LINKAGES BETWEEN VOLCANOTECTONIC SETTING, ORE-FLUID COMPOSITION, AND PRECIOUS BASE METAL PRESENCE: A UNIQUE PROSPECT OF EROSIONAL LOW SULFIDATION RELATED TO INTERMEDIATE SULFIDATION SYSTEM, AT KULON PROGO, YOGYAKARTA

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ABSTRACT

Menoreh Hills is a part of the Oligo-Miosen Sunda Banda Arc (Cenozoic island arc) that saw the subduction process and generate a lot of potential areas presence precious base metals and gold deposit as in Wonogiri, Trenggalek, and Tumpangpitu. Study area is located at Kabupaten Kulon Progo, Special Region of Yogyakarta Province, with geography coordinates of 110°00'00" BT - 110°15'02" BT and 7°35'00" LS - 7°50'30" LS and has 1024 km² (32 km x 32 km) wide. Geology of the study area is dominated by Late Oligocene to Pliocene volcanic rocks and limestones. Stratigraphically, this area is consisting of some litologic formations, which from the oldest to the youngest are Nanggulan Formation, Kaligesing/Dukuh Formation, Jonggrangan Formation, Sentolo Formation, and Alluvial Deposits. Some intrusions of diorite, andesite, and dacite are found at the Kaligesing/Dukuh Formation. Alteration and mineralization processes have happened within the host rock of Kaligesing/Dukuh Formation, with the diorite, andesite, and dacite intrusions as the heat sources. Epithermal deposits of both vein and bulk-tonnage styles may be broadly grouped into high, intermediate, and low sulfidation types based on the sulfidation states of their hypogene sulfide assemblages. The high and low sulfidation types may be subdivided using additional parameters, particularly related igneous rock types and metal content. Silicified quartz veins with crustiform texture were found in Plampang, Sangon and Bagelen accompanied by gold, galena, sphalerite, pyrite, chalcopyrite, molybdenite, covellite, barite, magnetite and hematite mineralization. It also found polymetallic (Zn-Pb-Cu-Au) vein deposits at plampang II and III indicating a change from low to intermediate sulfidation. From the geomagnetic survey shows the lineament in the pattern of minerals control structure which is relatively NE-SW. Fluid inclusion analysis showed homogenization temperature 174,1° - 186,2°C and pressure 4,62 - 11,50 bar, based on the data it is estimated that quartz fluid mineral carrier formed in Epithermal zone. The result of AAS analysis shows that metal elements are Au, Ag, Cu, Pb, Zn, As, Sb and Mo and gold content ranges from 0.10 to 0.42 ppm is in the rock while in quartz veins between 0.52 - 1.45 ppm.

Keyword: Alteration, Base Metal, Low-Intermediate Sulfidation

METHODOLOGY

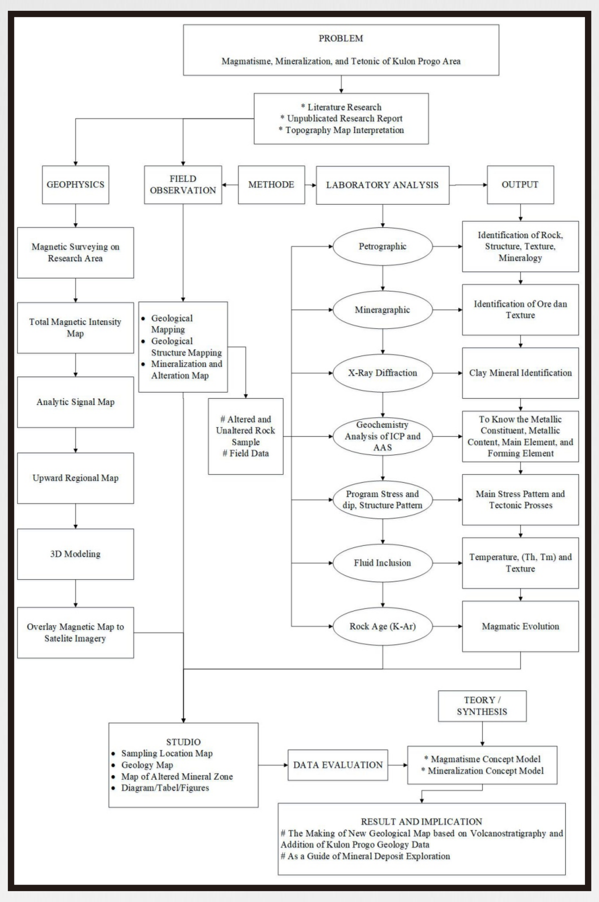


Figure 1. Shows the flow chart of the research processes which include acquisition, geochemistry analysis, geological literature research, and geophysical data processing.

REGIONAL GEOLOGY

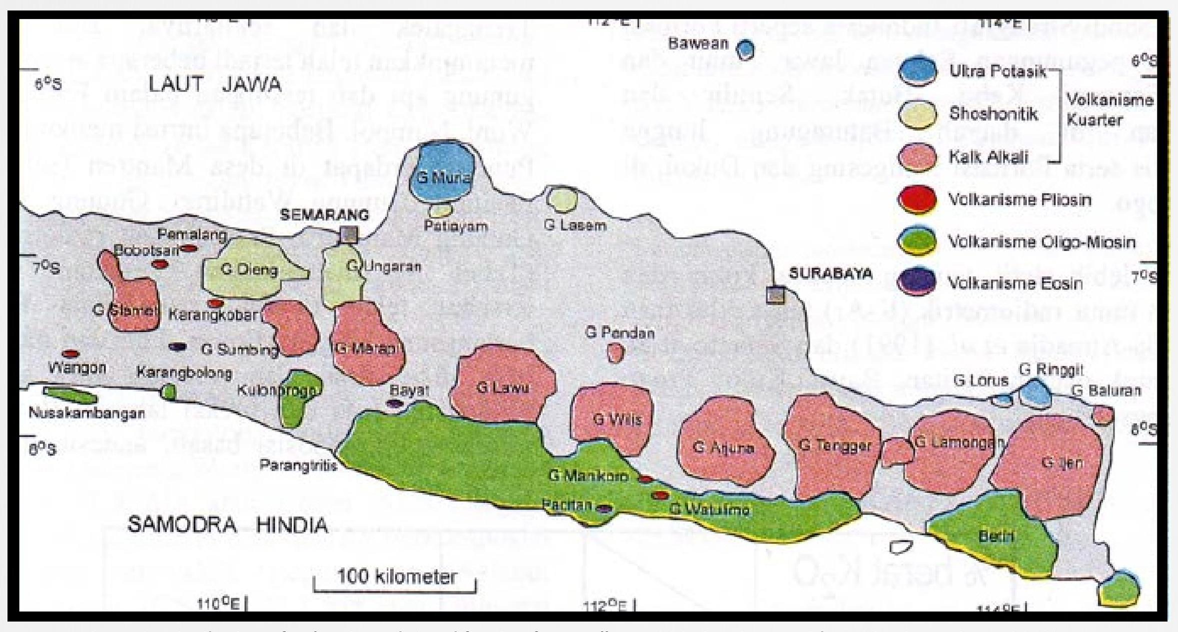


Figure 2. Distribution of Volcanic Rock (modification from Bellon, 1989, Soeria-Atmajda, 1994, in Harjanto 2008)

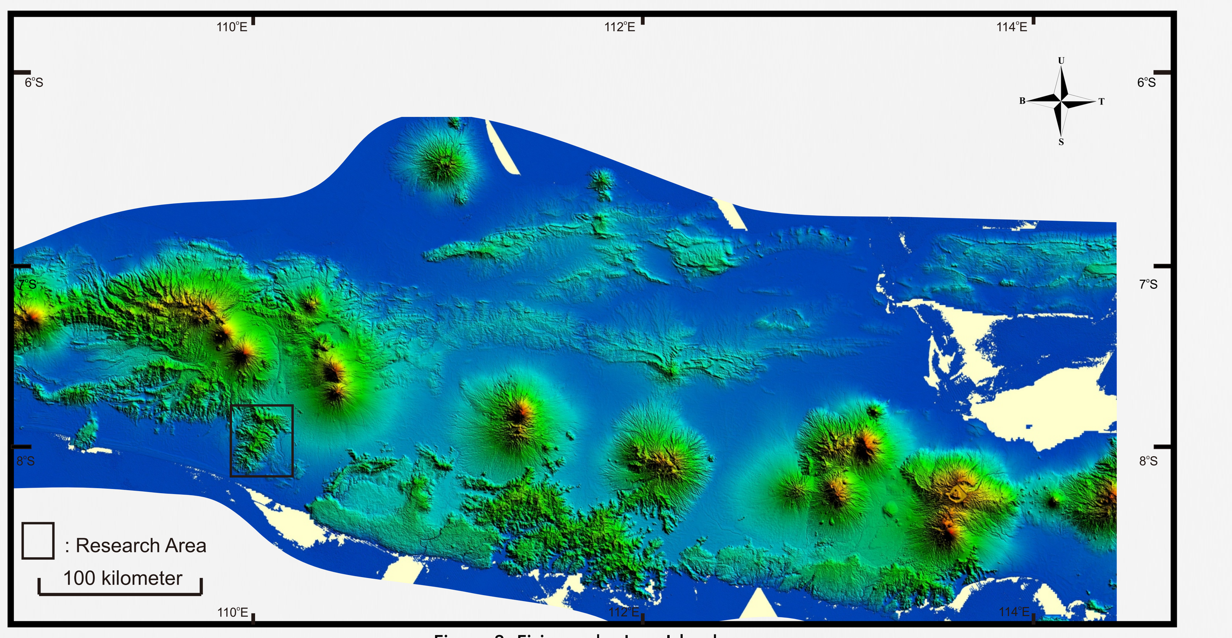
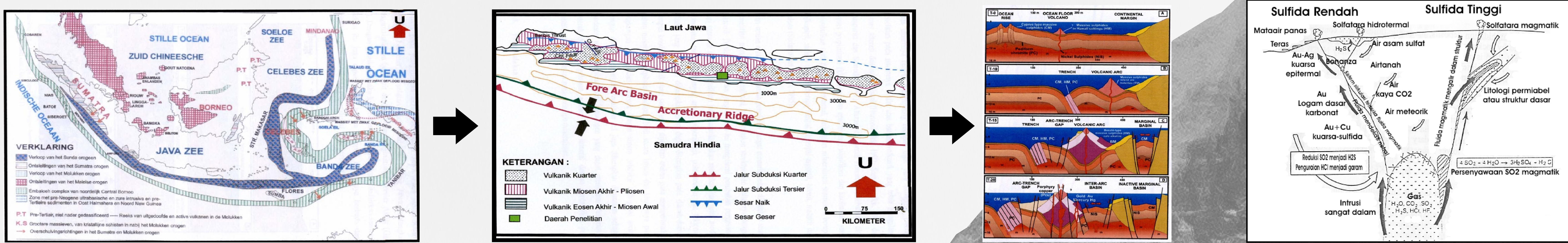


Figure 3. Fisiography Java Island

Van Bemmelen, 1949 divides Central Java into six physiographic zones, namely the Quarter Mountain, the Northern Alluvial Plain of Java, the North Serayu Antiklinorium, the Dome and the Ridge in the Central Depression Zone, the Central Depression Zone and the Southern Mountains. Based on the division, Kulon Progo is part of the Central Depression Zone.

Magmatic activity in the Kulon Progo region occurred in the Oligocene - Miocene (Bemmelen, 1949) with the spread of west - east volcanic rocks. During the Tertiary Period the Kulon Progo region is thought to have undergone a deformation of at least twice the tectonic phase period (Sopaheluwakan, 1994 and Soeria Atmadja et al 1991), first occurring in the Final Oligocene - the Initial Miocene and the second occurring in the Central Miocene - magmatic. The existence of strain-pattern faults, fault-up and magmatic arc shifts from north to south and then changed from south to north indicates the development of tectonic order. In this case the pressure force changes to a compression force. This symptom is also associated with the change in the speed of the Indian-Australian ocean plate to the Eurasian plate. Javanese tectonic evolution during Tertiary shows a continuous subduction path from the Indies-Australian plate infiltrated Java (Hamilton, 1979 and Katili, 1971). While the Tertiary Magmatic arc is slightly shifted to the north and the Quarter magmatic arc coincides with the Central Miocene magmatic arc (Soeria Atmadja et al, 1991) with its subduction path shifting southward. Another tectonic development is that the Karangsambung-Meratus subduction lane becomes inactive due to clogging by the presence of the continental material. Sribudiyani, et al. (2003) said that based on new seismic and drilling data in East Java interpreted the presence of continental fragments (called micro plates of East Java) as the cause of the subduction of southwest-northeast direction (Meratus pattern) to east-west Java).

VOLCANOTECTONIC SETTING



a. Metaloganic Map of Indonesia (Westerveld, 1939, in Harjanto, 2008), b. The development of subduction zone and magmatic arc in tertiary era until now (Modification by Soeria-Atmaja, dkk, 1994, and Simanjuntak and Barber, 1996, in Harjanto, 2008). c. The correlation between convergent island arc and mineralization (Mitchell, dan Garson, 1981, in Harjanto, 2008), d. Epythermal Deposition Model (Corbett and Leach, 1998) (Corbett, dan Leach)

RESULT & DISCUSSION

Geological Map
Kulon Progo, Yogyakarta

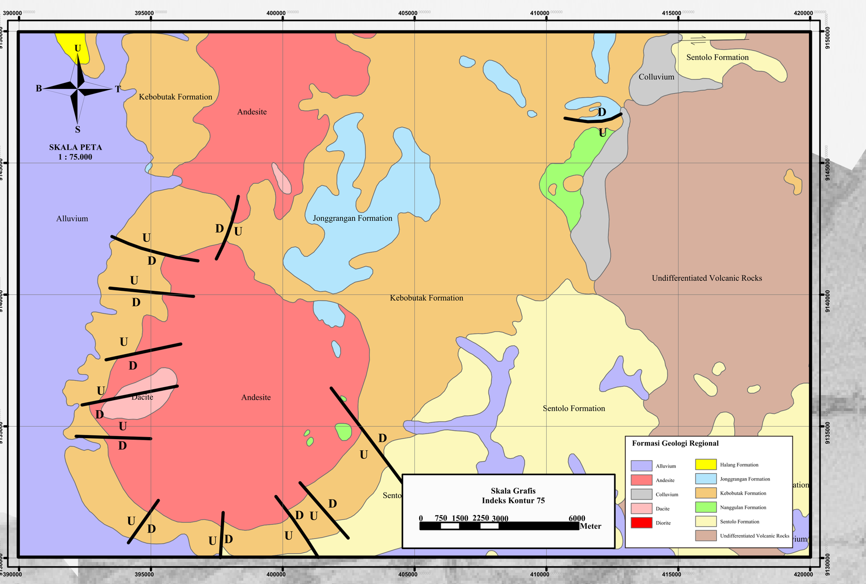


Figure 8. Geological Map of Kulon Progo (Research Team, MGEI IST. Akprind Yogyakarta Student Chapter)

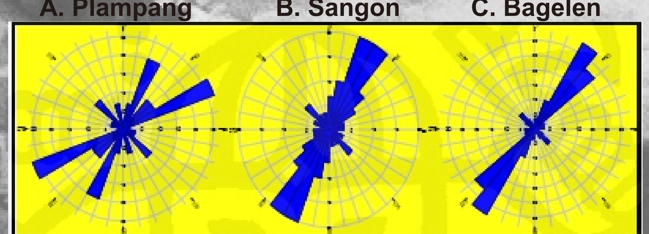


Figure 9. Roset Diagram (Harjanto, 2008)

Landsat Imagery
Kulon Progo, Yogyakarta

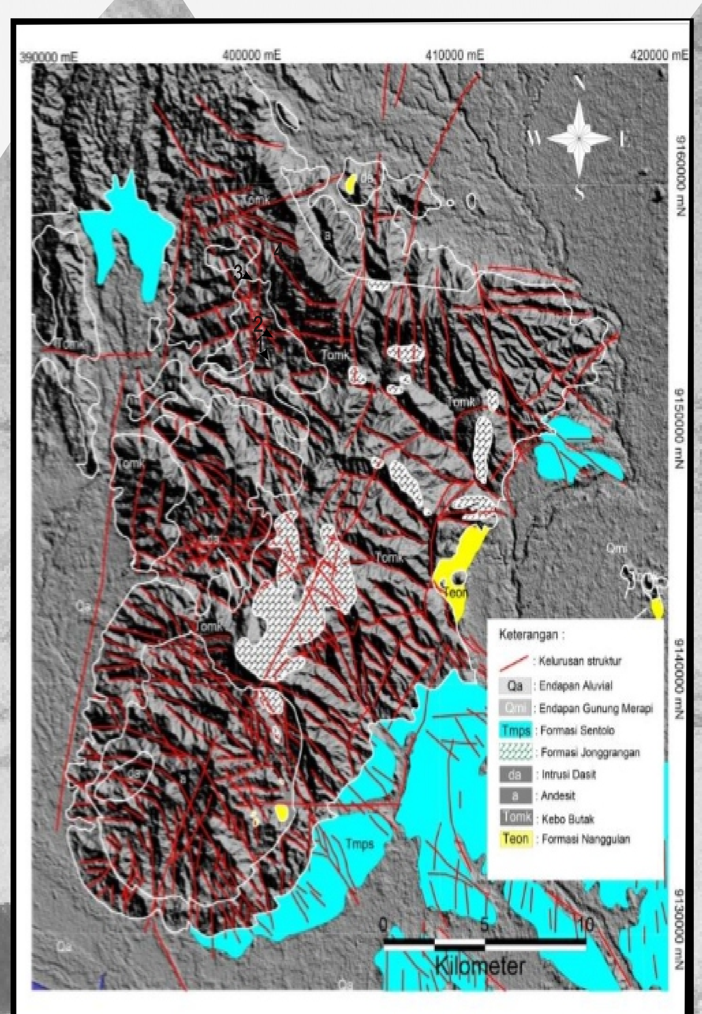


Figure 10. Landsat Imagery (Asmoro Widagdo, 2016)

Vein Model
Kulon Progo, Yogyakarta

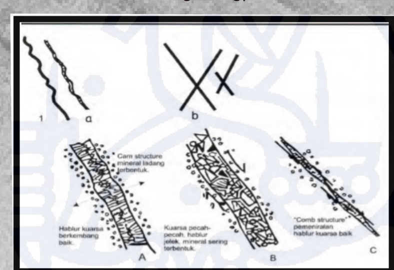
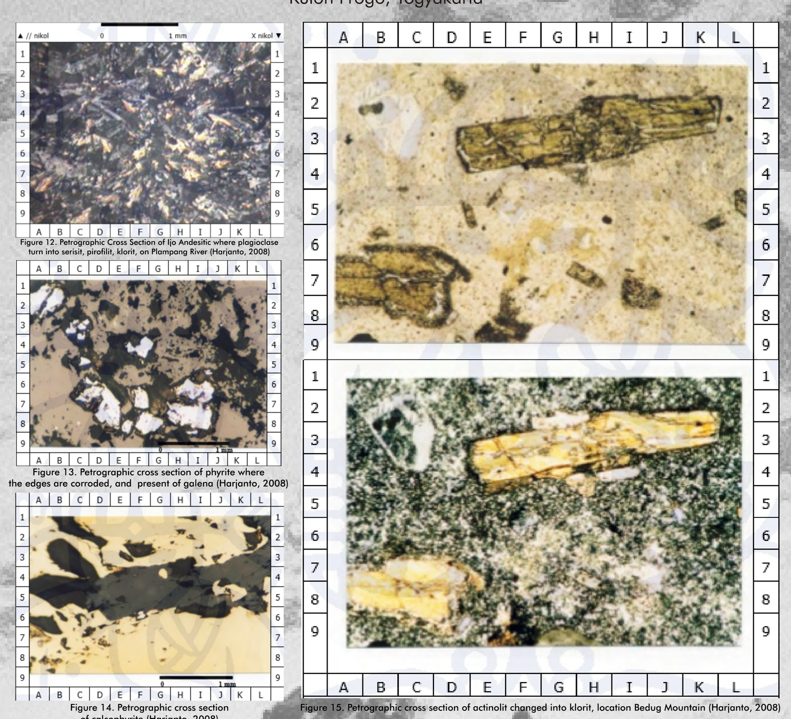


Figure 11. Vein Model (Harjanto, 2008)

Petrographic Cross Section
Kulon Progo, Yogyakarta



Mineralization Map
Kulon Progo, Yogyakarta

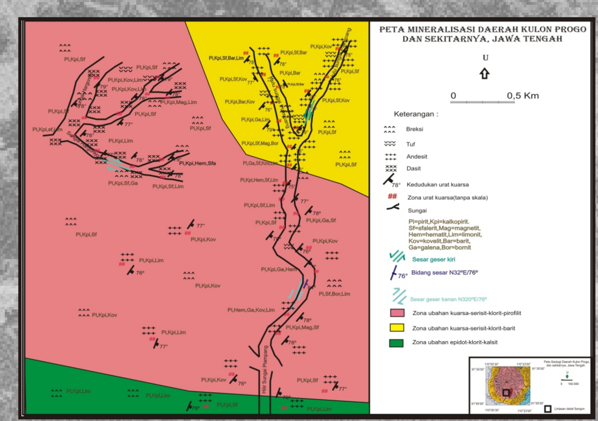


Figure 16. Vein Model (Harjanto, 2008)

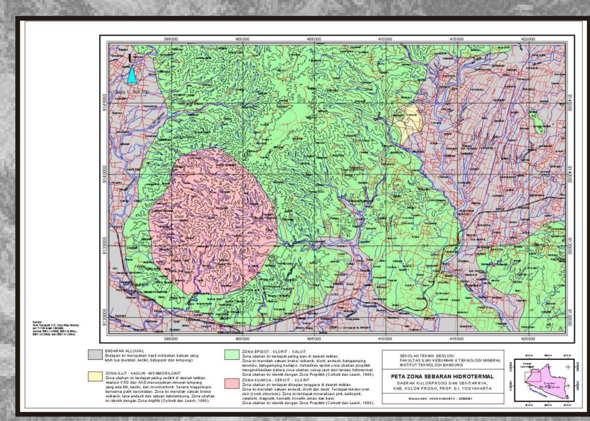


Figure 17. Hydrothermal Distribution Zone Map (Harjanto, 2008)

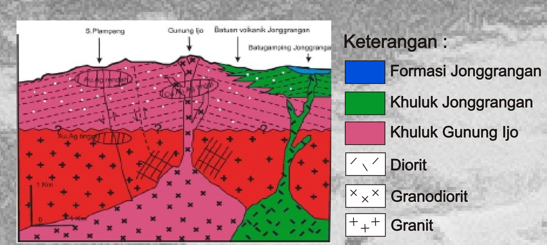


Figure 19. Hydrothermal Fluid Flow Model in Kulon Progo (Harjanto, 2008)

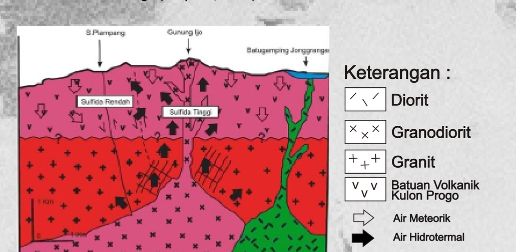


Figure 18. Hydrothermal Fluid Flow Model in Kulon Progo (Harjanto, 2008)

Outcrop
Kulon Progo, Yogyakarta

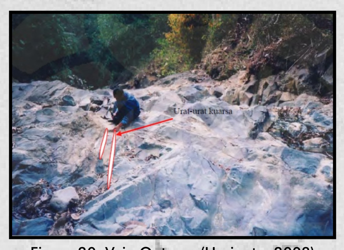


Figure 20. Vein Outcrop (Harjanto, 2008)

Figure 21. Left Slip Fault (Harjanto, 2008)

GEOPHYSICS

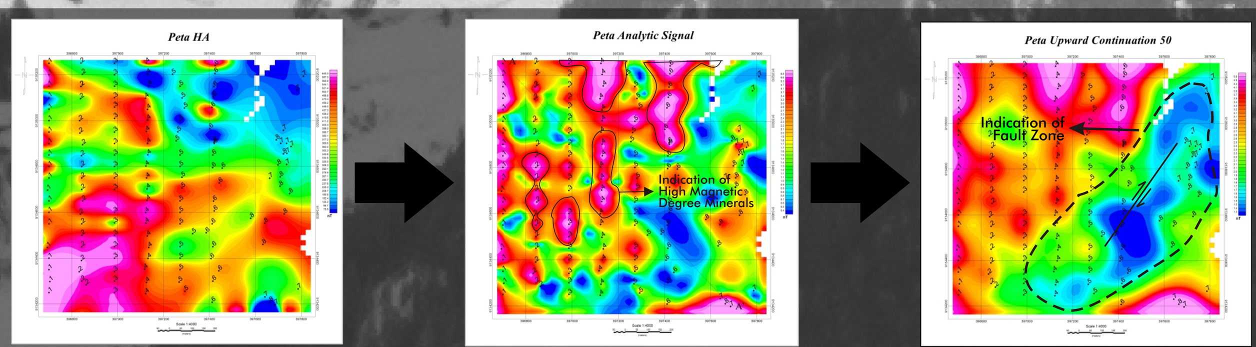


Figure 22. Magnetic Map of research area

The result of geomagnetic method data acquisition had obtained the map of delta H lateral distribution as seen on the map above (Figure a.) the mentioned map above requires some filtering stages in order to distinguish the referred anomaly. Analytic Signal filtering process was done to attain the more detailed magnetic anomaly in research area. (Figure b.) Upward Continuation Regional Map. (Figure c.) is able to show the magnetic anomaly in regional scale so that the direction of the anomaly towards the satellite imagery can be detected. 3D modeling (Figure d.) can provide the information of the anomaly direction vertically into the subsurface. The overlaid magnetic map will help the interpretation process. The overall process of mapping was used to interpret shear zone in the form of fault structure.

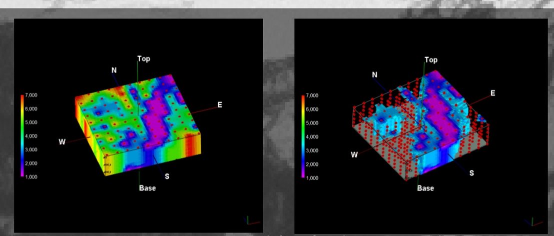


Figure 23. 3D Magnetic Modeling for shear zone indication

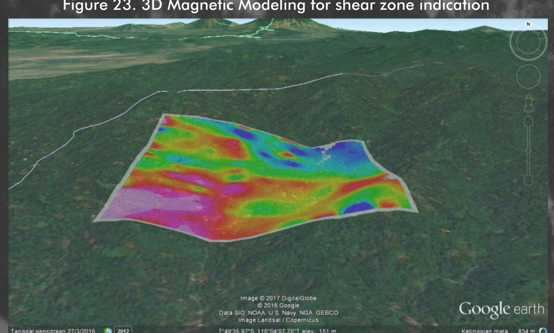


Figure 24. Magnetic Map Overlaying with Google Earth Mapping

GEOCHEMISTRY

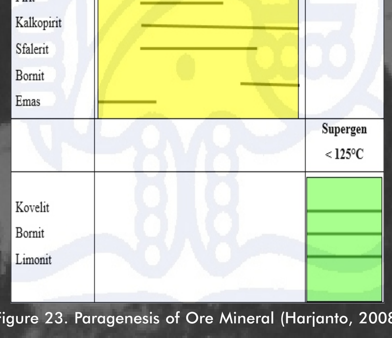


Figure 23. Paragenesis of Ore Mineral (Harjanto, 2008)

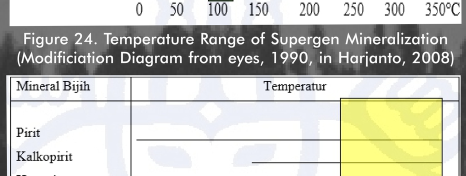


Figure 24. Temperature Range of Supergen Mineralization (Modificiation Diagram from eyes, 1990, in Harjanto, 2008)

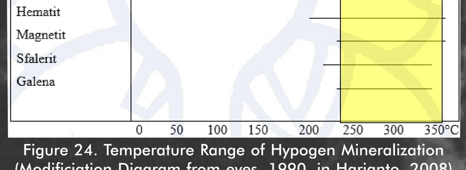


Figure 24. Temperature Range of Hypogen Mineralization (Modificiation Diagram from eyes, 1990, in Harjanto, 2008)

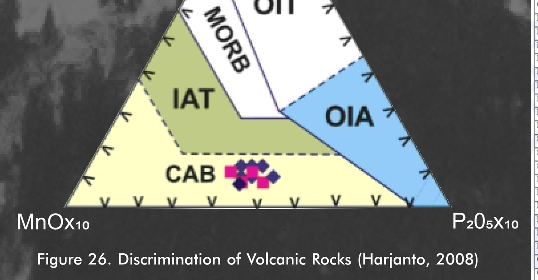


Figure 26. Discrimination of Volcanic Rocks (Harjanto, 2008)

Parameter	Kisaran	Rata-rata
Temperatur cair (Tm)	-1,2 - - 0,6 °C	-0,1 °C
Temperature homogenisasi (Th)	181,3 - 221,4 °C	198,7 °C
Kadar Na Cl (menurut Roedder's, 1984)	1,0 - 2,2 %WT	1,7 %WT
Kedalaman (menurut Haas, 1971)	95,8 - 163,5 m	163,5 m
Pressure (menurut Haas, 1971)	9,71 - 23,58 bar	15,58 bar

Figure 27. Result of Fluid Inclusion Analysis (Harjanto, 2008)

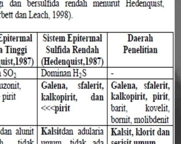


Figure 27. Micrographic Cross Section of Quartz Vein (Harjanto, 2008)

Tabel V. 6. Hasil Analisis AAS (dalam ppm) di daerah Kulon Progo

Nomor Conto	Au	Ag	Cu	Pb	Zn	As	Sb	Mo	Batuan/ Urat
KP.01	<0,005	5,937	37,35	5,40	41,60	-	-	-	Andesit
KP.1C	0,09	3,70	11,50	25,0	25,10	12,40	2,60	0,35	Urat
KP.05	<0,005	10,99	179,40	11,75	420,85	-	-	-	Urat
KP.09	0,415	4,063	338,30	104,85	58,65	-	-	-	Urat
KP.12	0,170	8,80	9,20	14,0	9,40	18,70	10,90	0,45	Urat
KP.13	0,005	7,48	34,15	41,50	95,45	-	-	-	Andesit
KP.18	0,098	1,787	28,75	43,80	35,80	-	-	-	Urat
KP.19	0,036	10,25	20,85	6,50	14,95	-	-	-	Dasit
KP.22	0,032	1,687	9,50	23,80	24,75	-	-	-	Diorit
SN.1	0,002	3,70	20,30	6,0	26,60	-	-	0,30	Andesit
SN.2	0,523	3,20	9,80	4,0	20,70	-	-	4,10	Urat
SN.3	0,007	8,60	331,9	204,0	138,10	-	-	11,60	Urat
PL.1	0,016	10,80	18,10	11,0	37,30	-	-	6,90	Urat
PL.2	0,363	2,50	58,10	5,0	93,90	-	-	2,70	Andesit
PL.3	1,452	2,90	81,90	28,0	347,40	-	-	0,70	Urat
PL.4	0,526	4,80	219,30	81,0	596,0	-	-	<0,30	Urat
PL.5	0,008	2,50	42,80	4,0	79,40	-	-	2,0	Andesit
PL.6	0,008	2,20	38,90	1,0	64,50	-	-	3,30	Andesit
CR.1	0,152	3,10	60,60	413,0	410,4	-	-	114,0	Urat
CR.2	0,780	1,90	9,70	35,0	83,20	-	-	80,30	Urat
CR.3	0,012	2,40	15,30	114,0	124,8	-	-	81,20	Dasit

Figure 28. Result of AAS Analysis in ppm (Harjanto, 2008)

Tabel VI. 1 Perbandingan tipe ubahan daerah penelitian dengan sistem epitermal bersulfida tinggi dan bersulfida rendah menurut Hedenquist, (1987 dalam Corbett dan Leach, 1998).

Parameter	Sistem Epitermal Sulfida Tinggi (Hedenquist,1987)	Sistem Epitermal Sulfida Rendah (Hedenquist,1987)	Daerah Penelitian
Fluida	Dominan SO_2	Dominan H_2S	-
Asosiasi Mineral	Enargit,luzonit, dan >>> pirit	Galena, sfalerit, kalkopirit, dan <<<pirit	Galena, sfalerit, kalkopirit, pirit, barit, kovelit, bornit, molibdenit
Mineral Ubahan	Pirofilit dan alunit melimpah, tidak ada adularia dan kalsit, diaspor umum, klorit tidak ada atau sedikit.	Kalsitdan adularia umum, tidak ada diaspor,klorit dan serisit umum	Kalsit, klorit dan serisit umum
Mineral Ekonomis	Au ± Cu	Au ± Ag	Au
Mineral Asesoris	As dan Te	Pb, Zn, Cu, As, Te, Hg dan Sb	Pb, Zn, Cu, As, Ag, Mo dan Sb
Kemurnian Emas	Tinggi	Bervariasi	Elektrum
Temperatur	100°C-320°C	100°C-320°C	100°C-350°C
Tekstur Mineralisasi	*Vuggy* dan kuarsa masif	*Crustiform, fine comb, colloform banded, vuggy* dan *bladed calcite*	*Fine comb, vuggy* dan *bladed calcite*

Figure 29. Comparison between L.S. & H.S. Epithermal System (Harjanto, 2008)

CONCLUSION

1. The process of magmatisme in the regions Kulon Progo happened a two-year period , namely: magmatisme late oligocene - early miosen produce mikrodiorite, andesite , dacite , while magmatism late miocene produce mikrodiorite Telu and dacite.
2. Based on chemistry composition, volcanic rocks in the Kulon Progo included in the calc alkaline by mineral composition of andesite until dacite basaltic. The elements lanthanum (20-28 ppm) , Itterbium (1,54-2 ppm) and cerium (25,4-28,4 ppm) shows that the sample of volcanic rocks in the Kulon Progo originated from tectonic between the transitional bow with the banks of the continent active.
3. Alteration zoning in the Kulon Progo could be divided into 3 alteration zoning quartz chlorit serisite composition identical to the phylite, alteration zoning epidot-klorit-kalsit equal to zone and custom propilitik zoning illit-kaolin-monmorilonit often called argilik zone . Thus this region including in the system mesotermal - epitermal with hydrothermal fluid ph composition almost neutral.
4. Mineralization that accompanies alterasi hidrotermal in the Kulon Progo is mineralization sulphide consists of pyrites , galena , sphalerite , kovelit , bornite and kalkopirit . In addition there are mineral barite and precious metals gold and mineral oxide ores of oxide of iron , magnetite , hematite , molybdenite and limonite who commonly encountered as sign of zone oxidation at alteration filik zone . Other metals as silver , copper , pumbum , zinc and arsenic also emerge as the results of the analysis chemistry . Intrusion microdiorite telu and dasit intrusion curug is a source of heat in the establishment of the ore mineralization in the Kulon Progo.
5. The result analysis of the AAS the composition metallic element there is Au , Ag , Cu , Pb , Zn , As , Sb , and Mo .Gold content ranged from 0.002 ppm until 0.036 ppm to rocks while in vein of quartz and a geological fault zone ranged from 0.005 ppm until 1.453 ppm . Gold content mostly located in regions Plampang that was between 0,008 ppm until 1.453 ppm . A kind of the gold is elektrum because measuring small and present together with another element .

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