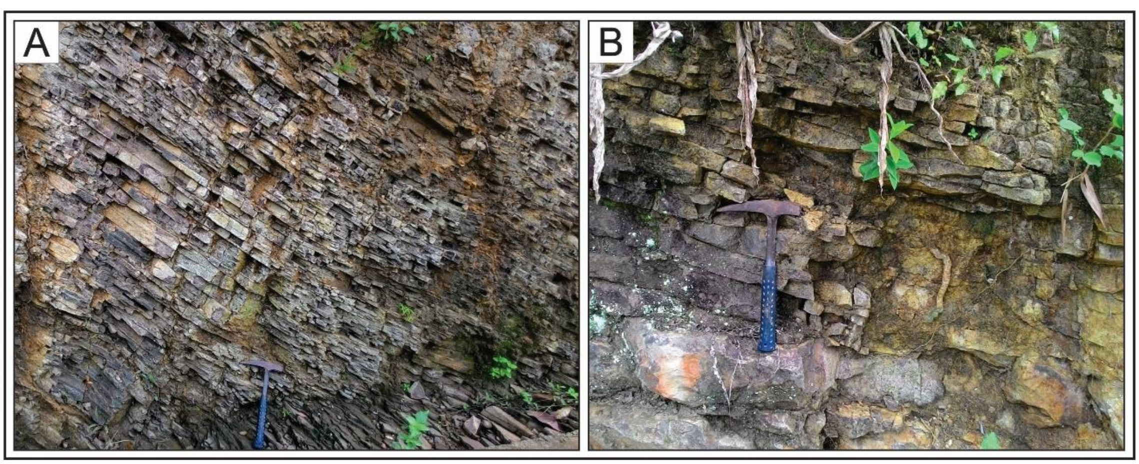

Fig. 2. (A) Lava outcrop in first location (CCI-L01) and (B) second location (CCI-L02, right) showing sheeting joint structure.

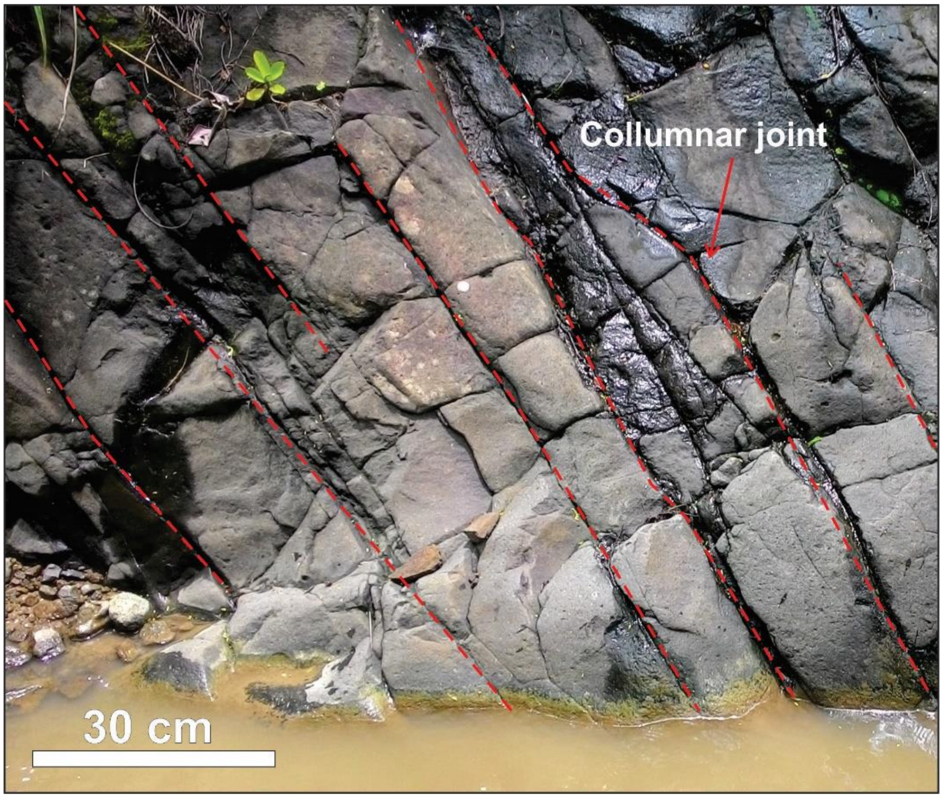

Fig. 3. Dyke remnant outcrop showing columnar joint structure with dip slope about 5-750 in variated direction

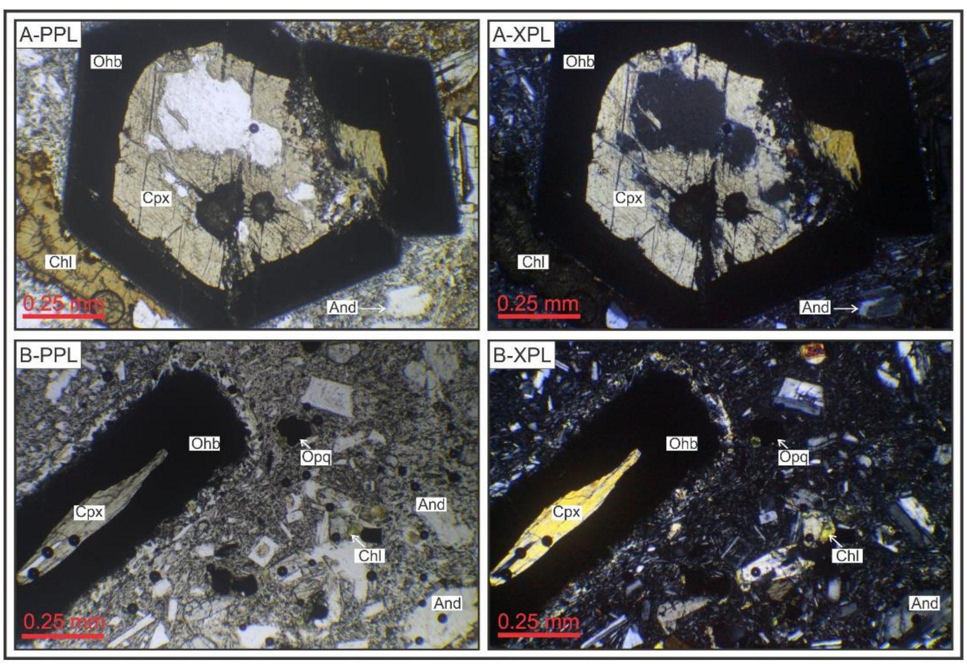

Fig. 4. Photomicrograph of sample CCI-L01 (A) and CCI-L02 (B) showing oxidized hornblende with Fe-Oxide at rim and clinopyroxene at the core. (Ohb: oxyhornblende; Cpx: clinopyroxene; Chl: chlorite; And: andesine; Opq: opaque).

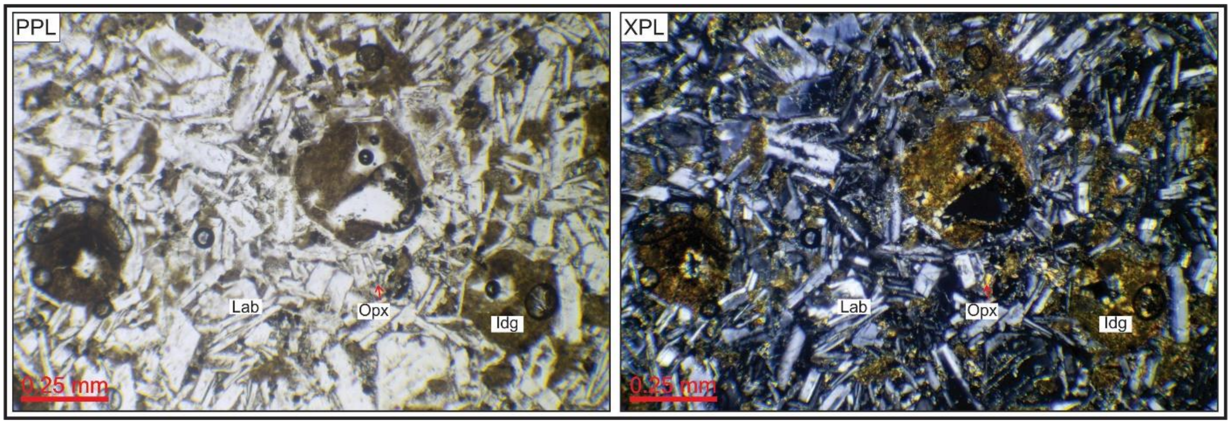

Fig 5. Photomicrograph of sample of sample CCI-L03 showing intergrowth texture between labradorite and iddingsite (Lab: labradorite; Opx: orthopyroxene; Idg: iddingsite).