1. INTRODUCTION

Indonesia is a country having many volcanoes and rich in geothermal energy. The geothermal resource potential in Indonesia reaches approximately 28.579 MW(e1). By now, only about 1,948 MW of that much energy potency has been utilized for electricity power generation2). The rest has not been utilized optimally. According to International Energy Agency, geothermal power can contribute to 3.5% to the world-wide power production by 2050. To reach this goal, the development of Enhanced Geothermal Systems (EGS) is a major challenge. This technology allows the exploitation of low-enthalpy reservoirs developed in depths of up to several kilometers (Meller, 2014) 3). 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, various surveys, and data analysis have been conducted by several experts. It is estimated that Rawa Danau geothermal resource could produce 2x55MW electric power generation (Hutapea et al, 2010)4). This paper provides analysis and evaluation of research performed in Batukuwung - Parakasak Mount 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. IJSTR staff will edit and complete the final formatting of your paper.

2 RESEARCH METHODOLOGY

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 analyze and evaluate data and information from four basic surveys: geology, geochemistry, geophysics and shallow drilling at Batukuwung and Rawa Danau at Serang Regency, West Java. Surface manifestation indicating the geothermal resource existence is in many objects. The dominant surface manifestation is hot water springs. Observation and survey in the area shows a water spring behind Batukuwung bath having temperature to reach 630°C. Meanwhile using indicator paper, the spring water has normal pH (=7). Geology, geochemistry and geophysical data of Batukuwung-Parakasak area are important in analysis of geothermal activity and the impact. According to Lagat (2009)5), rock alteration simply means changing the mineralogy of the rock. The primary minerals are replaced by the secondary minerals because there has been a change in the prevailing conditions subjected to the rock. These changes could be caused by changes in temperature, pressure, or chemical conditions or any combination of these. Hydrothermal alteration is a change in the mineralogy as a result of interaction of the rock with hot water fluids, called "hydrothermal fluids". The fluids carry metals in solution, either from a nearby igneous source, or from leaching out of some nearby rocks.

3 RESULT AND DISCUSSION

Along with the need for renewable energy, geology, geochemistry, geophysical and shallow well drilling surveys that can assist in the exploration of geothermal energy have been performed. The result is expected to generate information about the geothermal resource in the area of Batukuwung – Rawa Danau and surrounding area, Padarincang District, Serang Regency, West Java Province.

3.1. Geology

Beginning the research, a geological mapping has been performed. Geologically, Batukuwung and surrounding area consists of four rock units (Figure 1). The stratigraphic sequence of the research area is based on the main constituent rocks and the special features of each rock unit. Four rock units are grouped, those are 1) Parakasak Lava Andesite, 2) Volcanic Breccia, 3) Wangun Lava Andesite, and 4) Swamp Alluvial. Grouping of these rock units are also referred on regional geology by Santosa (1991)6).
With respect to the rock units existed in the area, Syah Alam et al (2014) found almost similar four major rock units, those are: 1) Mt. Parakasak lapili tuff, 2) Mt. Parakasak volcanic breccia, 3) Mt. Karang volcanic breccia, and 4) Rawa Danau sediment. The basic rocks in Batukuwung area which are dominantly occupied by lava andesite, volcanic breccia, and volcanic alluvial may have strong influenced to form geothermal resource due to volcanic and magma activity in the regional area of Rawa Danau. With the existence of caldera and fluid flow in the lake investigation of geology found volcanic rocks that experienced alteration. Mielke et al (2015) performed research in Tauhara geothermal area, Iceland. Lithologically the rocks in the area are andesite lava and breccia, rhyolite lava breccia, sandstone, siltstone, mudstone, breccia and tuff. They found that with hydrothermal alteration intensity that has been investigated, variations in permeability, porosity, thermal conductivity and specific heat capacity are related to lithology and intensity and nature of hydrothermal alteration.

3.2. Geochemistry
Most geothermal exploration apply geochemistry survey and data analysis. Rock alteration due to heat from the earth is one of the indication in rock chemical composition change. Hydrothermal alteration is a very complex process that involves mineralogical, chemical, and texture changes caused by the interaction of hot fluids with the rock it passes through, under physio-chemical evolution conditions. Alteration process is a form of metasomatism, which is the exchange of chemical components between liquids and wall rocks (Pirajno, 1992). The temperature and pH of the fluid are the most important of many factors that affect the mineralogy of the hydrothermal system. Under conditions that are saturated, hot, hydrostatic, pressure is directly related to temperature, while gas pressure and the ratio of elemental concentrations depend on pH. Other variables only have a small influence on mineralogical changes. Corbett and Leach (1996) provide the following types of alteration: Advanced Argillic, Argillic, Phyllic, Outer Propylitic, Propylitic, Potassic, and Skarn. Based on the above type classification of alteration, Batukuwung geothermal altered rocks can be grouped (Figure 2) into:

1. Smectite - Illite-Smectite - Kaolinite – Calcite Zone
The presence of this set of alteration minerals is found in the XRD results. In XRD analysis of rock sample from a location, the alteration zone can be compared to an argillic type alteration zone (Corbett and Leach, 1997) with a comparative temperature of ± 150°-180°C. Comparison of mineral alteration temperature ranges in the argillic zone (modification from Lawless et al., 1998).

2. Chlorite - Zeolite - Illite-Smectite ± Calcite ± Secondary Quartz ± Adularia Zone
This zone is based on the interpretation and similarity of rock characters in the outcrops and presence of mineral sets - alteration minerals found in XRD results. In comparison with the above XRD analysis method, petrology and petrography analysis of subsurface rock fragments could also refer to Corbett and Leach method. Supriadi et al (2018) who performs petrology and petrography analysis found alteration of subsurface rock to form smectite-chlorite and illite-smectite-chlorite and sericite zone predicting 140° C - 220° C.

According to several geothermal experts, it is known that epidote is an indicator of mineral that formed by high temperature hydrothermal alteration. Nyandigisi et al (2016) performed study in high temperature of active geothermal field who classify altered mineral as High Temperature Hydrothermal Alteration Minerals (HTAMs). HTAMs are known to occur at stable pressure and temperature regimes for example epidote occurs at temperature of over 250°C. To understand more detail of Batukuwung geothermal potential, it is valuable to perform survey of subsurface mineralogy by drilling shallow exploration wells.
3.3. Geophysics
To increase the analysis dan evaluation of Batukuwung geothermal resource, geophysical surveys have been conducted by experts. Those are gravity, resistivity and Magneto-Telluric methods. Since Batukuwung is the southern part of Rawa Danau Caldera, data dan analysis is in part of caldera area. Geophysical data from surveys has been reported by Indonesian Ministry of Energy and Mineral Resources (2017)14. From these survey and data it can be analized possible geothermal sistem in Batukuwung area. Possible rocks as reservoir rocks are young volcanic rock of Mount Parakasak products in the form of lava or pyroclastic. The rock is quite good because it has been deformed in the Quaternary Volcanic period so that it is possible to form intensive and permeable fracture patterns (Susmanto,2014)15.

3.4. Shallow Exploration Well Drilling
Using data from Ministry of Energy and Mineral Resources, there is a shallow geothermal exploration well that has been drilled in Mount Parakasak area finding a temperature of 1520°C at 300m depth (PT. Sintesa Banten Geothermal, 2016)16. Using a linear regression line method it can be predicted that geothermal temperature at a depth of 500m could reach 226.4°C and at 1000 m may reach 440.2°C. It is quite potential geothermal resource.

3.5. Geothermal System of Batukuwung Field
From the results of this study, it can be interpreted the geothermal system model (Figure 3). The data used is in the form of surface data and there are limitations, zones that can be determined with the data in the form of upflow and outflow zone, cap rock zone, and transition zone. In geothermal systems, the cap rock consists of impermeable rock layers and has the ability to hold hot steam in the reservoir (Gupta, H., et al., 2007)17). In this zone, rock layers dominated by clay minerals are needed. In the Batukuwung Geothermal Field, the cap-rock zone is compared to the argillic alteration zone in the Wangun Cipurut area with a temperature range of 150-180°C. The transition zone is generally characterized by the presence of minerals calcite, chlorite, and zeolite (Gupta, et al., 2007). This zone is compared to the sub-propylitic alteration zone in the Wangun Pakis area and its surroundings. The temperature range in the transition zone is 200-220°C. With respect to the geothermal system of Batukuwung area, West Java, Sumotarto et al (2017)18 also found closely similar geothermal system of Arjuno-Welirang-Penanggungan (AWP) geothermal area in East Java. Meanwhile, based on the temperature and geothermal field location and according to geothermal resource classification by Fauzie (2015)19, Batukuwung geothermal field is of low-enthalpy type.

![Figure 3: Geothermal System Model of Mount Parakasak - Batukuwung Area.](image)

Concerning the effect of alteration, it is not only on chemical effect that has altered the mineral and element composition, but physical effect also happens. Mikisek et al (2012)20 found in a research that hydrothermal alteration records the physical-chemical changes of rock and mineral phases caused by the interaction of hot fluids and wall rock, which can impact effective permeability, porosity, thermal parameters, rock strength and other rock properties. Comparing the results of this survey with other area in Indonesia, in further step it can be estimated the energy potential using Hochstein (1990) method, Fauziyiyah et al (2016)21 has applied the method. In Ampallas area, closely similar geothermal area with Batukuwung, it can be obtained the speculative resource potential for geothermal system, which is about 30 MWe, although this is just the speculative potential. It means that this potential is not very accurate. Meanwhile Yudiantoro et al (2019)22 performed hydrothermal alteration analysis at Parangtritis geothermal area. Closely similar to Batukuwung geothermal area, Yudiantoro et al (2019) found that the volcanic rocks of the studied area are composed of volcanic breccias and andesite lavas. The magmatism activities have generated hydrothermal fluids until now and interact with meteoric water, wall rocks up on the surface to produce hydrothermal alteration rocks and manifestation of hot water springs.

4 CONCLUSIONS
From the results of the research described in the above chapters, some conclusions can be drawn including:

1. In the geothermal research area of Batukuwung and its surroundings there are four unofficial lithology units (from old to young), namely:
   a. Andesit Parakasak Lava Unit.
   b. Volcanic Breccia Unit.
   c. Andesite Lava Unit of Wangun Pakis.
   d. Swamp Deposition Unit.

2. The Batukuwung research area consists of two alteration zones, namely:
   a. Illit-Smektit - Kaolinit - Calcite Zone (Argill Zone) with temperature range of 150° -180° C.
   b. Chlorite - Zeolite - Illite-Smectite ± Calcite ± Secondary Quartz ± Adularia Zone (Sub-Propylitic Zone) with temperature range of 200° -220° C.
3. Geology, geochemistry and geophysical surveys found volcanic rocks are formed in the geothermal system of Batukuwung geothermal area. Shallow well drilling found a temperature of 152°C at 300m depth that can be predicted to reach 226.4°C at a depth of 500m and 440.2°C at 1000m.

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