Volcanostratigraphy of Batukuwung-Parakasak Geothermal Area, Serang Regency, West Java.

Untung Sumotarto ¹, F. Hendrasto¹, W. Triadi¹
¹Teknik Geologi, FTKE, Universitas Trisakti.

untung.s@trisakti.ac.id, f_hendrasto@trisakti.ac.id

Abstract. Geothermal resource and reserve have been utilized at Batukuwung-Parakasak area, Serang Regency, West Java. As in general geothermal areas, geologically there are volcanic rocks distributed in the area. Structural as well as lithological condition are causing geothermal fluids exposed as hot water springs around the area. Regional geologically, there are four lithological units, the whole are of Quarternary age. By applying volcanostratigraphic method, it can be mapped into nine volcanostratigraphic units. Based on volcanostratigraphic principles there could be interpreted volcanic process that have been controlled the volcanostratigraphic litology units’ generation. Concerning the geothermal potential, volcanostratigraphic geological mapping has helped understanding the geothermal system modelling of the area, further contributed to the geothermal exploration as well as utilization activities.

1. Introduction

Along with the progress of the times, energy needs are increasing. Currently the main supplier of energy in Indonesia is energy derived from fossils (oil and natural gas), where the energy can not be renewed and its existence is decreasing. For that reason alternative renewable energy need to be developed as a substitute for fossil energy. One of potential renewable energy is geothermal energy.

With the growth of human population in Indonesia, the government of Indonesia has long developed the country, including increasing electric power generation. Geothermal electric generation has actually long been developed due to the fact about volcanic activity in Indonesia islands as of the result of tectonic and volcanic activities. The geothermal field that has long been developed since 1970s is Kamojang area, West Java. The following area that has been able to generate geothermal electric power are Salak, Darajat, Dieng, Lahendong, Ulubelu, and many others.

Geothermal is closely related to volcanism activity. The cause of the occurrence of volcanism is due to the occurrence of collision processes between different earth plates that will produce a source of heat or volcano that is close to the surface. Indonesia is heavily influenced by the collision between the Indo-Australian Plate and the Eurasian Plate which produces many volcanic activities. According to various sources, Indonesia's geothermal potential is around 28,132 MW or about 40% of the world (Figure 1) [1].

One of the most important processes in meeting the needs of geothermal energy is geothermal exploration. In this connection, one aspect of the approach taken in this research is to perform research work which is used to create hydrogeological model in a geothermal system.
Along with the need for renewable energy, the authors perform a research that can assist in the exploration of geothermal energy especially about volcanostratigraphy studies. The result is expected to generate information about the origin of heat source in the area of potential geothermal field of Batu Kuwung – Rawa Danau and Surrounding area, Padarincang District, Serang Resident, West Java Province.

Rawa Danau volcanic area in West Java Province near Serang, capital city of Banten Province, has geothermal potential, shown by existence of hot water springs. Exploration activities have been conducted. This paper provides analysis and evaluation of research performed in 2017 in Parakasa Mount - Batukuwung area. Further and more detail exploration analysis may be conducted to explore more detail the area as well as capacity of possible potential in the area.

2. Geological Overview
Prefeasibility survey has been performed in the area, beginning with field recognissance of the Parakasak Mount - Batukuwung geothermal area. Geological condition of the area must be firstly searched to expand the survey especially for geological exploration of the area. Volcanological area is very specific of Parakasa Mount - Batukuwung geothermal area. Figure 2 shows specific morphology of the Parakasa volcano. Figure 3 and 4 provide geological map and cross section of the Parakasa Mount - Batukuwung geothermal survey area.

Hot springs appear in Mount Parakasak - Batukuwung area indicates the possible resource of geothermal energy underneath the area. Although the volcanic rocks are mostly of Quarter age, the existence of heat source from the magmatic source could be analysed further to explore the geothermal potential of the area.
Geologically, the area consists of four rock units (Figure 4). The stratigraphic sequence of the research area is based on the main constituent rocks and the special features of each rock unit. Grouping of these rock units are based on dominant lithologic features. Contact between rock units is sometimes unclear or even not found in the field, because the condition is too rotted or covered by soil thick enough. Therefore, the withdrawal of its unit boundaries is supported by topographical interpretation and outcrop observation location compiled based on the function of time (age) by cross cutting law and based on regional equality [2].

The sequence of four rock units from the old to the young is as follows:

1. Parakasak Lava Andesite
   This unit is a volcanic product in the form of lava flow coming out from the eruption crater of Mount Parakasak. This rock unit covers the research area of about 40% of the research area. This unit extends from the south to the east of the map, located in Angsana Village, Wangun, and Condong.

2. Volcanic Breccia
   This unit is a volcanic breccia composed of fragments of gravel sized with angular shape. Volcanic breccia is pyroclastic rocks produced from volcanic products (eruptions/bursts) that were deposited to the surface of the earth in the form of lava with andesite fragments and tuff grains. This rock unit covers about 20% of the research area, occupies the middle area of the study area and spreads to the northeast. This unit is found in the villages of Wangun Cipurut, Ci Suwarna, and Nengger.

3. Wangun Lava Andesite
   This unit is a lava flow producing extrusive volcanic rock, which comes out through the eruption of the Mount Wangunpakis. This unit covers approximately 30% of the research area, extending from a crater at the center of the map area to the west and northwest area. This unit is located in Wangunpakis Village, Wanguntengah, Wangunicipurut, and Lawangseketeng.

4. Swamp Alluvial
   This unit is a loose material of the sediment from the volcanic activity with fragments sizing from pebble to sand which is generally deposited on the river bed of Batu Kuwung area. This unit covers approximately 10% of the research area. This unit occupies the area around Batukuwung, Begog, Cikoneng, Barengkok, Citunduh, Nengger, Cilehem, and Bungur.

3. Volcanostratigraphy
   To describe sequence of rock formation in the area, there are various stratigraphic base on describing the rock formation sequence. Because most geothermal areas are associated with volcanic activity, rocks formation sequence is mostly described based on volcanostratigraphic criteria [3]. In this method two ways to give a name for a rock unit i.e. purely based on petrological terminology and by considering the genesis of the rock unit [4].

   With respect to the existence of various volcanic rocks in general (lava andesite, breccia, etc) and the reality of geothermal potential in the area, the volcanostratigraphy of the area may be applied. The interpretation of the lavatic rock was first performed in this vulcanostratigraphic study to determine where lava was generated from and exists within of the research area. While the analysis of volcanic products was carried out after determining where the existence of this lava dome in the study area. Both of these analyzes used direct primary data captured in the form of photographs and samples of the volcanic dome area, as well as with assistance from geomorphological maps that have been made in the study area. From this interpretation, it can be produced a surface vulcanostratigraphic map of the research area (Figure 3).

   The rock unit notification in this study uses abbreviation PR (Parakasak Rock). There are nine units of volcanic activity products in the study area interpreted from the topography and morphology of the area. The volcanic rock hills consists of PR-A to PR-PARAKASAK which are distributed as shown in Figure 3.
Figure 3. Regional geological map of Mount Parakasak - Batukuwung Area.

Vulkanostatigraphic units in Batukuwung and surrounding areas are grouped based on the map of distribution of the product of lava flow and other volcanic activities in the area and reinforced with rock outcrop data in the field of research area. From the lava flow hills and volcanic products that have been interpreted, it can be known the constituent rock, the origin of the lava and volcanic activity, its composition and spreading.

The volcanostatigraphic rock units are named based on various method. Using example of rock at Rawa Danau area [5], the volcanostatigraphic rock units in Batukuwung area are as follows:

1. Volcanostatigraphy Unit PR-A
   Composed of andesite igneous rocks with sheeting joint structures of lava flow and massive andesite igneous rocks. There is also volcanic breccias as a product of crushed lava flow (based on existing outcrop data).

2. Volcanostatigraphy Unit PR-B
   Composed of andesite igneous rocks with extrusive igneous structures in the form of sheeting joints, which are formed by lava flows process (based on existing outcrop data).

3. Volcanostatigraphy Unit PR-C
Almost similar to PR-B this unit is composed of andesite igneous rocks with extrusive igneous structures in the form of sheeting joints, which are formed by lava flows process (based on existing outcrop data).

**Figure 4.** Volcanostratigraphic map of Batukuwung and surrounding area, Padarincang District, Serang Resident, Banten Province

4. Volcanostratigraphy Unit PR-D  
   Composed of altered andesite rocks with sheeting joints structure which are formed by lava flow process (based on data outcrops on the surface).

5. Volcanostratigraphy Unit PR-E  
   Composed of andesite and volcanic breccia (based on existing outcrop data)

6. Volcanostratigraphy Unit PR-KWP  
   Composed of volcanic breccia rocks, tuffs, and andesite igneous rocks (based on existing outcrop data).

7. Volcanostratigraphy Unit PR-BK  
   Composed of gravel (lapilli) and tuff which is the product of sedimentation from Parakasak volcano activity (based on existing outcrop data).

8. Volcanostratigraphy Unit PR-PARAKASAK  
   Composed of andesite igneous rocks with sheeting joints structure that are formed at the young volcano rocks of the study area (based on existing outcrop data).
9. Volcanostratigraphy Unit PR-KARANG
   Composed of volcanic breccia (as compared to the regional geological map of Anyer sheet).

   Figure 5 shows Sequence of Volcanostratigraphy of Batukuwung Area, Padarincang District, Serang Resident, Banten Province.

| Age   | Volcanic Rock Unit | Comparison to S. Santoso (1991) | Description                                      |
|-------|--------------------|---------------------------------|--------------------------------------------------|
| Quaternary | PR-BK            | Rawa Danau Alluvial (Qi) | Gravel, sand deposits                            |
|       | PR-KWP             | Lava Flow, Mt. Wangun          |                                                  |
|       | PR-A               | Lava & Pyroclastics, Mt. Wangun (Qhvp) | Lava & Plagioclase Andesite                      |
|       | PR-B               | Mt. Parakasak Lava Flow & Pyroclastics | Overlapped from Mt. Wangun                       |
|       | PR-E               | Mt. Parakasak Lava Flow & - 3 |                                                  |
|       | PR-C               | Mt. Parakasak Lava Flow & - 2 |                                                  |
|       | PR-PARAKASAM       | Mt. Parakasak Lava Flow & - 1 |                                                  |
|       | PR-KARANG          | Mt. Karang Lava               |                                                  |
|       |                    | Mt. Parakasak Lava            |                                                  |

Figure 5. Volcanostratigraphy Sequence of Batukuwung Area, Padarincang District, Serang Resident, Banten Province.

4. Geothermal Potential
The geothermal system commonly found in Indonesia is the hydrothermal system. The hydrothermal system is defined as a type of geothermal system in which heat transfer from a heat source to the earth's surface is through a free convection process involving a meteoric fluid with or without a magmatic fluid trace. An example of a meteoric fluid is the rainwater that permeates far below the soil surface. Important components of the hydrothermal system are: heat source, thermal fluid reservoir, recharge area, discharge area with surface manifestations found in the field.

Geothermal system can be analysed based on volcanic activity of the area [6]. The geothermal system analysis in Batukuwung area is based on the fact that there are many young Quartenary volcanoes in the area i.e. Mounts Parakasak, Karang, Wangun and many others. The existence of various volcanic rocks as part of volcanic network with large caldera forming swamp and lake Rawa
Danau has generated a geothermal system in the area. Solfatara, hot springs, rock alterations and new deposits indicate a geothermal potential in Batukuwung area.

Based on volcanosтратigraphic analysis and from the potential of heat source, it can be interpreted also the potential of reservoir spreading in Batukuwung area and its surroundings. The interpretation is based on the relationship between volcanic rocks and geothermal manifestation from heat source found in the area. The interpretation can be drawn on the spread of the reservoir from volcanosтратigraphic units of PR-C to PR-D (Figure 6). According to the volcanosтратigraphic geological map and supporting geochemical data, geothermal system model of Batukuwung area is provided in Figure 7.

From the research of Vulcanostratigraphy which has been conducted in Batukuwung area and its surroundings, it can be interpreted the origin of heat source and possibly the potential layer of geothermal reservoir from the cross-sectional surface of vulcanostratigraphy in the research area (Figure 7). From the analysis of the existence of surface manifestation and the presence of volcanic rocks in the area, the source zone of heat can be interpreted to be at Mount Wangun Pakis volcanic caldera.

![Geothermal system map of Batukuwung area showing heat source and reservoir existence.](image)

**Figure 6.** Geothermal system map of Batukuwung area showing heat source and reservoir existence.
5. Conclusions
Batukuwung is an area in Serang Resident of Banten Province having geothermal surface manifestation. Geological survey and analysis have been performed by many researchers and experts in Batukuwung and Rawa Danau areas. The existence of young Quarternary volcanoes in the area has generated geothermal potential. Volcanism and magmatic activity has produced heat transfer to provide geothermal surface manifestations, including many hot springs in Batukuwung area. According to volcanostratigraphic sequence of generation, rock units in Batukuwung area can be grouped into nine units. Based on volcanostratigraphic rock units, the geothermal system in the area could be interpreted according to existing and obtained surface data. Using these limited result, data and information from this survey and study, the geothermal potential of the area is recommended to be explored further to obtain more detail geology, geochemistry and geophysical characters of the area as well as information about geothermal reserve. Shallow well drillings may obtain more data and information to explore the geothermal potential of Batukuwung area.

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