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RESEARCH ARTICLE

Volcanism in The Pre-Semilir Formation at Giriloyo Region; Allegedly as Source of Kebo-Butak Formation in the Western Southern Mountains

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Abstract

Kebo-Butak Formation was known to be the oldest volcanic rocks limited in regional terms in the lower Baturagung Hills, Gedangsari area, Gunungkidul Regency. The main constituents of the Kebo-Butak Formation consist of intersection of volcanic-clastic rocks and calcareous sediments, locally also found basalt lava with pillow structures; which distinguished it from other volcanic rock formations in the Southern Mountains. This study aims to determine the relationship of volcanic rocks exposed in Giriloyo with the Kebo-Butak Formation in the Baturagung Hills; the chronostratigraphy and the history of volcanic activities that produced the volcanic rocks of Giriloyo. This research was approached by volcanic geological mapping using surface mapping suported by gravity anayses. From the bottom to the top of the frontier areas result volcaniclastic rocks consisting of black tuffs with several fragments of volcanic bombs with basalt composition intersecting with thin basaltic lava inserted by calcareous claystone having an age of N5-7 (Early Miocene); pyroxene-rich basalt volcanic sequence consists of thick layers of tuff with creamy-brown color intersecting with lava and breccia inserted by calcareous sandstone aged N7-8; dikes, lava and agglomerates with basaltic composition and lava and agglomerates with andesitic composition. Stratigraphically, the volcanic rocks exposed at Giriloyo correlated with the volcanic rocks exposed at Karangtalun (Wukirsari) were under the Semilir Formation, bordered with normal fault N210°E/77°, the hanging wall composed by light grey tuff of Semilir Formation. Gravity analyses found high anomalies below the Semilir Formation exposed at Karangtalun-Munthuk (east of study area) continued to below the Giriloyo area. The high anomalies were identified as the igneous/ignimbrite volcanic sequence. Descriptively and stratigraphically, the Giriloyo volcanic sequence are a part of Kebo-Butak Formation. The petrogenesis of the volcanic rocks will be discussed in further research to interpret magmatological properties, the evolving paleo-volcano, and the absolute age of the rocks.

Keywords: volcanic rock, Kebo-Butak Formation, black tuffs, basaltic lava, agglomerate, and stratigraphy

1. Introduction

Giriloyo is part of Sudimoro Range, which is administratively located in Wukirsari Village, Imogiri District, Bantul Regency, Yogyakarta Special Region, at 7°53'24 "-7°55'48" S and 110°24'-110°25'48 "E (Fig. 1). Earthquake, took place on 27 May 2006, has exposed volcanic rocks beneath the Nglanggeran and Semilir Formations on the surface, consisting of layers of black tuffs, breccias and basaltic lavas, agglomerates and basalt dikes in the wide areas of Imogiri District (Mulyaningsih et al., 2009), one of them was Pucung-Dengkeng area (Mulyaningsih & Sanyoto, 2012) and Giriloyo-Wukirsari 2km south of Dengkeng (Mulyaningsih et al., 2018). Descriptively, volcanic rocks that exposed at Giriloyo have similarities with the members of the Kebo-Butak Formation exposed at Gedangsari (Gunungkidul Regency), and stratigraphically, those rocks were beneath the Semilir Formation.

Landscape of Giriloyo as a part of Sudimoro Range saw circular feature facing to the west. Regionally, lithology composed Sudimoro Range were Semilir Formation and locally of Nglanggeran Formation, such as Wonolelo and Dengkeng (Bronto et al., 2009; Mulyaningsih & Sanyoto, 2012). Rahardjo et al. (1995) and Surono et al. (1992) determine the Southern Mountain stratigraphy; from the bottom to the top are Kebo-Butak Formation, Semilir Formation, Nglanggeran Formation, Sambipitu Formation, Oyo Formation and Wonosari Formation; the three oldest formations were volcanic origin, while the others were calcareous sedimentary rocks. The Kebo-Butak Formation was volcanic origin deposited in submarine, so that often intersecting with calcareous sedimentary rocks in the frontier facies, while the nearest vents were lava with pillow structures and thick beds of tuff and lapillistone (Mulyaningsih, 2016). The distinguished volcanic origin of the Semilir Formation was composed by very widely distributed volcanic sequences of dacitic-ryolitic tuff and lapillistone by very explosive Plinian-Mega-Plinian volcanic eruptions (Mulyaningsih & Sanyoto, 2012; Mulyaningsih et al., 2011; Bronto et al., 2008). According to Mulyaningsih, et al. (2018) the ancient volcano of Giriloyo was formed in a constructive phase of the sub-marine, at the top of the Lower Miocene N5-9 (Mulyaningsih, 2009).

Circular with horseshoe-shape geomorphology, radially sloping to the east, north, and south forming dome, so that geomorphologically it was thought to had been formed by active tectonism of submarine volcanoes, and by extraterrestrial descent, further deformed with varied structural patterns. The volcanic sequence should be part of the Kebo-Butak Formation, not to Nglanggeran Formation even Semilir Formation, covering central to the proximal facies, with a period of activity as long as the Kebo-Butak Formation that located at Baturagung Range. The aims of study were to determine the volcanic origin of Giriloyo formation, the relationship of the volcanic sequence with the Kebo-Butak Formation in the Baturagung Range, and the chronostratigraphy and history of the volcanic activities that built Giriloyo volcanic facies.

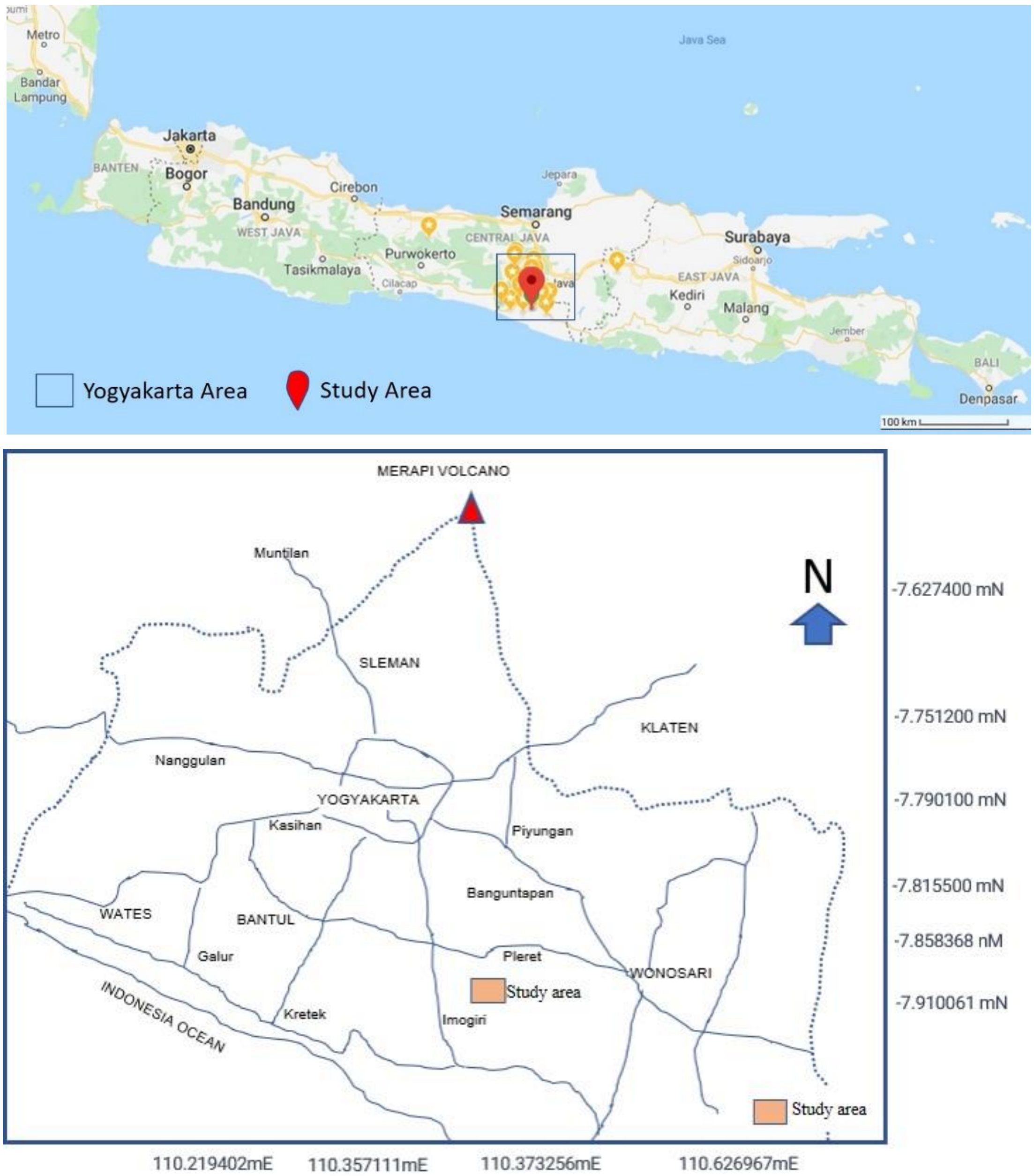

Fig. 1. Stress map of the study area.

2. Regional Geological Setting

Subduction of Indian-Australian Plate beneath the Eurasian Plate has recorded under south of Java Island (Smith et al., 2005; Zahirovic, et al., 2014; Zulfakriza et al., 2014). It controlled the tectonic of study area since Late Eocene resulted Tertiary Volcanic Arc along Southern Mountain, South Java Island (Suria-atmadja, et al., 1994; Koulali et al., 2017). That tectonic setting referred to the long-lived volcanism since Late Eocene to Late Miocene (Smith at al., 2011). Evidence of the earliest magmatism was Late Eocene located at Pacitan resulted basalt with pillow structures (Suria-atmadja, et al., 1994); represented to the lowermost part of Besole Formation aged Oligocene-Early Miocene. In Central Java at the same time, the magmatic event resulted tholeiitic volcanic rocks, as Luk Ulo Formation. The resultant volcanic products of this event were Old Andesite Formation (Oligocene-Early Miocene) which is limited to the center of West Progo Mountain. Outcrops of calc-alkaline basalt flow with pillow structures underlie the volcani-clastic of the Semilir Formation (Middle Miocene), as called as Kebo-Butak Formation (Late Oligocene-Early Miocene).

Referring to Rahardjo et al. (1995), regional stratigraphy of the western Southern Mountains, respectively, is composed of Middle Miocene of Semilir Formation, Middle Miocene of Nglanggeran Formation, Middle-Upper Miocene of Sambipitu Formation, Upper Miocene of Oyo Formation and Late Miocene to Early Pliocene of Wonosari Formation. On the top of Wonosari Formation, there is a Pliocene Kepek Member. Furthermore, Rahardjo et al. (1995) also describe the development of geological structures that are horizontal faults directed northwest-southeast which cut thrust faults of southwest-northeast, leaving a wedge extending on the north-northwest to the west of the Southern Mountains in Imogiri area. According to Surono et al. (1992), the rocks in the publication of Rahardjo et al. (1995) hitched above the Lower-Middle Miocene of Kebo-Butak Formation, at Gedangsari-Terbah (Gunungkidul Regency).

According to Surono et al (1992), Surono (2008), Kebo-Butak Formation from the bottom to the top are composed of basalt lava with pillow structures, intersecting of marls, calcareous claystones and calcareous sandstones, glass- and crystals- rich sandstones. Mulyaningsih (2016) determined the Kebo-Butak Formation as deep-to-neritic volcanic rocks of construction phase volcanic origin, shown by the intersecting volcanic deposits and calcareous marine sediments. Semilir Formation lies on Kebo-Butak Formation in an unconformity manner, consisted of basal layer with basalt fragments which was locally exposed at Watuadeg (Bronto & Mulyaningsih, 2001). Above Semilir Formation was volcanic rocks of Nglanggeran Formation, consisted of andesitic agglomerate, breccia and lava, Nglanggeran Formation is formed by volcanism which takes place in a very long time duration in the constructive phase (Bronto et al, 2008).

3. Method

The research was approached by ancient volcanic geological studies referring to the present volcanoes. The concept of the present is the to the past was used to identify the genesis of lithology. Principally, an igneous rock was always produced by magmatic activity, implementing to the volcanic origin nor pluton; rhyolitic, dacitic, andesitic and basaltic should be volcanic origin.

A volcano can be a composite that formed by less viscous magma building stratotype, less viscous ultrabasic magma built shield volcano, and a very viscous-plastic magma (as dacitic-rhiolytic) capable to blockage the vents under the crater triggering very explosive eruptions (Bronto, 2010; Mulyaningsih, 2013; and Schminche, 2004). The hypothesis is that volcanic rocks which are composed of andesitic-basaltic origin must be resulted by composite volcanoes activities, which were able to build their bodies forming high cones. As a result, magma flowed through the cracks that formed around the crater pipe to form a parasitic volcanic cone.

The study was begun with reference to collect the secondary data, followed by field geological mapping. Mapping included stratigraphic measure sections, rock samplings (for thin sections), collecting and measuring geological structures, and gravity. The work was continued with laboratory analyses; 11 sites have been sampled on black tuffs, bomb fragments of volcanic breccias, agglomerates, lava, and dykes, resulted 14 samples (Fig. 2). All of them were analyzed under a polarized microscope using magnificent of 40x-200x, and 8 others were carried out bulk chemistry using X-Ray Fluorescence. Thin section analyses were done in the laboratory of petrology of IST AKPRIND own. X-Ray Fluorescence analyses were done in the laboratory of Center For Nuclear Mines Technology (PTBGN-BATAN). All data have been compiled, and synthesized using overlay system.

4. Results

Tracks of geological observations throughout Cengkehan-Watulumbung, Giriloyo-Cengkehan and Cengkehan River (Fig. 2). In general, geomorphology of study area forms hilly landscape extending west-east, separated by Cengkehan River as part of a circular feature of Sudimoro Range, trending southwest-northeast facing to the west-northwest (Fig. 3). Many deformations are illustrated within the 3D DEM (Fig. 3). In the central landscape, precisely to the north of Sudimoro Range (+ 507 m), the circular consists of tight pattern of contours on the opening area, then turns to the northeast to form a basin between Muntuk (near Becici Hill) and Sudimoro. The western site of the opening feature is Mount Makbul (+ 339 m) and in the east is Becici Hill (+ 306 m; Dlingo District). Inside the opening circular are tuff and lapillistone of Semilir Formation, in a sub-dendritic drainage pattern.

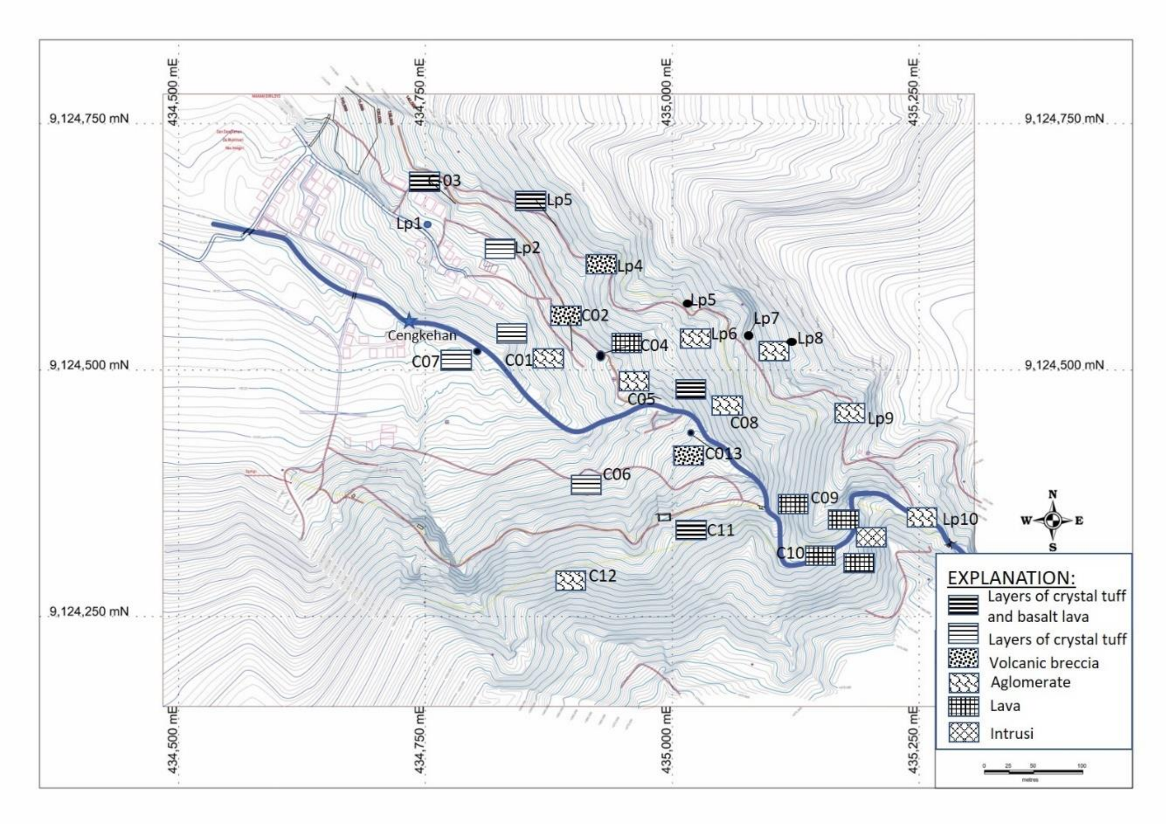

Fig. 2. Map of the track and location of observation

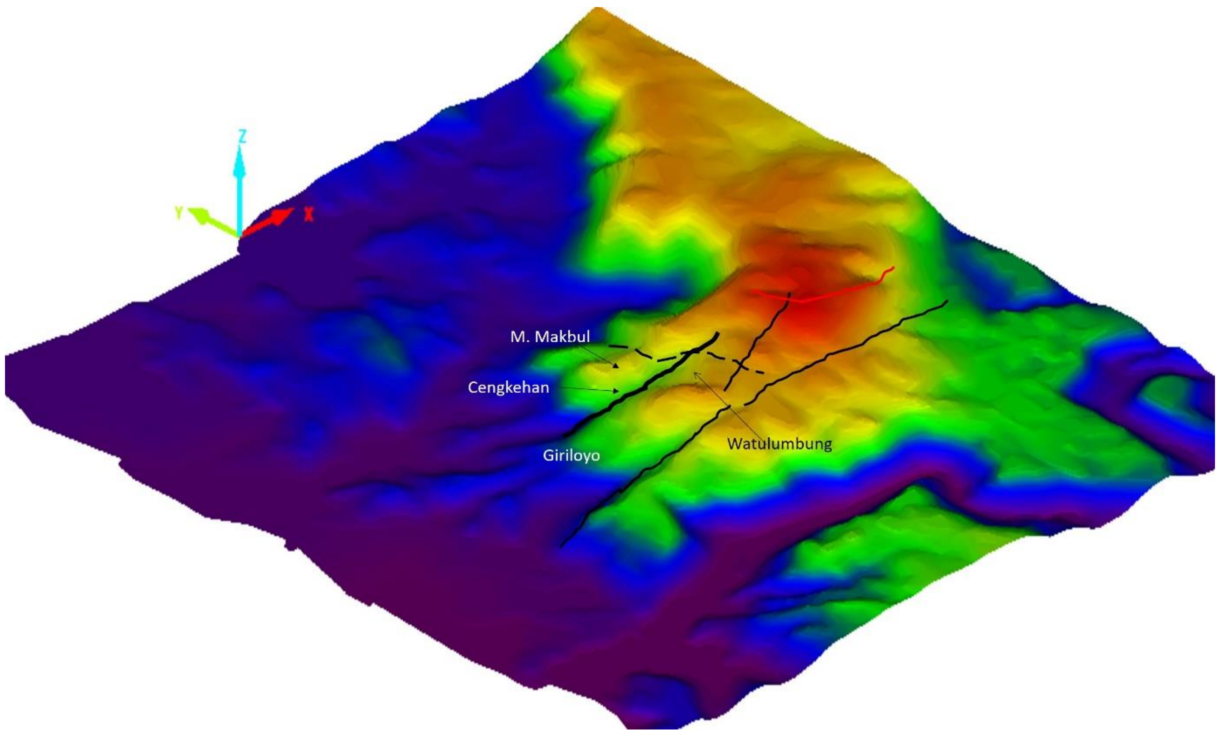

Fig. 3. The morphological appearance is based on DEM observation, describing the height in the middle with red feature as hilly topographic with east-west orientation.

The high landscape of Sudimoro Range consists of andesitic breccias, lava and dykes that composed of amphibole-rich andesite and pyroxene-rich andesite. Stratigraphically, the volcanic rocks composing Giriloyo are pyroclastic breccias, tuffs, lava, agglomerates and dykes varying in compositions; i e., basalt, pyroxene-rich andesite (basaltic andesite) and andesite. From the bottom to the top is intersecting tuff with black colour and basalt lava in about 15-20 m thickness; then intersecting black tuff and massive basalt breccia in about 10-12m thickness; calcareous claystone with laminated structures above the sequence having ages of N5-6 (Early Miocene). Above the calcareous claystone is brownish grey to yellowish dark grey (fresh), massive to layered tuff and pyroxene-rich andesitic breccia with the total thickness of 8-12m, unconformably above the breccia is agglomerate with pyroxene-rich andesitic bombs. Thin section analyses of lava and fragments of agglomerate show less vesicular structure, porphyritic-poikilitic, with very large phenocryst composed by 15-20% of augite-hedenbergite (pyroxene), 20-25% of smaller labradorite (plagioclase), ~5% of little grains of olivine embedded within smaller crystals and glass. Some lava has a layer of autoclastic breccia, some others then continually covered by agglomerate which is increasingly massive, and some others have pillow structures. The thickness of lava varies between 10 cm to 3 m. It's gradually having structures from sheetlike near waterfall to columnar near Watulumbung.

At Karangtalun and Bronjong (near Cegokan) at 7°52'58,3 "S and 110°26'39,7" E); its lithology consists of distinguished brown colour of pyroxene-rich sandstone, layered, @ 10-20 cm, having lithic fragments, and less calcareous. Those sedimentary rocks are looked interrelated to columnar lava; it's very different feature into Nglanggeran even Semilir Formation. The deposits are having an age of N5-7.

Massive volcanic breccia with block, bomb and little bit coral fragments were exposed at Pucung-Pilang and Sitimulyo at the coordinates of 110° 25 '40.5 "BT - 7° 51' 28.4"S. Below the volcanic breccia was layers of mudstone and calcareous sandstone having an age of N8-9 (upper Early Miocene). About 100m east of the outcrops, there was andesitic lava with andesine-labradorite, augite and pale green hornblende, the thickness is ~30-50m. It is vesicular, porphyritic with subhedral-anhedral shapes, 0.02-08mm Ø embedded in light grey glass. This lava is also exposed at Wonolelo (north of Sudimoro), that riches in sulphid minerals (pyrite). Layers of light grey tuff cover the volcanic breccia and lava at Wonolelo and Cinomati, Munthuk and lower Becici. It is correlated to the upper volcanic sequence at Giriloyo; i e. andesitic lava, agglomerate and dykes.

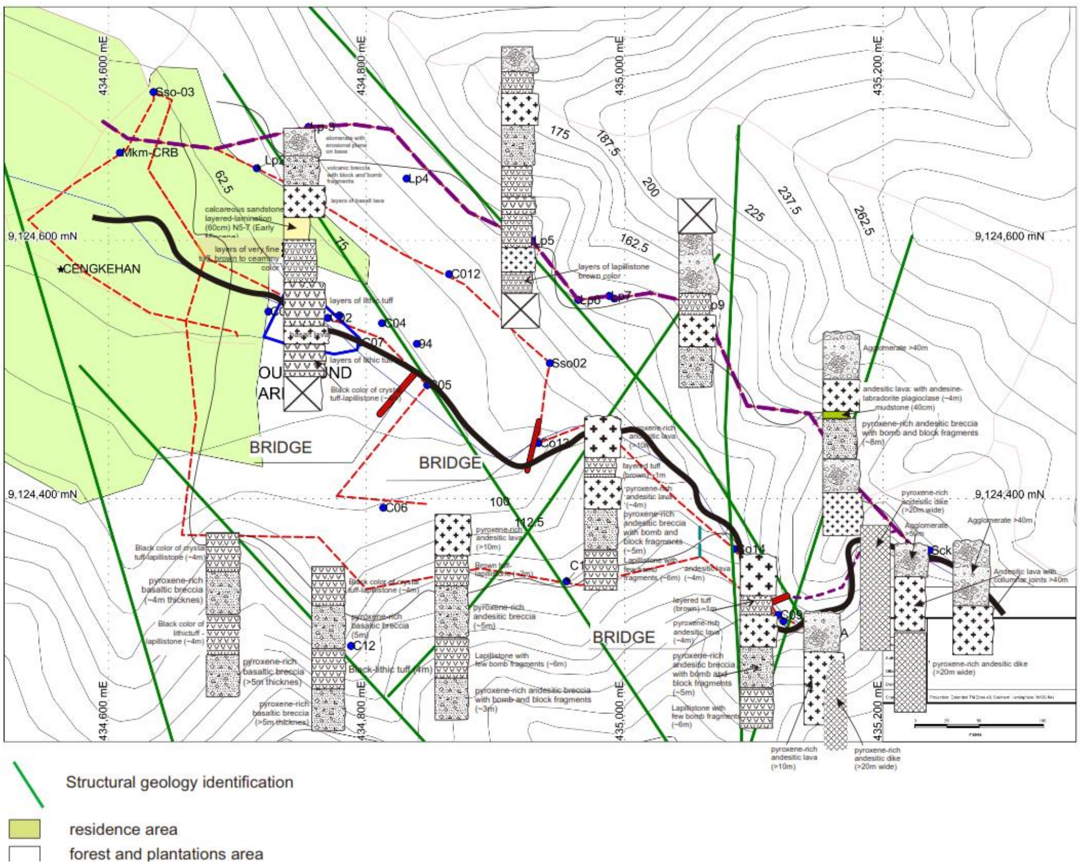

Fig. 4. Stratigraphic profiles of the volcanic rocks of Giriloyo-Cengkehan paleovolcano fields exposed at study area; green lines are interpreted faults (deformations)

Fig. 5. Volcanic rock outcrops along with Giriloyo-Cengkehan hamlets, composed by lithic and crystal tuff with thin lava layers, breccias, lava and agglomerate, and dykes

From the north to the south through Dengkeng to Cengkehan, in the coordinates of 110°25'3,2-11"E and 7°53'48-55"S, there are layers of dark-grey fine-tuffs and mudstone, covering black coarse tuff with layers of basaltic lava in about 10m thickness, dark brown crystal and lithic tuff. Among the layers of tuff and lava, there are chlorinated green tuff with granules of pyrite and rounds of basaltic bombs as matrix supported. Coverring tuff and lava is calcareous mudstone *Globoquadrina praedehiscens* Blow and Banner, *Globigerinoides Primordius* Blow & Banner, *Tripartite Globigerina* Koch and *Globigerina binaiensis* Koch having ages of N8-9. Andesitic breccia, lava and agglomerate lie on the sedimentary rocks.

As mention above, Cengkehan River is flowing in the middle of Sudimoro Range, separated south and north parts, forming Giriloyo palaeo-crater. It's covering an area with the altitude of 100-260m above sea level, the lithology consists of intersecting black tuffs and lavas; layers of black tuffs with bombs Ø 40cm, black tuffs, agglomerates and lava; layers of brown tuff, lapillistone, andesitic breccia and lava; sheets and columnar lava; dikes and chlorinated volcanic-clastic rocks.

Section along Watulumbung-Grenjeng (north of Cengkehan) consists of massive agglomerates and breccias, dikes, and massive lava. Lapillistone, lithic tuff and matrix-supported breccia in dark green color till very dark grey dominated the lithology at Grenjeng. Normal faults and dextral slip faults in the volcanic sequence Shawn triggering the mass movements. Fig. 4 explains measure sections stratigraphy at study area. The outcrops of Giriloyo volcanic rocks are explained in Fig. 5.

Thin section analysis on black tuff (sample of C1) determines deeply diagenetic tuff with poorly sorted of angular to very angular lithic and crystal clasts, with tuff sizes and composed by basaltic fragments, glasses, and crystals of pyroxene (augite-hedenbergite) and plagioclase (labradorite) cementing with silica. Agglomerate fragment (sample of C13) shows very hollow structure (due to the exhalation of gas when it freezes in the air), porphyritic with plagioclase (labradorite-andesine) and pyroxene (augite) phenocrysts in the groundmass of glass. The dike (sample of C10C) shows less vesicular, porphyritic with very large phenocrysts of pyroxene (augite) and plagioclase (labradorite) within the groundmass of fine-sized of aphanite crystals. Lava with columnar joints exposed at Watulumbung (sample No. C10B) is less vesicular, porphyritic with very large phenocrysts of pyroxene (augite) and plagioclase (labradorite) within the groundmass of glass and fine-sized of aphanite crystals. Sample No. C10A is lava with sheeting joints exposed at Watulumbung; vesicular structure, porphyritic with plagioclase (labradorite) and pyroxene (augite) phenocrysts in groundmass of glass. Most of the volcanic rocks exposed at Giriloyo were deeply deformed, forming shear faults, oblique normal faults, and normal faults trending north-south and east-west. Those faults are mostly cutting surface soils, so those are still active. Fig. 6 explains the thin sections of the varying volcanic rocks exposed at Giriloyo.

Observation near Mount Makbul reccords thick layers to massive lapillistone with pumice fragments and tuff of Semilir Formation. Above them is Nglanggeran Formation that composed by agglomerate, breccia and lava that were resulted by constructing phase volcanism (Mulyaningsih, 2015).

5. Discussion

The discovery of a group of volcanic rocks with the main composition of lava and andesite breccia under the Semilir Formation provides evidence of the construction stage of a composite volcano in Giriloyo-Imogiri. The distribution of the old volcanic rocks is indeed very wide from the Imogiri District to the east, but no contact with Semilir Formation in Giriloyo; it is directly boarded by agglomerates of Nglanggeran Formation. Tight contacts are found in Dengkeng-Pucung (Wukirsari; ± 1.5 km to the north of Giriloyo) and Wonolelo (Pleret District). In Pucung and Wonolelo, at the boundary between the layers of andesite lava and pyroclastic breccia (below) as primary products of composite volcanic cones and Semilir Formation (upper) nor the opposite, are epiclasticic sediments, both in the form of conglomerates and calcareous sediments of sandstone, siltstone and claystone, and mudstone. So, it was a time interval between not having a long enough volcanism and the stages of composite construction (Nglanggeran Formation) with the destruction stage of the caldera formation (Semilir Formation). The assumption is every basaltic volcanic rock are Kebo-Butak Formation, every dacitic volcanic-clastic rocks are Semilir Formation, and every andesitic volcanic rock is Nglanggeran Formation.

Wide distributed volcanic rocks were at Gunung Gede, Dengkeng-Pucung, Giriloyo-Cengkehan, Munthuk-Karangtalun and Wonolelo-Sudimoro. This situation answers the hypothesis that the Sudimoro Range, in which is Giriloyo, was an ancient volcano. Volcanic activity can take place for a long time, resulting in sulphidic mineral deposits. However, by the submarine situations, it was associated with clastic calcareous sediments. Layers of the fine-grains volcaniclastic deposits with dark-coloured rich in volcanic bombs in Cengkehan are increasingly coarse into Watulumbung and other places around it, aged in the ranges of N5-9 (Lower-Middle Miocene), indicates that volcanic activity was at least sourced in these.

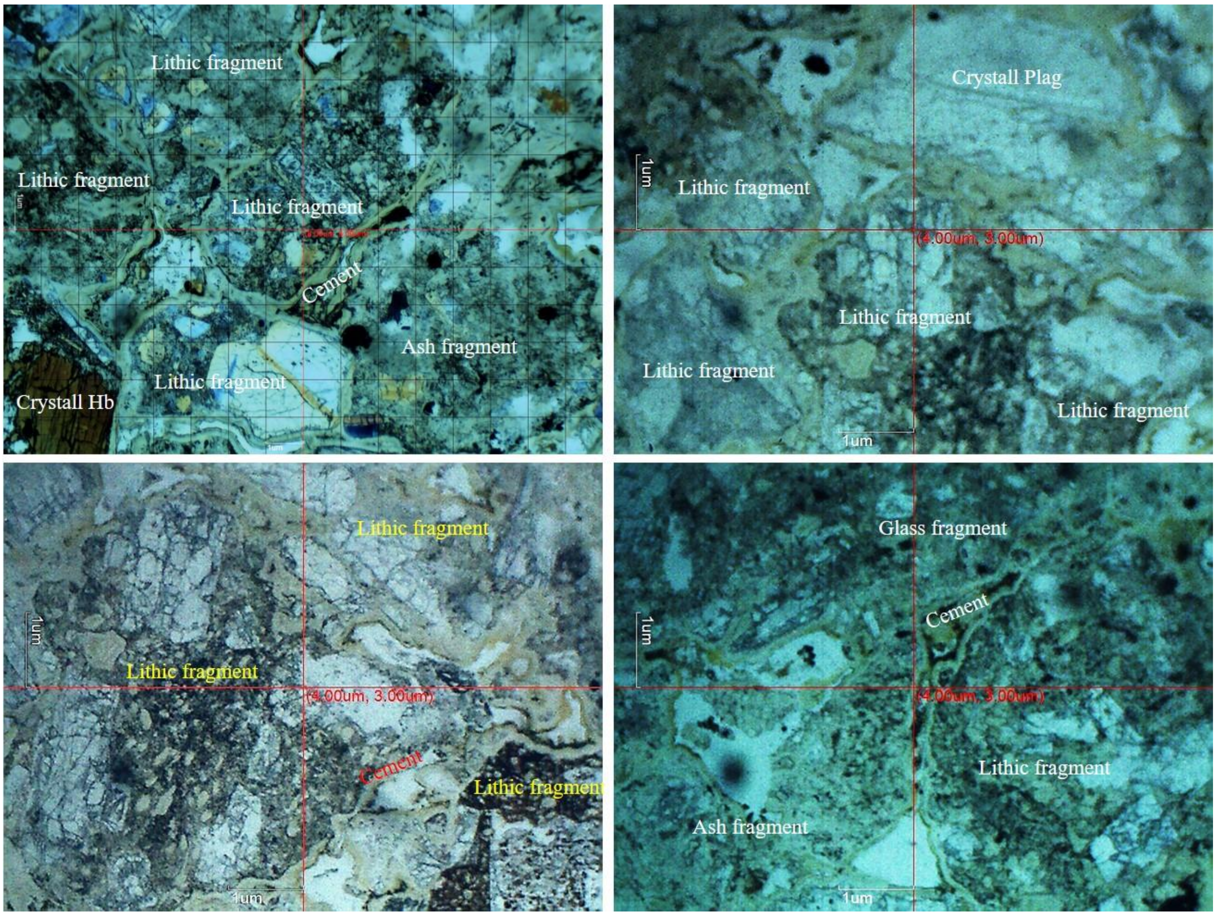

Fig. 6. Parallel Nikol of lithic tuffs exposed at Cengkehan; from the upper right counterclockwise are C01A, C01B, C02, and C03. It shows lithic fragments with irregular shapes but some featuring circle shape, vuggy and cementing with silicic materials

Based on the regional geology by the previous studies, reported Kebo-Butak Formation aged Late Oligocene to Early Miocene, was exposed at Tegalrejo-Gedangsari (Gunungkidul; Mulyaningsih, 2016) and Gunung Kebo and Butak (Bayat, Klaten; Surono et al., 1992). It consisted of submarine volcaniclastic deposits associated with calcareous sediments. The distinguished volcanic rocks were basalt (as sill, dykes and lava), black colour of rich-glass crystal tuffs, layered yellowish to creamy crystal tuff, and laminated light grey dacitic tuff (Mulyaningsih, 2016). That's why, Surono (2009) interpreted Kebo-Butak Formation as deep-sea turbiditic sequence affected by volcanic origin. But, petrologically, every lava nor shallow intrusion (such as andesite and basalt dyke and sill) should be volcanic origin (Mulyaningsih, 2015), so Kebo-Butak Formation were not turbiditic origin, but volcanic constituents.

The problem was, those volcanic rocks were assumed as submarine; Kebo-Butak Formation as deep-sea up to neritic, Semilir Formation could be neritic, transition to subaerial, and Nglanggeran Formation was neritic-transition. According to Mulyaningsih (2016), Surono et al. (1995) and Surono (2009), Kebo-Butak Formation were composed of intersecting fine-grains volcaniclastic rocks with basalt lava and calcareous sediments, some of them (massive lapillistone) contained coral and blocks of basalt fragments. The upper layers were crystal tuff with pyrite granules in basaltic-andesitic volcanic beds. Locally, there is basalt lava with pillow structures. Correlated to the volcanic rocks exposed at Giriloyo, there are some similarities for the structure, texture and composition. The volcanic rocks of Giriloyo consist of intersecting black colour of basaltic tuff riches lithic and crystals and basalt lava and breccia. Above them are basaltic to andesitic volcanic-clastic deposits. Both basaltic and andesitic sequences were separated by calcareous sediments of N5-9 (relatively). Watulumbung volcanic rock consists of lava with columnar joints, dykes, agglomerates and transitional lava and dikes (with sloping column structures). Gravity (Fig. 7) shows 3 peaks of Bouguer anomalies of 1.3-1.9 mGal (red-pink); among them are basins with low anomaly of -2.1 mGal in blue. The high anomalies are interpreted as volcanic/shallow igneous, while low anomaly is sedimentary rocks deposited between the volcanic highs. The gravity also illustrates a red shade overlaps to a circular high. That explains any superimposed volcanism, could be The Nglanggeran Formation over the other Nglanggeran Formation, or the Kebo-Butak Formation and the Nglanggeran Formation. So based on the similarities as mention above, the superimposed volcanism must be Kebo-Butak Formation overlie by Nglanggeran Formation.

In general, the high of east-southeast Giriloyo was the main volcano, while Giriloyo as a parasitic cone adjacent to the main volcano. Microseismic data collected at Watulumbung encountered weak fields in the south, that increasingly stronger to the north (Fig. 8). The weak fields are having east-west orientation interpreted as fault systems. Between them are heights that interpreted consist of lava and dykes. Those distinguished subsurface lineaments trending north-south near Waterfall (C13) and east-west through Grenjeng and cut off lineaments near waterfall. It can be synthesized that volcanism and tectonism were continually presented in long time duration.

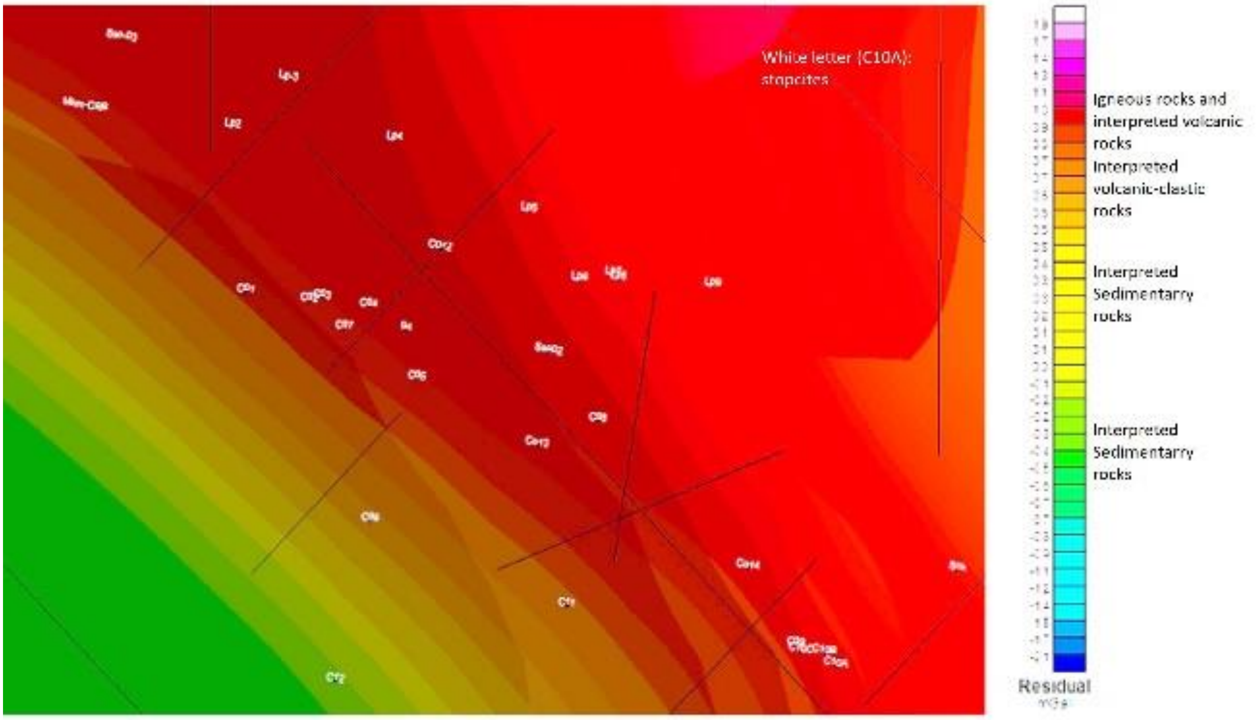

Fig. 7. The subsurface geological appearance of the Giriloyo volcanic rocks compiled with surface geological structures

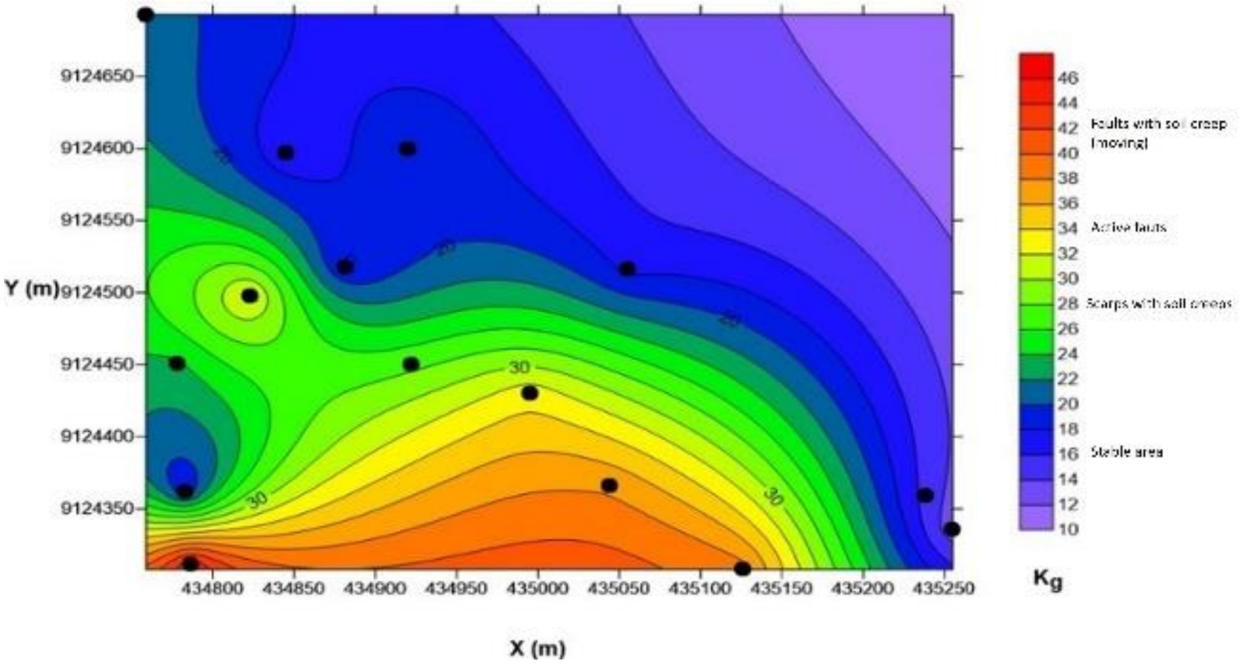

Fig. 8. General description of subsurface geological survey using microseismic method at Watulumbung (stopcite C10 and C13); on the surface composed of igneous intrusions, lava, and agglomerate

Lithology exposed at Giriloyo and the surrounding area consists of volcanic rocks, i e., intersections of blackish crystal tuff, lithic tuff and basalt lavas of creamy-brown colour crystall and lithic tuff, basaltic-andesitic breccia and lava, andesitic lava nd agglomerates, and basaltic-andesitic dikes. Stratigraphically, the rocks are below the Semilir Formation. There are no fossils found in those volcanic rocks, but about 500m to the west, northwest, east and north in Giriloyo, Pucung, lower Cengkehan, Munthuk and Karangtalun; there are calcareous sedimentarry rocks above the blackish tuff age of N5-6, N5-7 (Early Miocene), the calcareous rocks above the Semilir Formation are N8-9 and N5-N9 (lower Middle Miocene). If the volcanic rocks of Semilir Formation are formed by a very explosive eruption that can form a caldera, it only takes a short time. So, volcanic activity that produces volcanic rocks below the Semilir Formation is certainly not much older than the rocks that make up the Semilir Formation. When compared with regional geological data, stratigraphically, the Giriloyo volcanic rocks were same age as the Kebo-Butak Formation. Referring to Kebo-Butak Formation exposed at Gedangsari and Bayat, the volcanic rocks composing the Giriloyo area are part of a Tertiary volcano cluster developing in the early Miocene.

The composition of volcanic rocks in Giriloyo consists of dike, lava, agglomerate and fragmented tuff with bombs and blocks fragments; indicates as central volcano, or very close to the central facies. The columnar structure of the lava can be interpreted as a large volume of lava mass impounded within a basin (should be crater) and then stagnated and frozen slowly, to form a stocky column. Planar columns on a wide rock distribution, containing sulphide mineral, reflects the intrusion taking place over and over again. Subsurface data interpret the volcanic rocks extends at the bottom and deeply deformed. Based on gravity anomalies recognized at least three volcanic rock formations, (a) beneath the Semilir Formation, (b) Semilir Formaton and (c) Nglanggeran Formation.

Thin section observation into black tuffs are arranged by lithic and subhedral to euhedral crystals. The lthics are basaltic with labradorite plagioclase, which is well-certified within silicic cement. Andesitic-basaltic lava is vesicular, porphyritic, consists of labradorite (40%) and augite phenocrysts (30%) within glassy groundmass. Basalt with sloping column is vesicular, porphyritic consists of augite-hedenbergite (up to 4mm in diameter), large labradorite in glassy groundmass; basalt with planar column is massif, in equigranular, hypocrystalline (less glass), consists of small percent of labradorite (~20-30%) and larger augite (up to 6mm in diameter; 60%) and glass. Those rocks can be referred to as andesite, but compositionally, is very different to the Nglanggeran Formation exposed at Mount Nglanggeran (at Baturagung Range), that dominated by andesine, amphibole and clinopyroxene (Bronto et al., 2009).

Both stratigraphy and petrology of Giriloyo volcanic sequence is older than the Nglanggeran Formation. It is worth being of Kebo-Butak Formation in the Late Oligocene to Early Miocene.

6. Conclusion

Giriloyo was submarine ancient volcano since Late Oligocene-Early Miocene to Middle Miocene, resulting Kebo-Butak Formation and Nglanggeran Formation. No Semilir Formation between them. Active tectonism under controlled by volcanism carried out since the volcanism until now as well as intensive terrestrial denudation. Those were implicated by the repeated volcanism, during the long period. The evolving volcano is needed further research to interpret the magmatological and evolving volcanic activities.

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