HYDROTHERMAL MINERALIZATION AT GOMBONG AREA KEBUMEN REGENCY - CENTRAL JAVA

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Abstract: Circular (Polygonal) and linear features in LANDSAT imagery of Gombong area, Central Java, express magma activities and faults. Their formation is presumed followed by mineralization processes, which is initiated by magmatic and tectonic activities in Pliocene, shown by a close relationship between mineralized and fault zones.

Propylitic alteration assemblages, veins (mainly carbonate), and ore minerals consist of very fine grains of Fe, Cu, Pb, and Zn sulphides characterize mineralization in the studied area, hosted by Late Oligocene rock units of Gabon Formation. Latticed quartz vein from Lodeng River indicates that boiling hydrothermal fluid has formed it. Unfortunately, there is no fluid inclusion found in the samples for micro-thermometric studies; however, the sulphide mineral assemblage indicate that the temperature of the hydrothermal fluids in the studied area had cooled down from between 300 – 350^{o} C to below 300^{o} C.

Sari: Aktifitas magma dan sesar di daerah Gombong, Jawa Tengah yang diekspresikan dalam bentuk-bentuk melingkar (poligonal) dan kelurusan pada citra LANDSAT, diduga pembentukannya diikuti suatu proses mineralisasi yang diawali oleh aktifitas magmatik dan tektonik pada Kala Pliosen, ditunjukkan oleh adanya asosiasi yang erat antara zona mineralisasi dengan zona sesar.

Mineralisasi di daerah penelitian dicirikan oleh asosiasi ubahan propilitik, pembentukan urat (terutama karbonat), dan butiran sangat halus Fe, Cu, Pb, dan Zn sulfida pada Formasi Gabon berumur Oligosen Akhir *Boiling/lattice texture* pada urat kuarsa yang tersingkap di Kali Lodeng mengindikasikan kondisi fluida hidrotermal dalam keadaan mendidih. Walaupun tak dijumpai kandungan inklusi fluida yang dapat dipergunakan untuk analisis mikrotermometri, asosiasi minral sulfida mengindikasi temperatur fluida hidrotermal daerah penelitian berkisar dari 300 – 350^{o} C dan mengalami pendinginan hingga <300^{o} C.

INTRODUCTION

The studied area located in the Ayah District, Kebumen Regency, Central Java Province. A study has been carried out on circular (polygonal) and linear features are shown in LANDSAT imagery of the area, which have been interpreted as a manifestation of intrusive bodies and faults respectively (Figure 1). The formation of these features is presumed to be followed by mineralization.

The regional geology of the area is depicted in the Banyumas Sheet of the Geology Map of Java (Asikin et al., 1992), whilst Carlile & Mitchell (1994) include the area into the Neogene Sunda-Banda Magmatic Arc which is underlain by basement rock of the Late Cretaceous melange (Hamilton, 1979). Two periods of magmatic activities are recognised during arc formation, which are respectively, the Late Eocene to Early Miocene and the Late Miocene to Pliocene periods (Soeria Atmadja et al., 1991).

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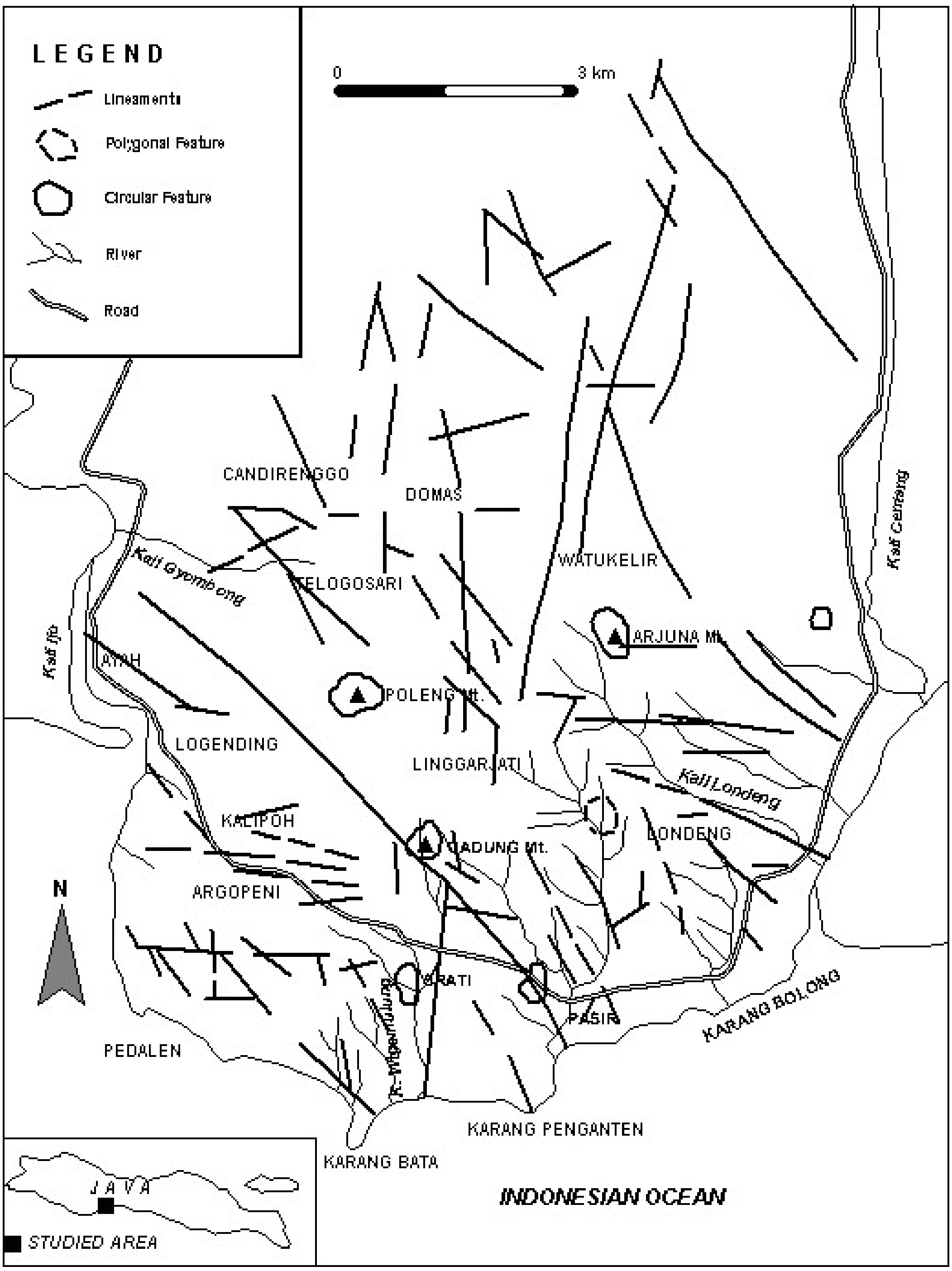

Figure 1. Lineaments, Circular, and other geographical features shown by LANDSAT imagery in the studied area. The lineaments and circular features are interpreted as the expression of faults and magma activities on the ground.

According to Asikin et al. (1992), tectonic activities during Late Pliocene resulted in the formation of NE - SW to NW - SE trending faults.

GEOLOGY STRUCTURE

Geology structures of the studied area included fault planes, shear and gash fractures, fault breccia, and milonitised rock. Field observation on a fault zone reveals that carbonate is the dominant filling material of openings (gash fracture) and coating material of sheared surfaces.

Fault breccia exposures are grey to white in colour, fragment surfaces are coated by carbonate, showing striations, sometimes containing very fine grains of pyrite. Carbonate coating also occurs on the surface of columnar joints as shown by the columnar joints at Puris Mountain and several locations along the Lodeng River.

Field and LANDSAT imagery data show that faults associated with mineralization are NE-SW and NW-SE trendings wrench faults. One exposed fault plane strikes N 005^o – 355^o E and dips 87^o E. These faults cut limestones of the Kalipucang Formation in several locations forming lineaments of steep cliff striking N 280^o E. These lineaments continue to the Petruk Cave in the western part of the studied area. Another indication of faulting in the limestone is exposed in the Gombong River as fault breccia composed of crystaline limestone material.

A fault zone in breccia of the Gabon Formation is exposed along the road that passes through Desa Srati. It is trending to N 115^o – 130^o E. No field observation were made to determine the type of the faults; however, according to Asikin et al. (1992) it is asumed to be a wrench fault formed during Late Pliocene.

MINERALIZATION

Indications

Mineralization within the studied area is hosted by andesite breccias of the Gabon Formation of Late Oligocene, which is intruded by greenish grey andesite during Early Miocene and uncoformably overlain by limestones of the Kalipucang Formation of Middle Miocene. The occurrence of mineralization is indicated by alteration assemblages, veinings, and very finely grained sulphide minerals.

Alteration Assemblages

Alteration assemblages in the studied area consist of silicified and propylitic zones. The silicified zone around quartz veins often show stockwork structure constituting of quartz + adularia ± illite ± sulphide ores, of which the original porphyritic texture of the rock has been destroyed (Photo 1).

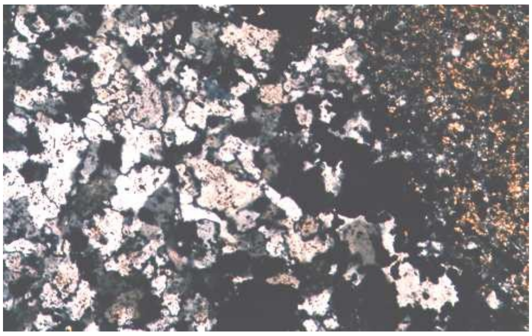

Photo 1. Photomicrograph of silicic assemblages constituting interlocking structure of quartz and adularia on the left hand side of photo, whilst on the right hand side of photo is an association of very fine masses (devitrified) silica, chlorite, and carbonate. (Cross polarization, magnification 20x).

The propylitic assemblage within fault zone in Desa Srati constitute of the association of clay (kaolinite) + carbonate + chlorite + epidote + sulphide minerals, the original porphyritic texture of the rock has been totally destroyed (Photo 2). Whilst, on the periphery of the fault zone the propylitic assemblage is characterized by the association of carbonate + chlorite + epidote + sulphide minerals, with the original porphyritic texture well preserved.

Photo 2. Photomicrograph of propylitic assemblage shows phenocrist chlorite and ore in a matrix built by very fine masses of chlorite and carbonate (Cross polarization, magnification 20x).

Veinings

Veinings in the studied area occur as individual vein and stockwork, filled by calcite (mainly) and quartz. A stockwork structure at Dusun Domas comprises braided thin veins within a very weathered and altered greenish red tuff. The veins are filled by calcite, relatively straight and variably 1 – 3 cm thick. At least two periods of vein filling with concentric pattern are noticeable (Photo 3).

Photo 3. Stockwork built by calcite veins in very weathered (altered?) tuff of Gabon Formation at Dusun Domas.

Individual calcite veins within the breccia unit at Desa Srati, are generally 15 – 30 cm long and 3 – 4 cm wide, showing pinch and swell structure. However, irregularly short calcite veins are also exposed in some locations. Calcite veining occurres within propylitically altered rock characterised by the association of clays + carbonate + chlorite + epidote + pyrite.

Whereas, pinched and swelled individual quartz vein is at least 2 m long and 2 cm wide is exposed along the Watugemulung River. Megascopically, the vein shows a brecciated texture with chalcedony fragments floating within a clear quartz matrix. Microscopically, vein sample shows a combination between very thin parallel and coloform lamination, containing very fine grained pyrite forming a discontinuous insertion. Many crystal growth zones are observed within the sample, but no fluid inclusions were observed for micro-thermometric analyses (Photo 4).

Photo 4. Photomicrograph growth zone of quartz crystal. Note that there are two periods of quartz formation and at least two periods of crystal growth zones for each formation. No fluid inclusions are observed within the growth zones.

The bigest quartz vein is exposed at the Lodeng River, trending N 240^{o} E dipping almost vertically, about 10 cm thick, brecciated, white to grey in colour, very rich in very fine grained sulphide minerals consisting of pyrite, chalcopyrite, galena, and sphalerite. The vein shows lattice texture indicating that the vein was formed in boiling condition (Photo 5), however, no fluid inclusion has been observed within the vein samples for microthermometric studies. The vein is formed within the weakest rock zones (i.e. with the highest permeability) surrounded by a silicified zone, characterised by the association of alteration minerals such as quartz + adularia +

illite/sericite + pyrite + galena + chalcopyrite + sphalerite. The host (wall) rock of the vein is volcanic breccia which has been altered into a propylitic zone, very rich in very fine grains of pyrite + galena + chalcopyrite + sphalerite.

Photo 5. Quartz vein sample from Londeng River shows lattice texture indicating that boiling hydrothermal fluid forms the vein.

Sulphide minerals

Sulphur-bearing minerals can be observed in association with fault zones such as in the Srati Village, especially in association with the quartz vein in the Lodeng River the sulphide minerals are abundant. They are very fine grained pyrite, chalcopyrite, galena, and sphalerite. The abundance of sulphide minerals is reflected in Table 1, by the high percentage of Fe, Cu, Pb, and Zn content in base metal chemical analyses.

Mineralization Processes

Asikin et al (1992) indicate that mineralization in the studied area started at the same time with the intrusion of andesite into the Gabon Formation during Early Miocene. However, there is no indication of mineralization (e.g. altered rock) within the wall rock surrounding (close to) the intrusive bodies (Arjuna Mountain, Poleng Mountain, and Gadung Mountain), which suggests that andesite intrusion activities during this age might not be followed by mineralization processes.

Other possibilities which caused the mineralized zones not to be exposed arround the intrusion bodies in the studied area, are that they are either being covered by a very thick wall rock or that the mineralization processes were hampered by the low permeability of the wall rock.

Sumantri et al (1997) concluded that there is a close relationship between the distribution of hydrothermal alteration assemblages and fault zones, and based on this fact presume that the mineralization processes occured either at the same time or soon after fault development during Late Pliocene.

After experiencing several periods of uplift and the deposition of rock unit of the Kalipucang Formation, tectonic activities during Late Pliocene resulted in the development NE – SW to NW – SE trending wrench faults (Asikin et al., 1992), which initiated the mineralization processes (Sumantri et al., 1997). This resulted in the fault (zones) becoming the high permeability zones which acted as the channel for mineralizing hydrothermal fluids to rise to the surface.

The formation of alteration mineral assemblages depend upon temperature, pressure, permeability of country rock, chemical composition of hydrothermal fluid (pH), and the length of time during which alteration processes took place (Browne, 1978). In the studied area the permeability of the rock is very prominently affecting the formation of the alteration association which in some locations have been enhanced by faulting.

The emplacement of the magma body during the Miocene – Pliocene magmatic activities initiated mineralization in the studied area. Hot acidic magmatic fluids, which contain dissolved metals and reactive gases rise to the surface through country rocks and are reduced by reaction with the country rocks and through mixing with circulating CO_2-rich meteoric waters. The CO_2 content of the meteoric water was most probably derived from dissolution of limestone of the Kalipucang Formation. These magmatic fluids rise up relatively slow depending upon the characteristic permeability of the rock, therefore there would be enough time to react with the country rock and mix with CO_2-rich meteoric waters. The resultant fluid is a cooler near-neutral pH fluid, which resulted in a propylitic alteration assemblage and the deposition of mainly calcite in open fractures forming stockwork in some places and coatings of columnar joint planes, as in the case in the Puris Mountain and Lodeng River.

Table 1. Chemical Analyses Data of Base Metal Content of Rock Samples From The Studied Area

Sample No.	Base Metal Content (ppm)		
	Cu	Pb	Zn
ST01	67,580	56,25	102,590
ST02	44,581	41,459	89,522
ST03	91,413	30,068	85,526
ST04	98,868	43,315	132,429
ST05	45,061	33,110	69,072
ST07	63,811	41,833	91,8143
ST08	76,997	41,349	100,465
ST09	113,163	41,348	106,031
SP10	59,974	40,365	97,873
WK11	29,241	38,567	87,479
WK12	173,483	41,045	149,323
AR13	87,427	46,338	101,740
WK14	67,220	47,567	112,719
GD15	64,575	39,590	74,793
WK16	47,785	89,041	34,787
KD17	101,663	47,134	85,463
KD18	79,002	53,076	108,220
KD19	109,325	55,456	96,030

Permeability of the country rock will be enhanced by faulting through which the magmatic fluids are channeled up to the surface. The magmatic fluids are not only hot and with low pH, but also supersaturated with silica due to complexes content of the fluids (Fournier, 1985), resulting in the development of a silica and clay cap within the channel which will hamper the fluids to rise furthermore to the surface, causing increased fluid pressure. At the time fluid pressure is greater than the lithostatic pressure (triggered by fault formation during Late Pliocene tectonic activity), fluids are channeled up through reactivated fault zones and rise rapidly with minimal rock reaction and mixing with circulating CO_2-rich meteoric waters. This processes will result in the formation of chalcedony veins and a silicified zone (associated by stockwork veining within the zone), and the deposition of high temperature sulphides such as chalcopyrite and pyrite. Furthermore, sudden decrease in pressure will cause the fluids to boil, depositing bladed calcite which will be subsequently replaced by quartz due to the decrease in temperature (i.e. carbonate dissolution) resulting in the formation of boiling texture and brecciation of the quartz vein as well as deposition of low temperature sulphides such as galena and sphalerite, as in the case in the Lodeng River. Accoording to Hannington et al. (1988), the pyrite – chalcopyrite assemblage is deposited at a temperature between 300^o – 350^o C, whilst the sphalerite – galena assemblage is deposited below 300^o C.

CONCLUSIONS

Several conclusions can be drawn from the study, including:

1. Hydrothermal mineralization in South Gombong Area being expressed on LANDSAT Imagery by circular and linear features, which represent surface expressions of andesite intrusion, and faults.
2. Mineralization processes is initiated by magmatic activity during the Miocene – Pliocene period, and then triggered by faults during Late Pliocene. The faults act as channels for hydrothermal fluid to rise to the surface.
3. Mineralization in the studied area is indicated by veinings, alteration assemblages, and sulphide minerals.
4. Two alteration mineral assemblages, quartz + adularia + illite/sericite + chlorite + sulphides minerals (pyrite, galena, chalcopyrite, and sphalerite) and clay mineral + carbonate + epidote + sulphide minerals (pyrite + galena + chalcopyrite + sphalerite) assemblages, indicate mineralization in the studied area.
5. The formation of alteration mineral assemblages is controlled by the permeability of the host rock which in some places is enhanced by faulting.
6. Based on the sulphide mineral association, fluids temperature cooled from between 300^o – 350^o C to below 300^o C.

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