International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Fluid Inclusion Analysis of Gold Mineralization in Arinem Cisewu and Its Surrounding, Garut Regency, West Java, Indonesia

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***Abstract*— *Garut Regency, especially Arinem area and its surrounding is generally comprised of igneous rock from the activity of ancient magmatic and young volcano of Papandayan, accountable for potential ore deposit. Arinem Cisewu and its surrounding is an area of alteration and mineralization, such as gold, copper, lead and zinc (Purwanto, et al., 2019). There are lithology units resulted from ancient volcanism process in the form of volcanic sediment and intrusion, and other geological processes assisting the formation of ore mineral deposit. Geological structures controlling the ore deposit potential was found in the research area. The location of our research is a part of Mining Permit of Aneka Tambang Mining Company and also several artisanal mining of gold, copper and galena that had been closed down. Previous research showed that the area and its vicinity has Epithermal Low Sulfidation deposit type which generally could be identified in the quartz veins (Antam, 2016 & Purwanto, et al., 2019). This research is a continuation of the previous one in order to know the temperature of mineralization and alteration zone, as well as lithology and geological structure in research area. The general method of this research is surface mapping, and the temperature data was obtain by fluid inclusion analysis of the quartz vein samples acquired in the area. There are 4 samples of quartz vein but only 2 are eligible to be analyzed and interpreted to represent the temperature of mineralization in the area. Based on the analysis result, we conclude that the temperature of mineralization in the research area is between 231^{O}C – 420^{O}C.*

***Keywords*— *Intrusion, sulfidation, alteration, mineralization, quartz*.

I. INTRODUCTION

The southern part of West Java, particularly Garut Regency and its vicinity is mainly comprised of igneous rock resulted from the activities of ancient magmatic and young volcano of Papandayan, which is considered accountable for the formation of ore mineral deposit. Arinem Cisewu and its neighborhood is an area of alteration and mineralization, among them are gold, copper, lead and zinc (Purwanto, et al., 2019). The lithology units resulted from ancient volcanism, such as volcanic sediment and intrusion, as well as other geological processes had compensated the formation of ore deposit. Geological structure controlling the ore deposit potential was also identified in the research area. The area is partially belong to the Mining Permit of Aneka Tambang, aside from the area that used to be an artisanal mining of gold, copper and galena.

Previous study had pointed that the area is Epithermal Low Sulfidation deposit type, generally manifested in the quartz veins (Antam, 2016 & Purwanto, et al., 2019). This research, as a follow-up of the previous study, was conducted to learn the temperature of mineralization and alteration zones, as well as lithology and structures in the area. The general method was geological surface mapping, and fluid inclusion analysis was performed to quartz samples from the area of interest in order to estimate the temperature. There were 4 samples of quartz veins, but only 2 samples were eligible for the analysis and were interpreted to reflect the temperature of mineralization presented in the area. The result showed that the temperature of mineralization is between 231^{O}C – 420^{O}C.

II. RESEARCH OBJECTIVE

The objective of this research is to study the temperature of alteration and mineralization as well as lithology and its geological structures, particularly in order to collect detailed data of the temperature of ore mineral in research area.

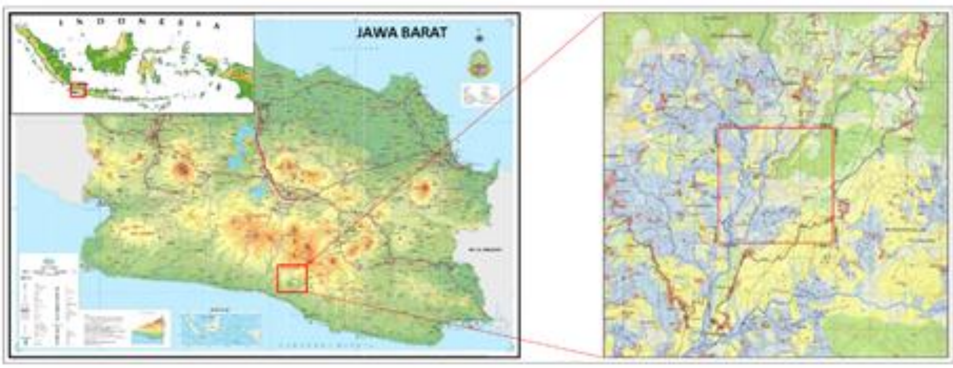

Figure 1. Location of the research area

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III. Regional Geology

Physiographically, the area of this research is a part of the Southern Mountain of West Java which is a wavy low hills and is in the plain and mountainside of Papandayan. The stratigraphy constructing the area is mainly Jampang Formation and Bentang Formation. The Early – Mid Miocene Jampang Formation is comprised of breccia overlain by tuffaceous sandstone and andesite lava in various thickness at different locations. On top of Jampang Formation, the Late Miocene of Bentang Formation was unconformably deposited which was composed of tuffaceous sandstone with a bit of lava in the bottom. The lower part of formation is made of tuffaceous sandstone interbedded with lava, and thereupon conglomerate with a lot of limestone fragments, then well-laminated tuffaceous sandstones, and claystone interbedded with sandstone on it. The geological structures developed in West Java is generally identified into two, that are; dextral strike-slip fault in northwest – southeast direction and sinistral strike-slip fault in northeast – southwest direction. In West Java, some of those faults were reckoned to have been rejuvenating motion since Pliocene Age until present (Asikin, 1986).

The geological structures developed in study area are dextral strike-slip fault in northwest – southeast direction ($N330^0E$) as the main fault controlling mineralization in this area, and also dextral strike-slip fault in $N\ 030^0\ E$ direction. Mineral bearing veins were found in quartz veins filling the shear joints in $N330^oE$ direction and extension joints in $N\ 005^0$-$005^0\ E$ direction. These quartz veins containing mineral were sampled to be analyzed in term of temperature, using the analysis of fluid inclusion.

IV. Alteration

Hydrothermal alteration is a complex process involving changes in terms of mineralogy, texture, and chemical composition of rocks. This process is a result of interaction between hydrothermal fluid and the rocks it passes through, in a specific physical and chemical condition (Pirajno, 1992). Alteration zone has distinctive characteristics and patterns to be identified with. The zonation pattern begins from the nearest zone to the ore deposit.

The result of megascopic and petrographic observation on several samples of altered rocks in the field indicated three alteration zones;

1. Silicic type (indicated by quartz mineral)
2. Argillic type (indicated by kaolinite and sericite mineral)
3. Propylitic type (indicated by albite, chlorite, ±epidote, ±sericite, ±halloysite, ±smectite mineral).

Silicic Type

Silicic alteration type was indicated by a group of silicic mineral (SiO_2), such as quartz. The alteration only occupied a small area that is 5% of the whole area of interest and is commonly found in epithermal mineralization system. The silicic alteration found in the study area had exposed to strong alteration process and could be found in dacite and andesite lava. It was formed in the earliest phase at volatile rich condition. After fluid rich phase, this alteration was exposed to leaching and became vuggy, and it could even be having brecciated which would open space for deposition of metals brought by hydrothermal fluid. This alteration spreading pattern was influenced by structures developed in the area.

(A)

(B)

(C)

Figure 2. The presence of Silicic alteration (A), Argillic alteration (B) and Propylitic alteration on Andesite.

Argillic Type

Argillic alteration is indicated by the presence of clay mineral aggregate build upon kaolinite and sericite. In the field, this alteration was generally manifested in white color. Argillic alteration was formed in the final phase when volatile rich hydrothermal fluid seeped out through the cracks during post – magmatic in pH of 4 – 5 and relatively low temperature of 200 - 250˚C (Corbett and Leach, 1997). The pattern of argillic alteration spreading was controlled by geological structures developed in the study area and it covers about 20% of the area.

Propylitic Type

The propylitic alteration is indicated by the presence of albite and chlorite mineral that partially substitute pyroxene in andesite and epidote rocks. This propylitic alteration was

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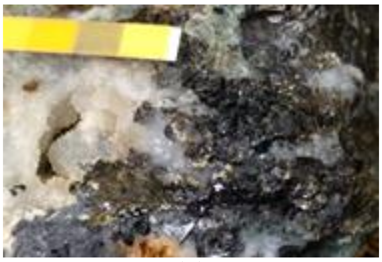
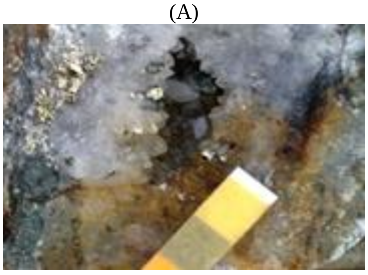
categorized in weak up to strong alteration. The field manifestation of this alteration still had the texture of its origin rock, but started to have the green color of chlorite mineral on certain places and there were spots that had been strongly altered and had strong green color. The spreading pattern of propylitic alteration in the area was controlled by geological structure developed there and it was about 75% of the study area. It occurred in the early stage of alteration at high temperature so it was found on almost all over the study area.

V. MINERALIZATION

The mineralization occurred in research area was relatively associated to quartz veins (or veinlets) in texture of banded, chloroform, vuggy and quartz breccia, and sheared often filled with quartz breccia in relatively northwest – southeast direction that were found in sandstone and andesite-basalt lava. The mineralization veins were the result of the filling process of hydrothermal fluid along with shear joint formation. Based on mineralography analysis and its presence in the field, the ore mineralization in study area were primary metal elements in the form of copper (Cu), lead (Pb) and zinc (Zn) and other secondary metal minerals, such as: pyrite (FeS_2), chalcopyrite ($CuFeS_2$), galena (Pbs), bornite (Cu_5FeS_4), magnetite (Fe_3O_4), gold (Au).

The texture of quartz veins found in the area were brecciated quartz, (chalcopyrite, galena, sphalerite), bended quartz (comb structure and it contains pyrite, chalcopyrite), and quartz vein (covellite and malachite).


(A)


(B)

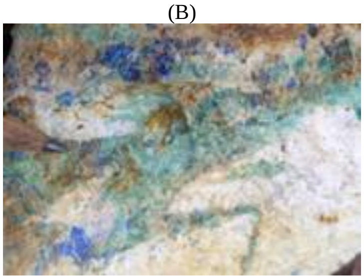
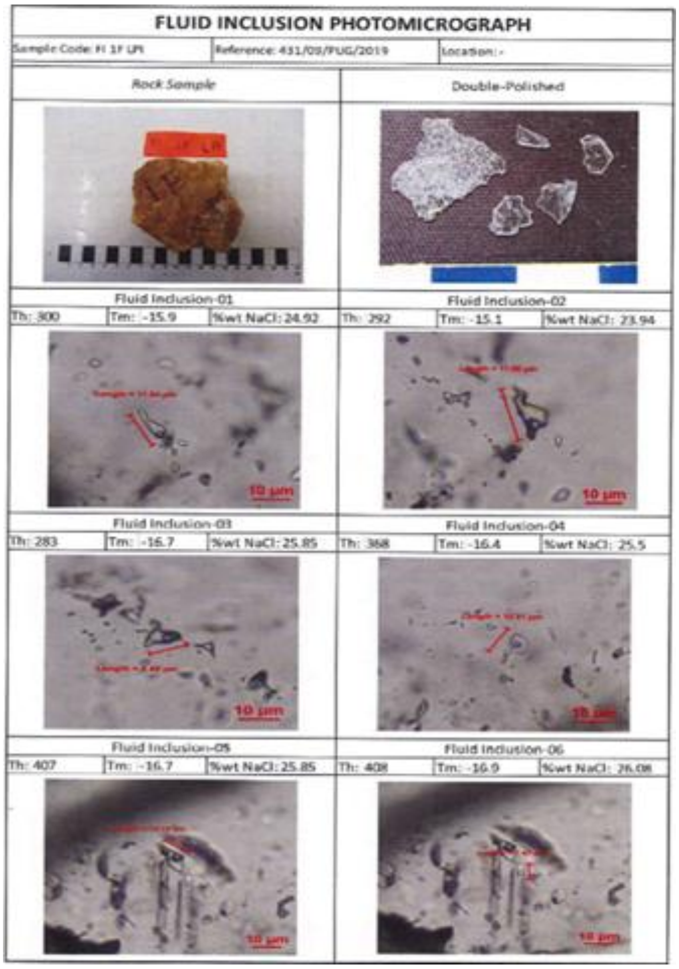

(C)

Figure 3. A. Brecciated Quartz, there are chalcopyrite, galena, sphalerite. B. Bended Quartz, comb structure and contains of mineral pyrite, chalcopyrite. C. Banded chloroform Quartz Vein there are malachite and covellite.

VI. FLUID INCLUSION

Fluid inclusion is a temperature measurement on the fluid trapped inside a mineral, in this case is quartz vein, during its formation. The method was performed on thin incision preparation. In this research, temperature was estimated on the quartz vein samples from 2 (two) observation locations in research area. The percentage of pressure and density of the fluid were calculated, in order to estimate the pressure, density, paleosurface depth, model and environment of mineralization. Salinity estimation was based on the assumption that the fluid was mainly composed of Na+ and Cl-, in terms of the equivalent weight total percentage of NaCl (Potter, 1978).

Fluid Inclusion Analysis of sample F1 1F LP1



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FLUID INCLUSION MICROTHERMOMETRY DATA SHEET

Reference	431/09/PUG/2019	Location	-
Sample Code	FI 1F LPI	Coordinate	-
Date	7/03/2019	Rock Type	silica quartz

Th-range:	Tm-Range:	% wt NaCl Range:
283°C - 420°C	(-13.9)°C - (-16.9)°C	22.41 - 26.08

No	Size (μm)	Th (°C)	Tm (°C)	% Wt NaCl	Phase
1	11.84	300	-15.9	24.92	Liquid + Vapour
2	17.06	292	-15.1	23.94	Liquid + Vapour
3	9.46	283	-16.7	25.85	Liquid + Vapour
4	10.91	368	-16.4	25.50	Liquid + Vapour
5	10.15	407	-16.7	25.85	Liquid + Vapour
6	7.47	408	-16.9	26.08	Liquid + Vapour
7	6.83	411	-16.4	25.50	Liquid + Vapour
8	6.81	286	-13.9	22.41	Liquid + Vapour
9	4.08	288	-14.9	23.69	Liquid + Vapour
10	8.50	367	-15.3	24.19	Liquid + Vapour
11	5.57	297	-14.9	23.69	Liquid + Vapour
12	3.67	411	-16.7	25.85	Liquid + Vapour
13	2.80	403	-16.7	25.85	Liquid + Vapour
14	7.11	420	-14.9	23.69	Liquid + Vapour
15	7.87	407	-16.7	25.85	Liquid + Vapour
16	15.81	408	-16.4	25.50	Liquid + Vapour
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Figure 4. The result of Fluid Inclusion analysis of sample F11F LP1

The sample with code F1 1F LP1, based on the fluid inclusion measurement, by combining the values of Th (homogenization temperature), Tm (melting temperature) and salinity, is a silicified rocks containing quartz veins and oxide contaminated. The silicified part is milky white in color, having many fine fractures due to deformation and oxide contamination. The quartz vein is composed of quartz anhedral, partly granular, sheeted, partly clear, containing many older generation of quartz mineral detritus. The fluid inclusion of the silicified rock is generally damaged. Fluid inclusion inside quartz vein is sparse, they are in various size, shape, type and generation. The size is generally between fine to medium (2,80 -17,60 μm), the shapes are anhedral and subhedral, some are necking down and partly damaged. The fluid inclusion is found to be unevenly spread, sometimes isolated (primer) and planar oriented (secondary).

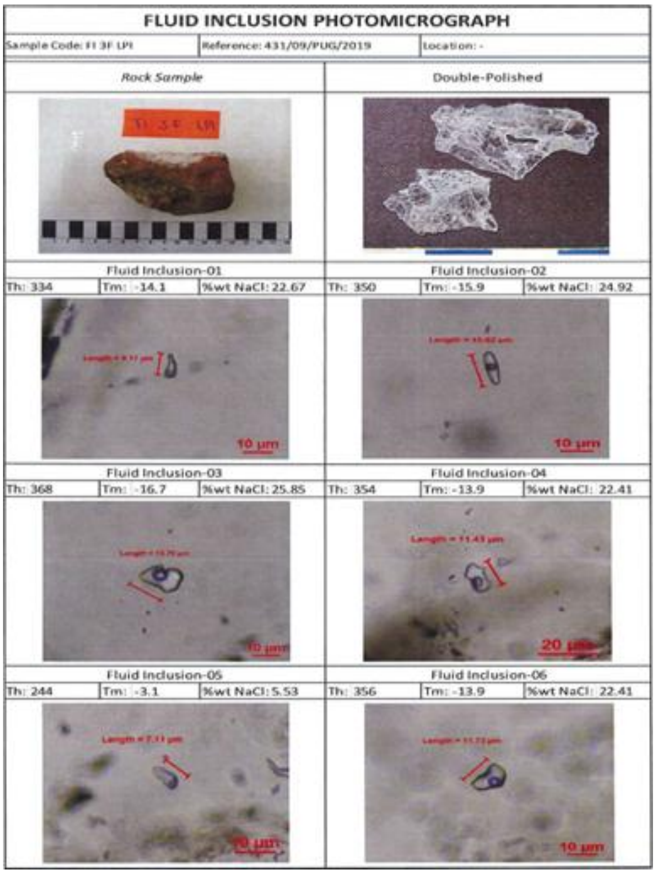
The result of microthermometry measurement of sample LP1 showed values of Th is between 283 – 420^{O}C, and Tm is between (-13,9)^{O}C – (-16,9)^{O}C, and the calculation had estimated the percentage of NaCl to be equivalent of 22,41-26,08 %WT

Fluid inclusion analysis of sample F1 3F LP1

Based on the analysis, the quartz vein sample is chalcedonic and microsilica silicified rock which is mostly milky white, containing a lot of altered mineral fragment of mica, sericite, clay, very fine mineral inclusion, opaque and the inclusion in general is damaged. The crystal of quartz vein is generally transparent but many impurities such as granules and fibers of altered mineral and amorphous were found. The quartz is opaque, anhedral, sheeted, having many fine fractures and damaged inclusions. The quartz veinlets are transparent, sheeted, drusy, some have crustiform texture, granular crystal.

Many fluid inclusions were found and most of them are single phase rich of water, some are rich of gas, the dimension is generally very fine, the shape is anhedral to subhedral, many are necking down and damaged, they are randomly spread all over. Fluid inclusion inside quartz vein is sparse, they were found in various size, shape, type and generation. Generally it has very fine up to medium size (5,20 -15,02 μm), anhedral and subhedral, some are necking down and partly damaged. The fluid inclusion is unevenly spread, some are isolated (primary) and others are planar oriented (secondary).

The microthermometry measurement result of sample LP1 showed values of Th is between 231 – 368^{O}C, and Tm is between (-2,9)^{O}C – (-16,7)^{O}C, and the calculation result had estimated the percentage of NaCl to be equivalent of 5,19-25,85 %WT.



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FLUID INCLUSION MICROTHERMOMETRY DATA SHEET

Reference	431/09/PUG/2019	Location	-
Sample Code	FI 3F LPI	Coordinate	-
Date	7/03/2019	Rock Type	silica quartz breccia

Th-range:	Tm-Range:	% wt NaCl Range:
231°C - 368°C	(-2.9)°C - (-16.7)°C	5.19 - 25.85

No	Size (μm)	Th (°C)	Tm (°C)	% Wt NaCl	Phase
1	9.17	334	-14.1	22.67	Liquid + Vapour
2	15.02	350	-15.9	24.92	Liquid + Vapour
3	13.79	368	-16.7	25.85	Liquid + Vapour
4	5.20	354	-13.9	22.41	Liquid + Vapour
5	7.11	244	-3.1	5.53	Liquid + Vapour
6	11.73	356	-13.9	22.41	Liquid + Vapour
7	5.94	236	-3.8	6.71	Liquid + Vapour
8	8.82	232	-0.2	0.36	Liquid + Vapour
9	9.82	347	-13.9	22.41	Liquid + Vapour
10	5.30	236	-3.1	5.53	Liquid + Vapour
11	11.89	325	-12.0	19.70	Liquid + Vapour
12	10.59	290	-12.0	19.70	Liquid + Vapour
13	12.92	231	-2.9	5.19	Liquid + Vapour
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Figure 5. Fluid inclusion analysis result of sample F1 3F LP1

Based on fluid inclusion analysis of those 2 (two) quartz vein samples, we interpreted that alteration and mineralization in the research area occur at temperature between 231^{O} C – 420^{O} C.

VII. Discussion

The location of our research is an area of artisanal gold mining that had been closed down, where the presence of gold is much related to galena, chalcopyrite and sphalerite and few secondary minerals such as malachite and covellite.

The research area have been categorized by researchers as low sulfidation type deposit, due to the presence of galena, as it unevenly spread in the location of alteration and mineralization zone. Galena is considered as an indication of low sulfidation deposit type near a fault zone with higher temperature.

Later on in this research, we found an abundant of galena along with pyrite chalcopyrite, sphalerite on the fault zone, quartz brecciated, and secondary mineral of covellite, malachite.

There are existences of silicic, argillic and propylitic alteration in research area where we could find carrier of gold, silver, zinc and lead ore mineral, such as chalcopyrite, sphalerite galena and pyrite. Based on the classification made by White (2009) or Silitoe (2015), the epithermal deposit of our study area then can be classified as Intermediate Sulfidation with the presence of galena and sphalerite particularly in some locations near the fault zone and quartz brecciated. While the area itself is generally an Epithermal Low Sulfidation type deposit.

The determination of deposit type is based on not only mineral presence, quartz texture and geological structures, but the temperature during mineral formation is also very important. In that case we had taken quartz vein samples in order to analyze the fluid trapped during vein formation and to interpret the minerals formed. Based on the fluid inclusion analysis result, it showed that the temperature is between 231^{O} C – 420^{O}C, of which there is a possibility of Epithermal Low Sulfidation deposit type in the area at the temperature of 200^{O}C and Intermediate Sulfidation deposit type at about 400^{O}C.

VIII. Conclusion

The Arinem Cisewu area is a region with the potential of ore mineral reserves inside quartz vein system. The presence of quartz vein as a result of hydrothermal activity can be found in shear joint controlled by dextral strike-slip as the main fault. The alteration had developed following fault zone from the main zone to the outmost part, that are Silicic Alteration, Argillic Alteration and Propylitic Alteration, respectively. There are carrier of ore mineral found in chalcopyrite, sphalerite and galena, and secondary mineral such as malachite and covellite. The analysis result of fluid inclusion in the area showed that the temperature is between 231^{O} C - 420^{O} C which could be classified as Epithermal Low Sulfidation, while some areas near fault zone and quartz brecciated is Epithermal Intermediate Sulfidation.

Acknowledgement

This research could be accomplished with the aids from various parties. Our thanks to UPN Veteran Yogyakarta for the opportunities and facilities on the laboratory, and Director for Research and Community Services, Ministry of Research and Technology/ National Research and Innovation Agency

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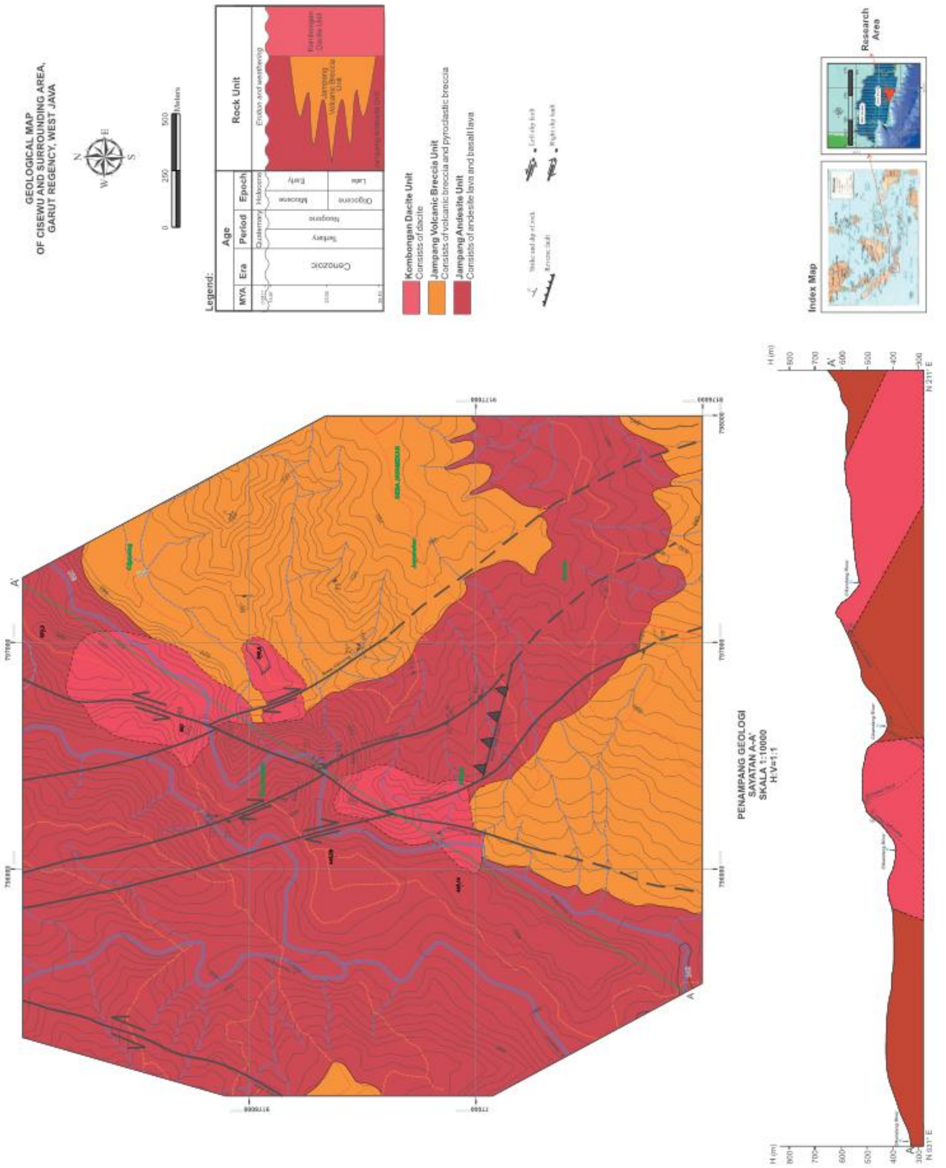

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