

New nomenclature of Mt. Penanggungan stratigraphy, Pasuruan and Mojokerto Regency, East Java

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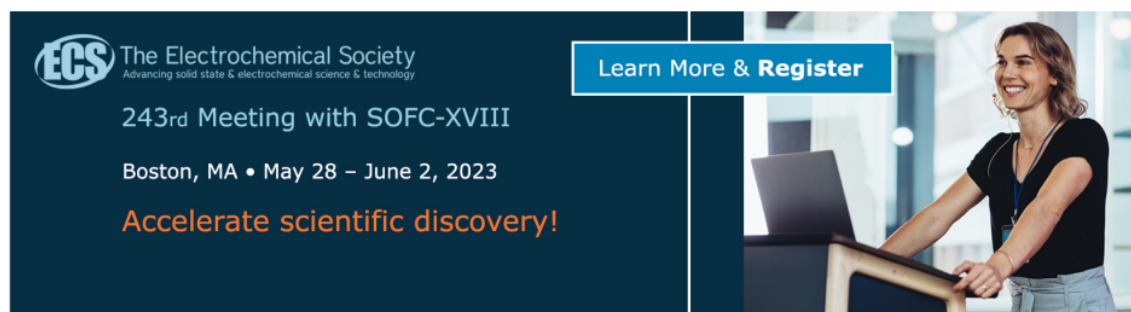
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New nomenclature of Mt. Penanggungan stratigraphy, Pasuruan and Mojokerto Regency, East Java

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Abstract. Mt. Penanggungan is geographically located in UTM X : 675400 to 685800, and UTM Y : 91621200 to 9153900, within the jurisdiction of Mojokerto and Pasuruan regency, East Java province. For long period, Mt. Penanggungan has been described as "Penanggungan Volcanics", in form of Upper Quarter - Pyroclastic Unit of Penanggungan. The research involved four steps: (1) Preparation step, (2) Data collection step, (3) Data analysis step, (4) Reporting step. Based on field data and adjusted with Van Zuidam (1983) modification, authors divided the morphology into 6 units: Upper volcanic slope (V1), Middle volcanic slope (V2), Lower volcanic slope (V3), Parasiter Cone (V4), Volcanic Cone (V5), and Volcanic Valley (V6). Research showed that Mt. Penanggungan has varied lithology, such as pyroclastic flow sedimentation, pyroclastic avalanche sedimentation, lahar and lava sedimentation. Every unit showed certain characters. Mt. Penanggungan and its parasiter cone could be categorised into Khuluk of Mt. Penanggungan, which were: Mt. Geting sand dune, Mt. Gajahmungkur sand dune, Mt. Bekel sand dune, Mt. Jambe sand dune, Mt. Kemuncup sand dune, Mt. Wangi sand dune, and Mt. Bendo sand dune. Mt. Penanggungan kept historical stories such as temples, shrine cave, altar of ritual, and *petirtaan*. These sites were mainly located on lava of Mt. Penanggungan and other lava of its parasiter cone. There were at least 120 remaining sites of Ancient Mataram (10th century) until Majapahit era (14th century).

1. Introduction

Penanggungan mountain is a 1,653 metres mountain from sea level. It is administratively located in Mojokerto and Pasuruan regency. It is about 45 km from the city of Mojokerto to the north. Mt. Penanggungan in Geological Mapping Sheet of Malang is determined as Penanggungan Volcanics of Pyroclastic unit of Mt. Penanggungan Kuartar Atas [5]. Based on Morphostratigraphy study, this volcano has 18 units of 6 morphosets and 12 morphounit. Mt. Penanggungan keeps ancient sites as the result of Ancient Mataram legacy in the 10th century until Majapahit era in the 14th century. These archaeological sites are spread on Mt. Penanggungan, from the bottom up to the peak and there were about 120 sites that can be found.



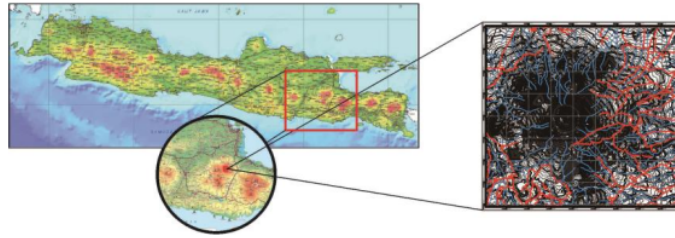


Figure 1. Research Location of Mt. Penanggungan

2 Method

The research involved four steps: (1) Preparation step, (2) Data collection step, (3) Data analysis step, (4) Reporting step. Preparation included library study permit preparation, tools preparation, and data collection area planning. Data collection step were implemented through morphology, stratigraphy, and petrology monitoring, and involved random sampling approach on obtaining sample of rock. Meanwhile, laboratory and studio analysis were used to implement data analysis step, and reporting step was implemented in studio to provide the whole research report.

2.1. Geological System

Penanggungan mountain is a 1,653 metres mount²¹ from sea level. It is administratively located in Mojokerto and Pasuruan regency, and coordinately located in UTM X : 675400 to 685800, and UTM Y : 91621200 to 9153900Mt. Penanggungan is located in volcanic arc of quarter Solo which bordered by Kendeng zone at north and Southern mountain at south [1]. These are located in volcanic line of Mt. Arjuna – Mt. Welirang – Mt. Butak – Mt. Penanggungan and volcanic line of Mt. Kelud – Mt. Arjuna – Mt. Bromo. Volcanic line of Mt. Penanggungan is Watukosek fault with direction from southwest – northeast to Porong.

Regional stratigraphy in research area consisted of stone unit of Middle Quarter Volcano, aged Middle Pleistocene until Early End of Pleistocene. These unit were overlaid by stone unit of Mt. Arjuna – Welirang, consisted of breccia, turf, lava, agglomerate, and lahar, with End of Pleistocene. On these unit, there were stone unit of Upper Quarter Volcano, which consisted of sedimentation of Mt. Penanggungan and Mt. Panderman, in form of parasite pyroclastic on the slope of Mt. Welirang and in form of holocene-aged andesite sedimentation on Mt. Kawi [5].

3. Result and Discussion

3.1. Geomorphology

Volcanic morphology is an interaction between endogene and exogen process to create earth surface to be a different and specific morphology as well. Thro²²ugh introducing morphology aspects on the field, authors wrote three units of contour in research area: Upper volcanic slope (V1), Middle volcanic slope (V2), Lower volcanic slope (V3), Parasiter Cone (V4), Volcanic Cone (V5), and Volcanic Valley (V6)

3.2. Volcanostratigraphy

Volcanostratigraphy categorisation of Khuluk Mt. Penanggungan [3] based on material elements of eruption and genetical unit of stone, consisted of honblende andesite lava, pyroclastic flow sedimentation, pyroclastic avalanche sedimentation, pyroclastic blow sedimentation, and lahar sedimentation. Khuluk Mt. Penanggungan has 7 parasiter cone sand dunes, which are Mt. Jambe (in the west), Mt. Gajah Mungkur (in the northeast), Mt. Bendo (in the south), Mt. Bekel (in the southwest), Mt. Genting (in the north), Mt. Kemucup (in the southeast), and Mt. Wangi (in the east).

The stone units from the oldest to the youngest were consisted of: Lava unit of Penanggungan 1 (Plv 1) Jambe, Lava unit of Penanggungan 2 (Plv 2) Gajahmungkur, Lava unit of Penanggungan 3 (Plv 3) Bekel, Pyroclastic flow unit of Penanggungan 1 (Pap 1) Bekel, Lava unit of Penanggungan 4 (Plv 4)

Bendo, Pyroclastic flow unit of Penanggungan 2 (Pap 2) Bendo, Lava unit of Penanggungan 5 (Plv 5) Genting, Lava unit of Penanggungan 6 (Plv 6) Wangi, Pyroclastic flow unit of Penanggungan 3 (Pap 3) Wangi, Lava unit of Penanggungan 7 (Plv 7) Kemuncup, Lava unit of Penanggungan 8 (Plv 8) Watesnegoro, Pyroclastic flow unit of Penanggungan 4 (Pap4) Kemuncup, Pyroclastic flow unit of Penanggungan 5 (Pap 5) Masjedong, Lava unit of Penanggungan (Plv 9) Kedungudi, Pyroclastic flow unit of Penanggungan 6 (Pap 6), Lahar unit of Arjuna-Welirang 1 (Alh 1) Janjing, Lahar unit of Penanggungan 1 (Plh 1) Bekel, Lahar unit of Penanggungan 2 (Plh 2) Kemucup, Lahar unit of Penanggungan 3 (Plh 3) Masjedong

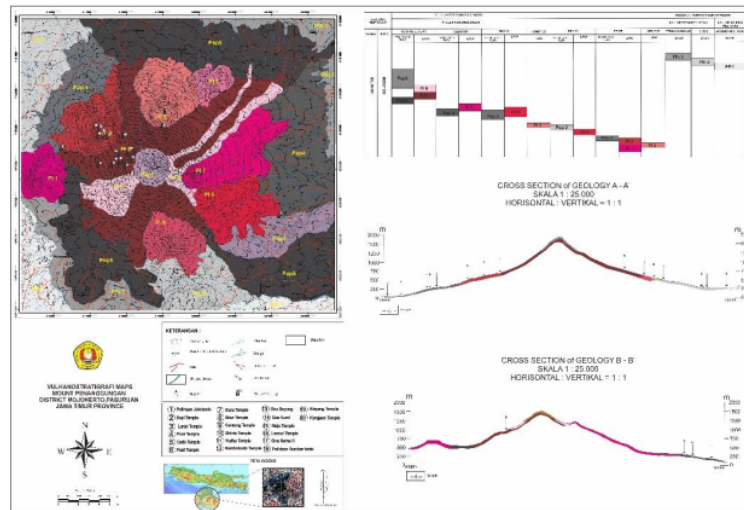


Figure 2. Vulkanostratigrafi maps of Mt. Penanggungan

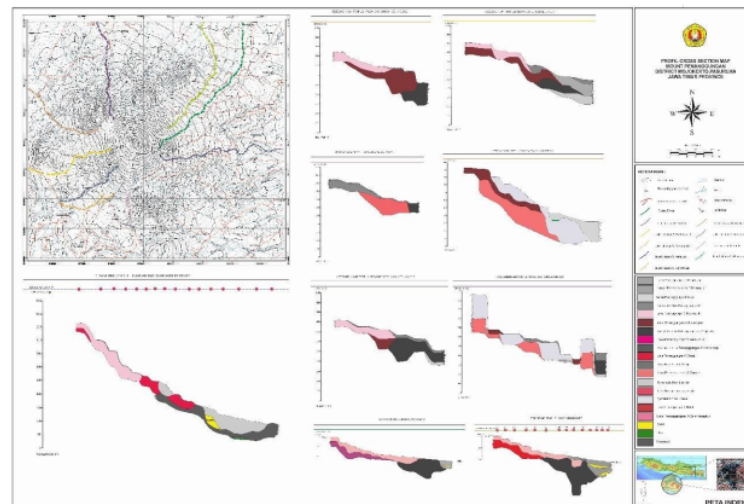


Figure 3. Profil cross section maps of Mt. Penanggungan

3.2.1. Lava unit of Penanggungan 1 (Plv 1) Jambe

It is consisted of blackish-grey-coloured pyrocene andesite lava, massively structured, with hypocrysaline crystalization degree texture, aphanitic-phaneritic, with euhedral-subhedral crystal form, with granular hypidiomorphic crystal connection, and inequigranular fabric. Mineral composition were consisted of plagioclase, pyrocene, hornblende, glass mass, and mineral opaque. Stratigraphically, the unit was conformably overlaid by pyroclastic flow unit of 1 (Pap 1) Bekel, and pyroclastic flow unit of Penanggungan 5 (Pap 5) Masjidong, lava unit of Penanggungan 8 Kedungudi (Plv 8). It is the oldest lava within the complex of Mt. Penanggungan. The unit is covered and exposed within Kedungudi area and in Mt. Jambe, in the west of Mt. Penanggungan. Spheroidal weathering was occurred there

3.2.2. Lava unit of Penanggungan (Plv 2) Gajahmungkur

The unit was created by andesite lava as the result of Mt. Gajahmungkur eruption. It is brown, with hypocrysaline crystalization degree texture, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, pyrocene, hornblende, glass mass, and mineral opaque. This lava has many cracks and weathered, such that condition make it a good aquifer, and water can be found here. This lava can be found in Mt. Gajahmungkur and in the north of Mt. Penanggungan, which relatively located 4.5 meter within research area to the north.

3.2.3. Lava unit of Mt. Penanggungan 3 (Plv 3) Bekel

The unit was created by andesite and basalt lava as the result of Mt. Bekel eruption. It is blackish-grey, with hypocrysaline crystalization degree texture, phaneric-aphanitic, with anhedral-subhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, pyrocene, hornblende, glass mass, and mineral opaque. Meanwhile, basalt lava is blackish-grey, massively structured, with hypocrysaline crystalization degree texture, aphanitic, with euhedral-subhedral crystal form, with panidiomorphic granular – hipidiomorphic granular connection, and porphiritic inequigranular fabric. Mineral composition were consisted of plagioclase, olivine, quartz, pyrocene, hornblende.

The lava is located in mt. Bekel area, Seloliman village, while the exposed is limited by Watutalang and Sumber river. Stratigraphically, it is conformably placed under Pyroclastic flow unit 1 (Pap 1) of Bekel, and lava unit of Penanggungan 5 (Plv 5) Masjidong as the result of Mt. Penanggungan eruption. The lava is the base of Kendalisodo Temple, which was originally carved on andesite lava of Mt. Bekel.

3.2.4. Pyroclastic flow unit of Penanggungan 1 (pap1) Bekel

The unit is pyroclastic flow as the result of Mt. Penanggungan eruption. The pyroclastic flow is grey, poorly sorted, close fabric, with subangular-angular, circularity degree, with 2 cm-12 cm items, pyrocene andesite fragment, sand matrix. This unit was founded in Seloliman village. This pyroclastic flow is stratigraphically placed under pyroclastic flow unit of Penanggungan 5 (Pjp 5) Masjidong and Lahar unit of Penanggungan 1 (Plh 1) Bekel.

3.2.5. Lava unit of Penanggungan 4 (Plv 4) Bendo

It is blackish-brownish grey coloured andesite lava, massively structured, with hypocrysaline crystalization degree texture, soft phaneric, with anhedral-subhedral crystal form, with inequigranular fabric. Mineral composition were consisted of plagioclase, pyrocene, mineral opaque, and glass mass. The lava andesite is the product of Mt. Bendo in the south of Mt. Penanggungan. It can be found in Belik village, and its existence on lava unit of Penanggungan 5 (Plv 5) Watesnegoro, was separated by Belik river. It is conformably overlaid under lava unit of Mt. Penanggungan 5 (Plv 5) Watesnegoro and Pyroclastic flow of Mt. Penanggungan 5 (Pap 5) Masjidong.

3.2.6. *Pyroclastic flow unit of Penanggungan 2 (Pap 2) Bendo*

It is the result of Mt. Bendo eruption, located in Belik village. It is brown-coloured sedimentation, close fabric, with subangular-angular circularity degree, 4-11 cm items, andesite fragment, with sand matrix. It is conformably overlaid under Pyroclastic flow of Mt. Penanggungan 5 (Pap 5) Masjedong

3.2.7. *Lava unit of Penanggungan 5 (Plv 5) Genting*

The unit is consisted of andesite lava lithology as the result of Mt. Genting eruption. It is brown coloured andesite lava, with hypocrysaline crystalization degree texture, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, hornblende, pyrocene, mineral opaque, and glass mass. It is conformably overlaid on the lava unit of Penanggungan (Plv 2) Gajahmungkur and under the lava unit of Penanggungan (Plv 8) Watesnegoro. It can be found in the north of Mt. Penanggungan, including Manduro-Wotan Masjedong. And its existence on lava unit of Penanggungan 5 (Plv 5) Watesnegoro, was established similarly, with faults on Genting area with 2m thickness, to the north. Statues can be found and carved on it.

3.2.8. *Lava unit of Penanggungan 6 (Plv 6) Wangi*

This unit is consisted of andesite lava as the result of Mt. Wangi eruption. It is brown coloured andesite lava, with hypocrysaline crystalization degree texture, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, mineral opaque, and glass mass. It is stratigraphically located under lava unit of Penanggungan 7 (Plv 7) Kemuncup. It is located in East sector of Mt. Penanggungan, including Wonosunyo area with 3.5 m thickness, with outcrops that can be found in sub-river stream of Wangi, in Jerukpurut area in Wonosunyo. It is evenly exposed in the research area, relatively to the west.

3.2.9. *Pyroclastic flow unit of Penanggungan 3 (Pap 3) Wangi*

It is dominantly consisted of brown coloured, poorly sorted, open fabric, angular-subangular circularity, with 305 cm-sized items of pyroclastic flow. Fragments that can be found there are: andesite with plagioclase, pyrocene, opaque, silica cement and glass mass. These are the results of Mt. Wangi eruption to the southeast to the east of Mt. Penanggungan, with angle to the east. Based on the observation on the cliff and outcrops of riverstream, the unit has 2-3 m thickness. These outcrops can be found in Wonosunyo and sub-riverstream of Wonosunyo and Sukoreno village.

3.2.10. *Lava unit of Penanggungan 7 (Plv 7) Kemuncup*

This unit is consisted of andesite lava as the result of Mt. Kemuncup eruption. It is grey coloured, with hypocrysaline crystalization degree texture, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, pyrocene, mineral opaque, and glass mass. It is sedimented on the pyroclastic flow of Penanggungan 4 (Pap4) Kemuncup. It is diversified in the east of Mt. Penanggungan, with 3 m thickness, in Wonosunyo village. It is similarly exposed in the research area to the east.

3.2.11. *Pyroclastic flow unit of Penanggungan 4 (Pap 4) Kemuncup*

The unit is the result of Mt. Kemuncup eruption, in form of pyroclastic flow with brownish-grey coloured, poorly sorted, close fabric, sub angular-sub rounded circularity. The fragments are grey andesite, with 0.2-20 cm (pebbles-cobble), with hypocrysaline crystalization degree texture, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, pyrocene, mineral opaque, and glass mass. The matrix are in form of sand stone with size approximately about 0.5-2 mm (coarse sand-very coarse sand), poorly sorted with plagioclase, mineral opaque, glass mass, and silica cement composition. It can be found in the east of Mt. Penanggungan, including Jerukpurut and Wonosunyo. The thickness is about 3m, based on outcrops on the cliff and path around Jerukpurut and Wonosunyo area. It is evenly spread in the research area with the layer to the east. It is stratigraphically located under the lava unit of Penanggungan 7 (Plv 7) Kemuncup.

3.2.12. Lava unit of penanggungan 8 (Plv 8) Watesnegoro

The unit is consisted of andesite lava as the result of Mt. Penanggungan eruption. It is grey coloured, with hypocrysaline crystalization degree texture, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, pyrocene, mineral opaque, and glass mass. Brecciation remains in form of cobbles, can be found on the lower parts of lava flow. It is stratigraphically located on the pyroclastic flow unit of Penanggungan 5 (Pap 5) Masjedong. It sedimented almost on the whole area of Mt. Penanggungan, including Kunjoroatas, Sukoreno, Genting and Gajahmungkur. With the angle to the north-northeast, it has 8 m unit thickness.

3.2.13. Pyroclastic flow unit of Penanggungan 5 (pap 5) Masjedong

It is the youngest eruption result of Mt. Penanggungan, consisted of brown coloured pyroclastic flow, poorly sorted, close fabric, with sub angular-sub rounded fragment circularity. The fragments are andesite with 2,-15 cm (pebbles-cobble), grey coloured, with hypocrysaline crystalization degree texture, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, pyrocene, mineral opaque, and glass mass. Mineral composition are composed by plagioclase, pyrocene, mineral opaque, and glass mass. The matrix are in form of sand stone with size approximately about 0.5-2 mm (coarse sand-very coarse sand), with plagioclase, mineral opaque, hornblende and basic mass composition. It is overlaid by lava unit of Mt. Penanggungan 8 (Plv 8) Watesnegoro and lava unit of Mt. Penanggungan 9 (Plv 9), overlay the pyroclastic flow unit of Penanggungan 4 (Pap 4) Kemuncup, and Penanggungan 3 (pap 3), and other existed units before. It is sedmineted in the north, the northeast, and the east part of Mt. Penanggungan, including Kunjorowesi, Wonosunyo, Waton, Masjedong and Bulusari, with 3-5 m thickness, with angle to the north, the northeast, and the west.

3.2.14. Lava unit of Penanggungan (Plv 9) Kedungudi

The unit is composed by igneous rock lithology, in form of hornblende andesite, with grey coloured andesite. It has hypocrysaline crystalization degree texture, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, pyrocene, hornblende, mineral opaque, and glass mass. It is conformably sedimented with wedge pattern and tend to be found on the valleys which go along to the lava unit of Penanggungan 8 (Plv 8) Watesnegoro. The lava is only can be found on the peak of Mt. Penanggungan, with Tamiajeng in the east sector, with 2.5 m thickness. in mining area, which can be found in sub river stream and Kunjorowesi mines, rsub river stream of Wonosunyo and Wangi.

3.2.15. Pyroclastic flow unit of Penanggungan 6 (Pap 6)

It is the youngest product, composed by pyroclastic flow lithology, with brown coloured pyroclastic, 2 mm-20 cm-seized andesite and pumice fragments, poorly sorted, close fabric, subangular-subrounded circularity. It is grey andesite fragment, with subhedral-anhedral crystal form, with inequigranular connection. Mineral composition were consisted of plagioclase, pyrocene, hornblende, mineral opaque, and glass mass. There is a 35 cm-diameter giant fragment that was found there. The matrix is in form of sand rock with 0.5 mm – 2 mm-sized matrix (coarse sand-very coarse sand), with plagioclase, mineral opaque, hornblende and basic mass composition. The fragment is white-coloured pumice, skoria, with 2mm-sized items, closed, subrounded, poorly sorted, with quartz mineral composition. The matrix are in form of sand stone with size approximately about 0.5-2 mm (coarse sand-very coarse sand), poorly sorted, consisted of plagioclase, pyrocene, and glass mass. The unit is located on the upper slope topography until the peak of the western part of Mt. Penanggungan in Tamiajeng with 2 meter sized-composition. It is stratigraphically sedimented on the alva unit of Penanggungan 9 (Plv 9) Kedungudi, which existed beforehand

3.2.16. Lahar unit of Arjuna Welirang 1 (Alh 1) Janjing

It is composed by lahar sedimentation with sand layer, together with pyroclastic flow. It is blackish-grey coloured sedimentation, open fabric, circle circularity, with size about 8cm-95cm, andesite fragment, with plagioclase, mineral opaque, hornblende composition. The fragment is blackish-grey coloured, massively structured, has hypocristaline crystalization degree texture, anhedral crystal form, aphanitic, with alotriomorphic granular connection, inequigranular cover, and the mineral composition are composed by plagioclase, quartz, hornblende, and pyrocene. The sedimentation can be found around Janjing river, as the border of Mt. Penanggungan and Mt. Arjuna Welirang eruption, which located in the south of Mt. Penanggungan. The sedimentation were sedimented in Penanggungan, Selotapan, and Kemendung village, with 0.4-1.1 meter thickness, with 2^0-6^0 angle. Stratigraphically, it is unconformably located on the lava unit of Penanggungan 1 Jambe (P11) and conformably located on the lahar unit of Penanggungan 3 (Plh 3) masjidong.

3.2.17. Lahar unit of Penanggungan 1 (Plh 1) Bekel

The unit is composed by lahar sedimentation with with sand layer, together with pyroclastic flow of Penanggungan 5 (Pap) Masjidong. Its dominantly consisted by sand and little bit of mud on the upper part of it. The fragment is andesite rocks with 6-36 cm-sized fragment.

3.2.18. Lahar unit of Penanggungan 2 (Plh 2) Kemucup

It is composed by lahar sedimentation lithology, with brownish-grey coloured unit, poorly sorted, open fabric with *sub angular - sub rounded* circularity, with andesite fragment size is about 0.2-40 cm (pebbles-cobbles). It is grey coloured fragment, with hypocristaline crystalization degree texture, subhedral-anhedral crystal form, with inequigranular connection. The mineral composition are composed by plagioclase, glass mass, mineral opaque, and pyrocene. Giant fragment can be found there, with 40cm diameter-size fragment. The matrix is in form of sand rock with 0.5 mm – 2 mm-sized matrix (coarse sand-very coarse sand), with plagioclase, mineral opaque, and basic mass composition. The unit is conformably overlaid under the lahar unit of Penanggungan 3 (Plh 3) masjidong, and on the pyroclastic flow unit of Penanggungan 4 (Pap 4) Kemucup. This unit is sedimented within the west sector of Mt. Penanggungan, as the evolution of pyroclastic of Kemuncup. It can be found in Jerukpurut, with 2 m-sized unit, with angling to the east.

3.2.19. Lahar unit of Penanggungan 3 (Plh 3) Masjidong

The unit is composed by lahar sedimentation with sand layer, with grey coloured unit, poorly sorted, open fabric with *sub angular - sub rounded* circularity, with andesite fragment size is about 0.2-35 cm (pebbles-cobbles), and its colour is grey. It has hypocristaline crystalization degree texture, subhedral-anhedral crystal form, with inequigranular connection. The mineral composition is composed by plagioclase, glass mass, mineral opaque, hornblende and pyrocene. Giant fragment can be found there, with 35 cm diameter-size fragment. The matrix is in form of sand rock with 0.5 mm – 2 mm-sized matrix (coarse sand-very coarse sand), with plagioclase, mineral opaque, hornblende, and basic mass composition. Stratigraphically, it has conform connection with pyroclastic flow unit of Penanggungan 2. It is sedimented in the north and east sector of Mt. Penanggungan, including the areas such as Watukosek, Kunjorowesi and Watonmasjedong. It is evenly spread within the research area to the north-northeast area.

2 Conclusion

Based on field data and adjusted with Van Zuidam (1983) modification, authors divided the morphology into 6 units: Upper volcanic slope (V1), Middle volcanic slope (V2), Lower volcanic slope (V3), Parasiter Cone (V4), Volcanic Cone (V5), and Volcanic Valley (V6)

Volcanostratigraphy level of Khuluk of Mt. Penanggungan based on material elements of volcanic lithology, dominantly consisted of hornblende andesite lava, pyroclastic flow sedimentation, pyroclastic avalanche sedimentation, pyroclastic blow sedimentation, and lahar sedimentation. Level within Khuluk

of Mt. Penanggungan were constructed by sand dune of Gajah Mungkur, sand dune of Bendo, sand dune of Bekel, sand dune of Genting, sand dune of Kemucup, and sand dune of Wangi.

Lithology diversity in form of lava, pyroclastic flow, pyroclastic blow, and lahar were put the research area within central phasies, proximal phasies, until medial phasies. The stone units from the oldest to the youngest were consisted of: Lava unit of Penanggungan 1 (Plv 1) Jambe, Lava unit of Penanggungan 2 (Plv 2) Gajahmungkur, Lava unit of Penanggungan 3 (Plv 3) Bekel, Pyroclastic flow unit of Penanggungan 1 (Pap 1) Bekel, Lava unit of Penanggungan 4 (Plv 4) Bendo, Pyroclastic flow unit of Penanggungan 2 (Pap 2) Bendo, Lava unit of Penanggungan 5 (Plv 5) Genting, Lava unit of Penanggungan 6 (Plv 6) Wangi, Pyroclastic flow unit of Penanggungan 3 (Pap 3) Wangi, Lava unit of Penanggungan 7 (Plv 7) Kemuncup, Lava unit of Penanggungan 8 (Plv 8) Watesnegoro, Pyroclastic flow unit of Penanggungan 4 (Pap4) Kemuncup, Pyroclastic flow unit of Penanggungan 5 (Pap 5) Masjedong, Lava unit of Penanggungan (Plv 9) Kedungudi, Pyroclastic flow unit of Penanggungan 6 (Pap 6), Lahar unit of Arjuna-Welirang 1 (Alh 1) Janjing, Lahar unit of Penanggungan 1 (Plh 1) Bekel, Lahar unit of Penanggungan 2 (Plh 2) Kemucup, Lahar unit of Penanggungan 3 (Plh 3) Masjedong

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