Conservation Zones of Penanggungan

by Kusumayudha Sari Bahagiarti

International Conference on Earth Science, Mineral, and Energy 2018

PREFACE

Dear authors from ICMT2018;

On behalf of all conference committees, I sincerely appreciate your participation and support for ICMT2018.

The 2nd International Conference on Manufacturing Technologies was successfully held in Florida Polytechnic University, FL, USA during January 15-17, 2018. Our conference venue, Florida Polytechnic University, is Florida's accredited public university with an exclusive focus on the core STEM disciplines of engineering, technology and applied science. ICMT2018 reflected the technology needs manufacturing technologies science. This proceeding contains the reviewed papers presented at the ICDME 2018 and covers trending and important issues related to manufacturing technologies and other main ICMT Topics.

ICMT2018 conference papers consisted of different types of presentations including keynote, oral, and poster presentations offered by researchers, engineers, and graduate students. ICMT2018 received 97 papers from different counties, only 41 papers were accepted to present at the conference. As a platform for technical exchange, each author has 15 minutes to introduce his or her research. In addition to the presentation, each author is encouraged to connect and exchange ideas with other scholars. The conference is also an opportunity to explore research on manufacturing technologies presented by different participants. With the fast globalization of technology and manufacturing, technical issues will be discussed and disseminated in a global forum in which researchers and engineers with international experiences are invited to share their expertise and views.

The support from all authors and committee members will surely lead to the success of ICMT2018. We hope that the participants of ICMT2018 will have fruitful discussions among each other and collaborate on future projects on manufacturing technologies.

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Conservation zones in a cultural heritages area of Penanggungan Volcano, based on volcanic-hydrogeological assessment, Mojokerto Regency, East Java, Indonesia

Conservation zones in a cultural heritages area of Penanggungan Volcano, based on volcanic-hydrogeological assessment, Mojokerto Regency, East Java, Indonesia

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Abstract. In the vicinity of Penanggungan volcano, Mojokerto regency, east Java, Indonesia, there is an area of cultural heritages, where numerous sites of ancient temples being distributed widely from the flank to near the summit. Fortunately the volcano has been not active anymore since the Holocene epoch. The surrounding area represents variety of volcanicstratigraphy, consisting of Watukosek *volcanic cone*, Arjuna - Welirang *volcanic cones* represented by Bulak dome, Penanggungan *volcanic cone* represented by Bekel dome, Gajahmungkur dome, Genting dome, Bendo dome and Kemuncup dome. Hydrogeologically, the study area performs an aquifer system comprises intergrain, fracture, and intergrain with fracture combination water bearing formations. Some springs occur in the fracture aquifer and the intergrains with fractures aquifer. In general the quality of groundwater is good. Catchment area occupies the summit toward the flank of Penanggungan volcano, whereas runoff area lies on the lowlands.

The distribution of ancient cultural sites in the study area can be divided into 5 (five) groups, including cultural sites group at Penanggungan Volcano, cultural sites group at Bekel Volcano, cultural sites group at Genting Volcano, cultural sites group at Kemuncup Volcano, and outer cultural sites group. Finally, based on its volcanic stratigraphy and hydrogeological conditions, the study area can be delineated to be three conservation zones namely zone of protected areas, zone of supporting areas, and zone of unprotected areas. The zone of protected areas is 5,577.78 hectares wide, containing units of protected forest area, critical land area, river border area, springs area, reserve area, cultural site and temple area, area with slope of above 45°, and geological heritage area.

Keywords: Cultural heritages, Volcanostratigraphy and Hydrogeological assessment, Conservation Zones

1. Introduction

Penanggungan is the name of a strato type Quaternary volcano, located in the Mojokerto regency and Pasuruan regency, East Java Province. This mountain has a function as a living space, land for cultivation, industrial, sand and rock mining, sources of groundwater utilization, and area with historical temples enclosures.

Utilization of landuse as a sector of industrial activity occupies the North and East of the mountain. The expanding industrial areas in the North part is approaching the sites of springs and historical temples in Wotanmasjedong Village. On the other hand, there is increasingly critical landscape damage due to

sand and stone mining in the villages of Kunjorowesi and Wonosunyo. The mining activity is now expanding to the Southeast side of the volcano.

Referring to government's regulation number 26/2008 on Protection of geological and areas providing groundwater, and East Java Governor Regulation no. 66/2015 on Preservation of Cultural Heritage of East Java Province, Penanggungan volcano has the criteria as a region that must be preserved and protected, therefore a study related to develop conservation zones is needed to be held.

This research was conducted to set up conservation zonation in Penanggungan volcano and surrounding area which is suitable with geological condition, hydrogeology, and distribution of historical sites, so that the land use will be not overlapping one another.

The location of the study area is geographically positioned at 7 ° 31'00 "LU - 7 ° 41'00" LS and 112 ° 35'00 "BT-112 ° 43'00" BT, with UTM (Universal Transverse Mercator) coordinate 674000mT - 690000mT and 9150000mU - 9170000mU zone 49 m. The maximum elevation reaches 1,605 meters above sea level (asl). Administratively, the scope of research area covers: Ngoro District and Trawas District of Mojokerto Regency, Gempol District and Prigen District of Pasuruan Regency. (Figure 1).

Figure 1. Location of the study area

2. Methods of Study

The method applied to this study is analyses and assessment on both primary and secondary data. The primary data obtained by surface mapping including geological mapping, hydrogeological mapping, historical sites mapping, landuse mapping, and observation of environmental carrying capacity. The entire data was then processed into a thematic map and in integration overlaying to create a zonation map of conservation area, based on geological, hydrogeological and cultural sites preservation.

In order to determine the volcanic geological and hydrogeological condition of the study area, some rock samples were taken for petrological analysis, and water samples were also taken for groundwater quality classification. Flow rate measurements of some springs were also done to get the data on groundwater potency.

3. Results and Disscussion

3.1 Volcanic Geology

Based on van Bemmelen [12] physiographic division, the study area is located in the central depression zone of East Java, on a flank and lowland of Penanggungan volcano. Referring to the classification of van Zuidam [14], the slope can be divided into seven classes, including flat or almost flat slope ranging 0 ° - 2 °, gentle incline slope ranging 2° - 4°, incline slope ranging 4° - 8°, very incline slope ranging 8° - 16°, moderately steep slope ranging 16° - 35°, steep slope ranging 35° - 55°, and very steep slope > 55°. Geomorphology of the study area can be divided into 6 (six) geomorphic units, such as old crater, volcanic cone, middle slope, foot slope, fault scarp, and aluvial plain. On the other side, the drainage pattern can be classified based on Howard (1967) vide van Zuidam ([13], [14]), into four types, including

radial, paralel, subdendritic, and dendritic. The radial pattern is found on the body, parallel pattern occupies the lower slope of Penanggungan volcano and middle slope of Arjuna – Welirang volcano (Mount Bulak). Subdendritic pattern occupies the Western slope and dendritic pattern exists on the Northeastern slope of Penanggungan volcano.

According to Santosa and Suwarti [9], rock units of Penanggungan volcano and its surroundings, from the older to the younger consists of the Central Quaternary Volcanic Rock (Qpvr), Quaternary Arjuna - Welirang Volcanic Rock (Qvaw), Quaternary Upper Volcanic Rock (Qvn), and Alluvial Deposits (Qa). On the other hand, referring to Bronto (2006), the volcano-stratigraphy of Penanggungan area can be described as consists of Watukosek *Khuluk* (crown); Arjuna - Welirang *Khuluk* including Bulak *Gumuk* (dome); Penanggungan *Khuluk* represented by Bekel *Gumuk*, Gajahmungkur *Gumuk*, Genting *Gumuk*, Bendo *Gumuk*, and Kemuncup *Gumuk*. Other deposits are colluvium and alluvium (Figure 2). The description of each unit can be found in Table 1.

Table 1. Description of Volcano-stratigraphy of the Penanggungan Area

Volcano-stratigraphy Unit	Rock Composition	Geological Time	Explanation
Alluvial deposits (Qa)	loose material of various grain size	Recent time.	resulting from weathering activity
Colluvium deposits (Qk)	loose volcanic material of various grain size	Holocene to Recent	derived from the accumulation of transported volcanic rock debris
Debris deposits	loose andesitic volcanic rocks It can be divided into Arjuna – Welirang debris (Awdb), Bekel debris (Bnd), Genting debris (Gdb), and Bendo debris (BNdb)	Holocene to Recent	formed due to weathering and debris movements.
Bendo *Gumuk* (Bnl)	pyroxene andesitic lava	Holocene	a member of Penganggungan *Khuluk,* a parasitic cone, located on the southern flank
Genting *Gumuk*	There were two eruption phases: First phase: Kemuncup dome, lava 1 (Kl1) porphyritic andesite pyroxene lava Second phase: Wangi dome lava 2 (Kl2) as vesicular textured pyroxes andesite lava, and volcanic breccia	Holocene.	parasitic member of Penangunggan volcano, located on the eastern side
Gajah Mungkur *Gumuk* (Gml)	pyroxene andesite lava	Holocene	a member of Penanggungan *Khuluk,* in the same age with Bekel lava 1. It is a parasitic

			cone of Penaggungan volcano, formed by a side eruption
Bekel *Gumuk*	Bekel lava 1 (Bl1): pyroxene hornblende andesite lava, partly altered and weathered, Bekel lava 2 (Bl2): basaltic andesite lava.	Holocene	another parasitic cone, results of the side eruption of Penanggungan volcano
Penanggungan *Khuluk*	hornblende andesite lava, pyroclastic flow (Pap), crystal tuff, tuff breccia, scoria, associated with sandstones and volcanic breccia	Holocene	Overlays the Watukosek Khuluk
Bulak *Gumuk* (Buvu)	pyroxene andesite lava, andesitic breccia, and tuff breccia	late Pleistocene	a parasitic cone of old Arjuna – Welirang, is an eccentric eruption before the existing of young Arjuna – Welirang, positioned on the north-northwest slope,
Watukosek *Khuluk* (Wvu)	volcanic breccia with altered micro diorite fragments	middle to late Pleistocene	represents the oldest volcanostratigraphy in the study area

Geological structure of the study area was developed related with volcanic activity, in the form of shear fractures and fault. In general the strike directions of the shear fractures are N22°W and N28°E, while the direction of the main stress is N 2°E. On the other hand, the fault belongs to left lateral slip fault.

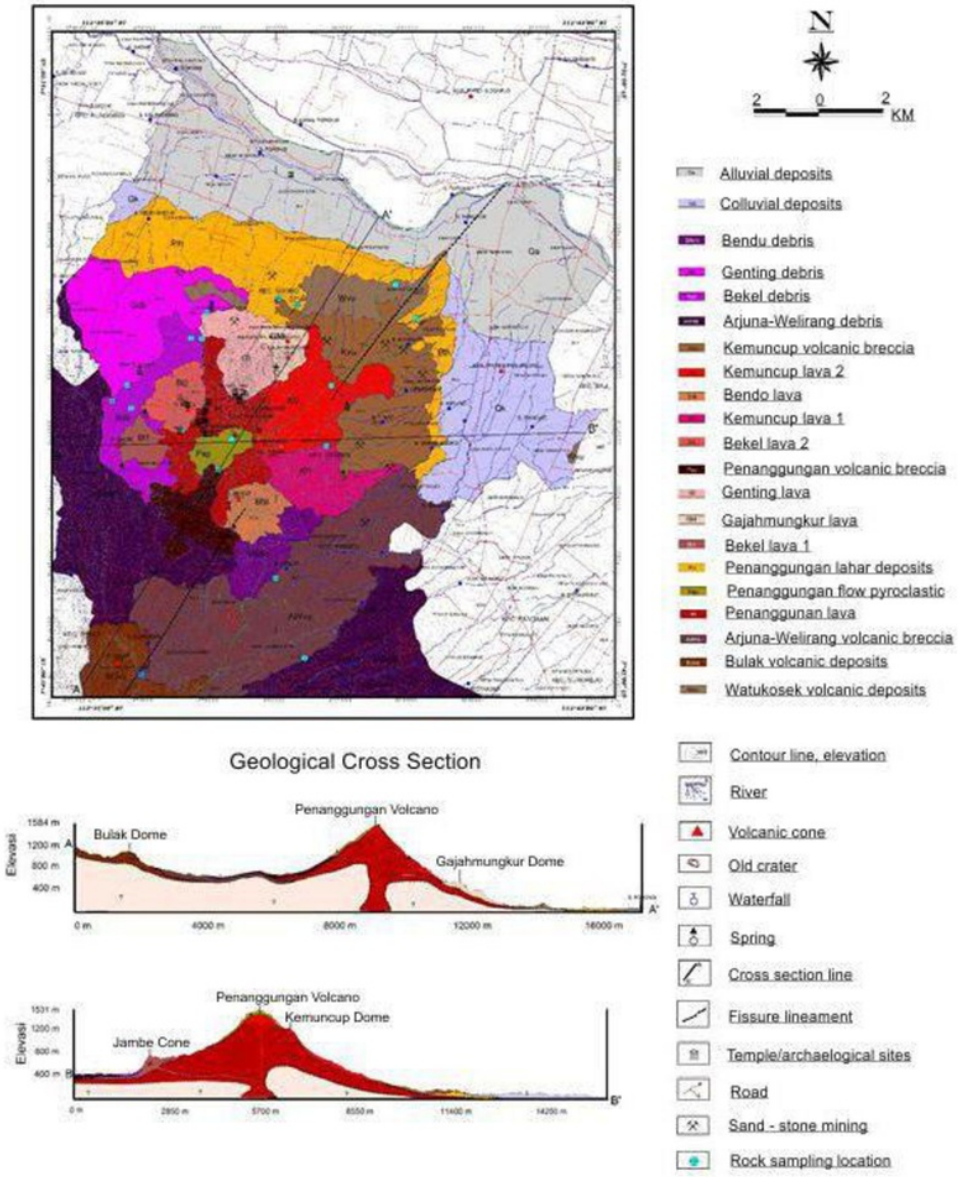


Figure 2. Geological map of Penanggungan Volcano and surrounding area

3.2 Hydrogeology

Basically the hydrogeological system of the study area includes in the Pasuruan Groundwater Basin. Based on its productivity, the aquifers of Pasuruan Groundwater Basin can be grouped into five types, namely: Productive aquifers with wide distribution, productive aquifers are broadly distributed, local productive aquifers, small productive local aquifers, and rare groundwater areas ([8]). The free surface water around Pandaan to Purwosari has an elevation of about 200 meters above sea level (asl), the more

towards the Northland the position of the free ground water surface gradually drops to about 50 meters asl, while in the northern part, the elevation of free groundwater table is only about 5 m asl [8].

Confined ground water conditions are located on the slopes of Mount Arjuno - Penanggungan - Welirang, with a depth of 1 to 5 meters. The hydraulic gradient is about 0.05. In the North direction this hydraulic pressure decreases to 0.01. There are springs of Pasuruan Groundwater Basin, that found evenly spread throughout the region except at the peak of the volcano and the coastal plains (Figure 3). The flow rates of the springs are also very diverse, ranging from 5 l/sec to 5000 l/sec. On the slopes of Arjuno volcano and Penanggungan volcano, springs are often found at altitudes between 50 to 1000 m asl. At Prigen District, springs have a water flow between 15 to 30 l/sec, in the lower areas such as Pandaan District, the flow rate of the springs is greater than that of the upper places, recorded as 20 to 40 l/sec, and in the Gempol - Beji area the springs flow rate varies between 10 - 40 l/sec.

Referring to Kusumayudha et.al [2], related to the hydrogeological properties of the lithology, aquifers of the study area can be divided into three types, including intergranular aquifer, intergranular and fissure aquifer, and fissure aquifer (Figure 4). The intergranular aquifer is composed of alluvial deposits sediments having uniform grains loose debris deposits, intergranular and fissure aquifer comprises volcanic deposits such as pyroclastic breccia, volcanic sandstone, while fissure aquifer is composed of lava and igneous rocks having fractures. All the aquifers represent free aquifers (Figure 3). Groundwater quality in the study area in general shows good quality. There are some springs existing in the Penanggungan area. They are potential to be developed as fresh water sources to fulfill the people need of water. The potency of springs of the study area is listed in the Table 2.

Table 2. Springs in Penanggungan Volcano and Surrounding Area.

No.	Name	Location &	Elevation (m.asl)	Flow Rate (l/sec)	Water Quality Description
1	Sumber Pesatren	Jedong Village,	235	0.071	colorless, odorless, tasteless, viscousless temperature 26°C, Ph 7.1, conductivity 0.07 ppt, TDS 79 ppm, electricity 0.116 mS.
2	Sumber Kunjorowesi	Kunjorowesi Village	520	0.024	colorless, odorless, tasteless, viscousless, temperature 25.1°C, Ph 7, conductivity 0.15 ppt, TDS 146 ppm, electricity 0.215 mS.
3	Sumber Jolotundo	Seloliman Village	557	0.38 and 0.12	colorless, odorless, tasteless, viscousless, temperature 25°C, Ph 7.2, conductivity 0.05 ppt, TDS 40 ppm, electricity 0.054 mS.
4	Sumber Reco Macan	Balekambang Village	357	0.17 L/sec	colorless, odorless, tasteless, viscousless, temperature 27°C, Ph 7, conductivity 0.08 ppt, TDS 73 ppm, electricity 0.104 mS.
5	Sumber Brugan	Kedungundi Village	554	0.15 L/sec	colorless, odorless, tasteless, viscousless, temperature 25°C, Ph 7.4, conductivity 0.11 ppt, TDS 113 ppm, electricity 0.166 mS.
6	Sumber Sendang Drajat	Penanggungan Village	582	0.49 L/sec, 0.37 L/sec, and 0.14 L/sec.	colorless, odorless, tasteless, viscousless, temperature 26°C, Ph 7.1, conductivity 0.10 ppt, TDS 111 ppm, electricity 0.167 mS.
7	Sumber Lumpang	Duyung Village	587	0.33 L/sec	colorless, odorless, tasteless, viscousless, temperature 25.4°C,

8	Sumber Temple Tetek	Belahan Village	297	0.07 L/sec and 0.28 L/sec,	Ph 6.59, conductivity 0.09 ppt, TDS 77 ppm, electricity 0.108 mS. colorless, odorless, tasteless, viscousless, temperature 26°C, Ph 6.85, conductivity 0.07 ppt, TDS 72 ppm, electricity 0.106 mS.
9	Sumber Betro	Betro Village	382	0.24 L/sec and 0.39 L/sec,	brownish white color, turbidy, odorless, brackish, viscousless, temperature 27.4°C, Ph 6.89, conductivity 0.08 ppt, TDS 77 ppm, electricity 0.110 mS.

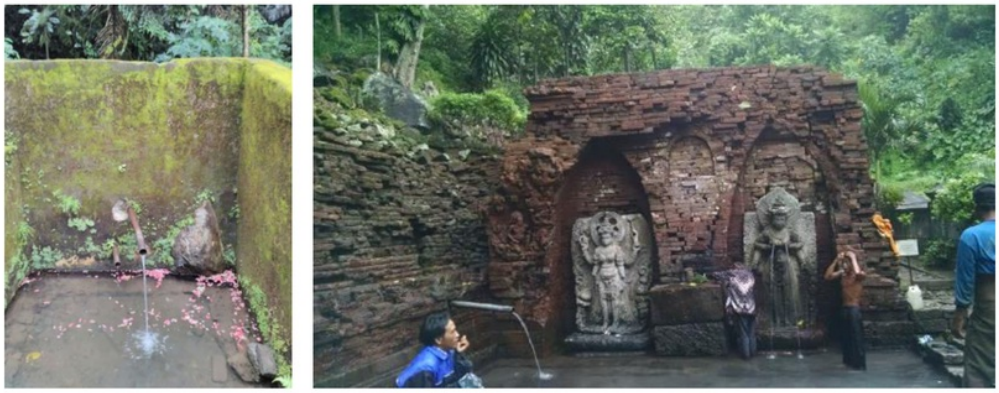


Figure 3. Sendang Drajat spring (left) and Tetek Temple spring (right)

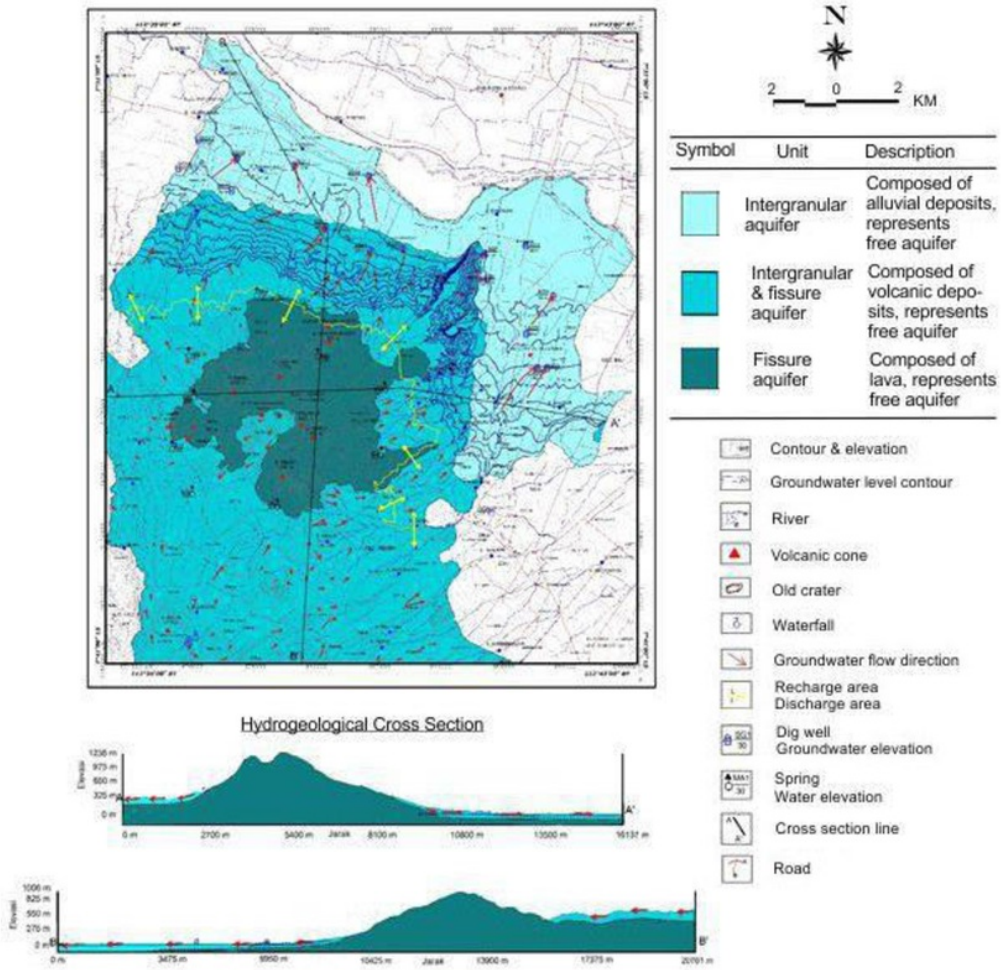


Figure 4. Hydrogeological map of Penanggungan volcano and surrounding area

3.3 Cultural Heritage

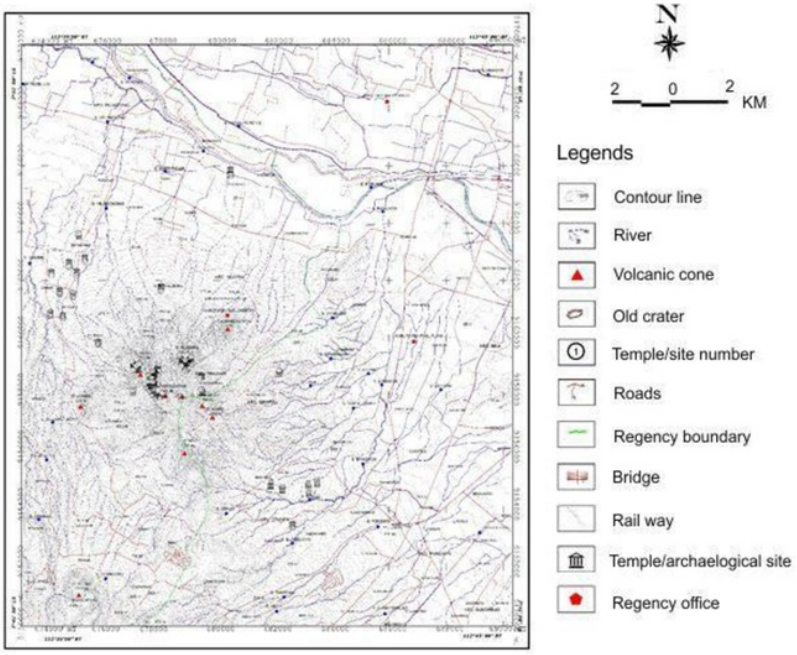
In the study area, there are 51 relic represented as temples and archaeological heritages of the ancient kingdoms of East Java, namely Kahuripan and Majapahit. The kingdoms existed during 10th to 12th century. The naming of the relics refers to the secondary data of Ubaya Exploration Team that has been done in the year 2012 to 2016. Material used to build the temples is andesite and red soil taken from Penanggungan volcanic products. Distribution of these archaeological sites can be grouped into 4 (four), consisting of group of Penanggungan sites, group of Bekel sites, group of Genting sites, group of Kemuncup site, and group of outer sites (Table 3).

Table 3. Group of Cultural Heritage distribusion

Name of the Group	Situation	The included cultural heritages
Group of Penanggungan Sites	Upper part slope	Consists of 18 temples: Bayi Temple, Kama 1 Temple, Wishnu Temple, Guru Temple, Shiwa Temple, Lurah

		Temple, Putri Temple, Pura Temple, Carik Temple, Genthong Temple, Shinta Temple, Jolotundo Temple, Pendawa Temple, Naga 1 Temple, Yudha Temple, Lemari Temple, Merak Temple, and XXX Temple (no name).
Group of Bekel Sites		Batu Berwajah, Reco Macan, Kama 2 Temple, Kama 3 Temple, Kendali Temple, and Kendalisodo Temple.
Group of Genting Sites		There are 8 temples: Griya Temple, Kama 4 Temple, Gajah Temple, Dharmawangsa Temple, YYY Temple (no name), Kerajaan Temple, Wayang Temple, and Jedong Temple
Group of Kemuncup Sites		Naga 2 Temple, Naga 3 Temple, and Tetek Temple
Group of Outer Part		
1. Southeastern part of Sukoren village. (6 sites)	Foot slope Southeast of Penanggungan volcano	Bricks cemetery site, ruins of temple site, Batu Lumpang site, Mbah Giri inscription site, Keramat Mencil site, and Keramat Sumo site.
2. Nortwestern part of Srigading and Kutogirang villages (9 sites)	Western part of the foot slope of Penanggungan volcano	Bricks Temple site, Batu Lumpang site, ancient bricks 1 site, ancient bricks 2 site, ancient bricks 3 site, stone temple sites, Lingga stone site, Kutogirang site, and ancient cemetery of Mbah Mendek site.
3. Nortern part (1 temple), located at Candiharjo village	berada pada daerah dataran rendah bagian Utara Gunung Penanggungan	Bangkal Temple.

Figure 5. Temple Genthong in Gunung Penanggungan (left) and Reco Macan Heritage

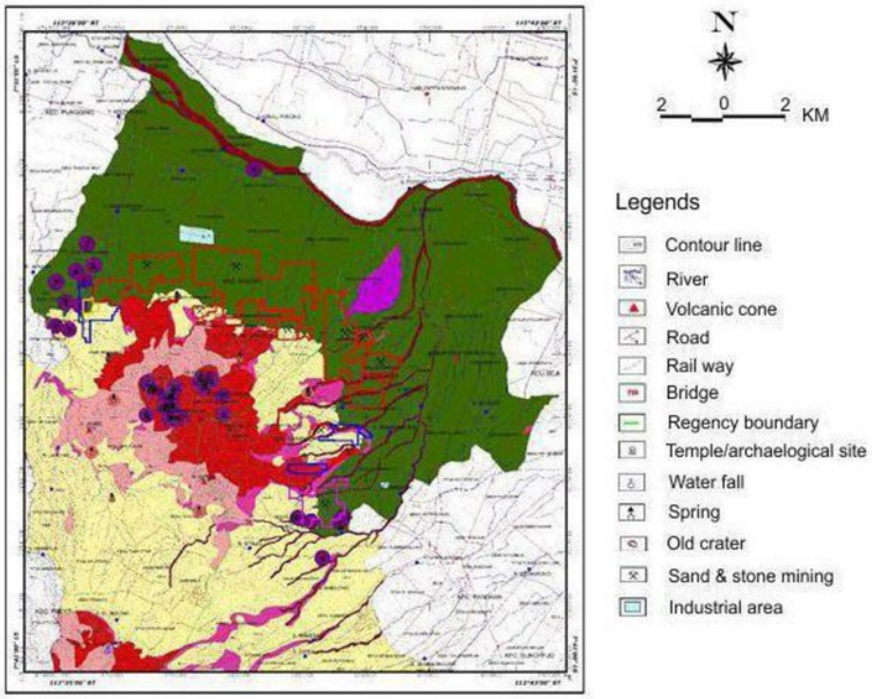


1. Batu Berwajah
2. Bayi Temple
3. Carik Temple
4. Genthong Temple
5. Guru Temple
6. Jolotundo Temple
7. Karma 1 Temple
8. Karma 2 Temple
9. Karma 3 Temple
10. Kendali Temple
11. Kendalisodo Temple
12. Lemari Temple
13. Lurah Temple
14. Merak Temple
15. Naga 3 Temple
16. Naga 2 Temple
17. Pendawa Temple
18. Pura Temple
19. Putri Temple
20. Shinta Temple
21. Shiva Temple
22. "XXX" Temple
23. Vishnu Temple
24. Yudha Temple
25. Jedong temple
26. Reco Macan Site
27. Tetek Temple
28. Bangkal Temple
29. Naga 1 Temple
30. Dharmawangsa Temple
31. Gajah Temple
32. Griya Temple
33. Karma 4 Temple
34. Kerajaan Temple
35. "YYY" Temple
36. Wayang Temple
37. Batu Bata Kuno 1 Site
38. Batu Bata Kuno 2 Site
39. Batu Bata Kuno 3 Site
40. Batu bata makam Site
41. Batu Lingga Sie
42. Batu Lumpang Site
43. Batu Lumpang Makam Site
44. Batu Prasasti Mbah Giri Site
45. Keramat Mencil Site
46. Keramat Sumo Site
47. Makam Kuno Mbah Mendek Site
48. Batu Candi Ruins
49. Batu Candi Site
50. Candi Bata Site
51. Kuto Girang Site

Figure 6. Map showing distribution of temples and archaeological sites

3.4 Conservation Zonation

By considering geological, volcano-statigraphical, and hydrogeological aspects, respecting the distribution of cultural heritage, and referring to the government regulations both central and regional, such a conservation zonation can be established in the study area. The conservation zonation covers 3 zones, namely conservation zone, supporting zone, and non-conservation zone. The area of conservation zone is, 5,577.78 hectares (Ha), containing protected forest area, steep slope area (above 45°), natural heritage area, cultural heritage area, river border area, springs area, geological heritage area, and critical land area. Protected forest area serve as areas of life buffer protection systems, water regulation, soil fertility, flood prevention, and erosion control. The supporting zone area is 5,493.10 Ha, and the non-conservation zone area is 10,781.40 Ha (Figure 7).



Area/Region (Large)	Land Function Unit	Symbol	Remarks
Conservation Zone (5,577.78 Ha)	Protected forrest		functioning as a protected area, life buffer system, water governance, flood prevention, erosion control, soil fertility, flora fauna habitat
	Steep slope (>45°)		functioning as a protection for rock/landslide prone areas
	Natural heritage		functioning as a space that can utilized for natural tourism activities, must be protected sustainability
	Cultural heritage		functioning as a protection against temples and archaelogical sites that have high historical value
	River border		functioning as a river protection from activities that disturb and damage the quality of river water along with river functions
	Spring		is part of the protected area that functions as one of groundwater protection
	Geological heritage		has unique characteristics of landscapes and geological processes, functioning as a protection of geological reserves
	Critical land		serves as a recharge area, a soil conservation zone, also used as a protected forest area
Supporting Zone (5,493.10 Ha)	Limited cultivation		has a hydrogeological relationship with recharge area so that the use of land as a cultivation is very restricted
Non-conservation Zone (10,781.40 Ha)	Productive landuse		functioning as productive landuse, intended for industrial, mining, buildings, public facilities, and settlement areas

Figure 7. Map of Conservation Zones of Penanggungan Volcano and Surrounding Area

Conclusions

The volcanic geology of Penanggungan area consists of Watukosek *Khuluk*, Arjuna - Welirang *Khuluk* that is represented as Bulak *Gumuk*, and Penanggungan *Khuluk* that is composed of Bekel *Gumuk*, Gajah Gungkur *Gumuk*, Genting *Gumuk*, Bendo *Gumuk*, and Kemuncup *Gumuk*. In addition, there are also debris deposits, collovium deposits, and alluvial deposits. Geological structures of the study area are

joints and fault that is classified into left lateral slip fault, formed due to volcanic activities of Penanggungan volcano

The hydrogeological conditions of Penanggungan area comprises three free aquifers showing intergranular, intergranular and fissure, and fissure aquifers types. The groundwater quality belongs to good classification. There are nine potential springs exist in the study area, that the water can be utilized for fulfilling the fresh water needs of people in the surrounding areas.

There are 51 historical sites of the ancient Kahuripan and Majapahit kingdoms. The distribution of temples and archaeological sites can be grouped into 3 (three) group, they are group of sites on Penanggungan volcano, roup of sites on Bekel dome, group of sites on Genting dome, group of sites on Kemuncup hill, and group of outer sites.

Based on volcanic geology, hydrogeology, and the existence of archaeological sites, the research area can be divided into 3 (three) zoning areas, including conservation zone (5,577.78 Ha), supporting zone (5,493.1 Ha), and unprotected zone (10,781.4 Ha). The conservation zone contains some units of protected forest area, the steep slope area, natural heritage area, cultural heritage area, river border area, springs area, spring area, geological heritage area, and critical land area.

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