GEOLOGICAL PROSPECTING AND ORE MINEALIZATION OF EPITHERMAL DEPOSIT IN THE SHWEBONTHA AREA, MONYWA DISTRICT, CENTRAL MYANMAR

Toe Naing Oo[1]

Abstract

The Shwebontha area is located about one-kilometer ENE of the Letpadaung Cu-Au deposit. This study is aimed to investigate and characterize the geological condition, rock, alteration and ore mineralization. The geology of the Shwebontha area consists of volcanic and volcaniclastic rocks of the Late Oligocene to Middle Miocene Magyigon Formation that served as the host rocks of ore mineralization. Geochemically, the volcanic rocks having calc-alkaline nature and they are classified as volcanic field (rhyolite). Three types of alteration are developed in vicinity of mineralized quartz veins including silicic, argillic, and propylitic alteration zones. Mineralization is characterized by gold-bearing silicified massive ore and chalcedonic quartz vein in rhyolite host rocks. Optical microscopy and X-ray diffractometer (XRD) analysis indicate that these veins typically contain several ore mineral assemblage such as pyrite, sphalerite, galena, chalcopyrite, gold, covellite, goethite and hematite, associated with gangue mineral characterized by quartz, calcite, chlorite/epidote and clay minerals. Based on the current available data from hydrothermal alteration, mineralization types and ore mineral assemblages from the Shwebontha area develops forming under an epithermal environment.

Keywords: Hydrothermal alteration, Ore mineralization, Geochemisty, Epithermal deposit, Shwebontha

Introduction

The Shwebontha area is located approximately 6.5 km NW of Monywa, across the Chindwin River in Salingyi Township, Central Myanmar (Figure 1). The study area is located between 22º 4' N and 22º 9' N and between 95º 0' E and 95º 6' E, covering approximately a 30-square-mile area. The terrain is a fairly rugged and moderately to densely vegetated. The study area can be reached by vehicles from Nyaungbingyi through Nyaungbingyi Yinmabin road and therefore, it is accessible throughout the year. The location of the study area is shown in Figure 1.

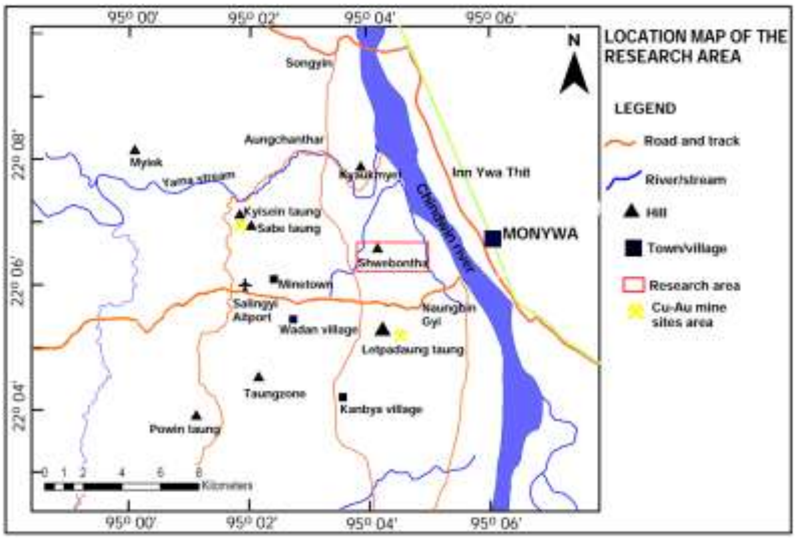


Figure 1. Location map of the study area

The Shwebontha area was discovered by Ivanhole Copper Company Limited in 1995 during the extensive exploration in the search for Cu-Au deposit, Au-Ag deposit and base metals

[1] Department of Geology, West Yangon University

mineralization in the Monywa district. An exploration program discovering of copper-gold and gold-base metal mineralization in the research area had been searched by based on the detailed geological, geochemical and geophysical investigations. This paper presents new data on hydrothermal alteration, mineralized quartz veins, sulfides mineralogy, ore chemistry at the Shwebontha area. The results of this study confirm that ore mineralization at the Shwebontha area is an epithermal deposit.

Regional Geologic Setting

Myanmar is divided into two tectonic provinces by the 1500 km long N-S trending Sagaing Fault (Khin Zaw, 2017) Figure 2. The eastern part of the country is the Sibumasu terrane; it encompasses the Shan Plateau, the Mogok-Mandalay-Mergui Belt (MMMB), and the Shan Scarps. The western part is the West Burma terrane comprising the Indo-Myanmar Ranges and the Central Volcanic Belt (also called the Inner Volcanic Magmatic Arc) (Mitchell et al., 2012) Figure 2. The Central Volcanic Belt is a N-S trending magmatic and metallogenic belt and located between the Western Inner Myanmar Tertiary Basin and the Eastern Inner Myanmar Tertiary Basin. It extends from Mt. Loamy and the Jade mines in the far north of Myanmar to the Gulf of Martaban in the south and beyond to the islands of west of Sumatra, Indonesia Figure 2. The Central Volcanic Belt is composed of Late Cretaceous to Tertiary granodioritic intrusive rocks with a subordinate sequence of Late Cretaceous to Quaternary volcanic rocks (Khin Zaw, 2017).

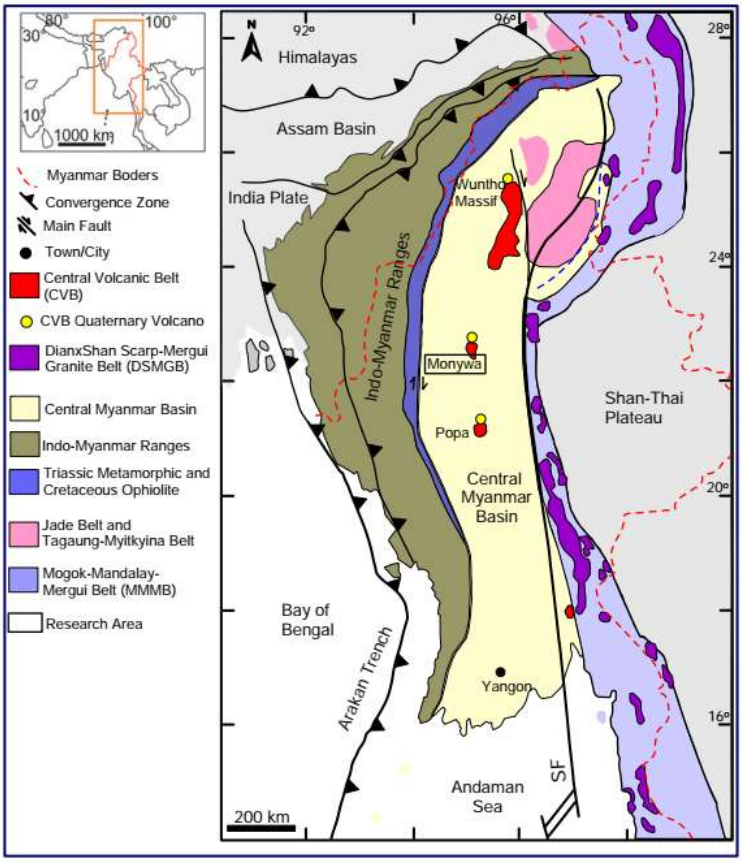


Figure 2. Simplified geological map showing structural features, Tertiary volcanoes, and Central Volcanic Belt in Myanmar and related regions (modified from Searle et al., 2007).

The Monywa District is located in the Central Volcanic Belt within the Central Volcanic Belt (Mitchell et al., 2011; Khin Zaw, 2017). The district has attracted the attention of geologists because of its great potential for economic Cu and Au deposits. In this district, metallic ores are found as both high-sulfidation epithermal-type Cu and low-sulfidation epithermal-type Au deposits. Before mining, the district's resources amounted to approximately 2 × 109 tons of ore containing more than 7 × 107 tons of Cu metal making Monywa the second largest Cu deposit in SE Asia (Mitchell et al. 2011; Zaw et al. 2017). The Monywa copper deposits and nearby gold-silver prospects (including Kyaukmyet) lie at a few kilometers east of a cluster of small inliers of basement rocks and granitic intrusions that coincide with a regional aeromagnetic anomaly on a geanticlinal axis (Kirwin, 1994; Maung Maung Naing, 2003). The basement rocks are overlain locally by volcanic rocks and both are overlain unconformably by eastward-dipping, probably Eocene, quartzofeldspathic sandstones with a prominent west-facing scarp slope at Powintaung. Most of the metallic deposits between Powintaung and the Chindwin River are hosted by the Magyigon Formation and porphyritic intrusions.

Research Methods

Methods employed in this research were petrography, X-ray diffractometry (XRD), X-ray Fluorescence (XRF) and Atomic absorption spectrometry (AAS) method. A total of thirty-four (34) samples were collected from the surface outcrops in the Shwebontha area, Monywa district: hydrothermally altered rock (15 samples) and mineralized quartz vein (10 samples). Fifteen samples were prepared for thin sections, doubly-polished thin sections, or polished sections. Thin sections and polished sections were determined petrographically to identify the primary and secondary (alteration) mineral assemblages. A detailed study on ore microscopy of polished thin sections using both transmitted and reflected light were done to observe ore mineral assemblages and textural relationships. Clay minerals were identified by XRD. Subsequently, a total of 12 representative rock samples were selected for whole-rock geochemistry. The concentrations of major and minor elements of 12 rhyolite rocks were analyzed by X-ray Fluorescence (XRF). In a subsequent study, a total of eight (8) representative ore samples were selected for ore geochemistry. Ore chemistry particularly for Au, Ag, Cu, Pb and Zn was determined by Atomic absorption spectrometry (AAS) method. All laboratory analyses were carried out at Geological Engineering Department, Faculty of Engineering, Gadjah Mada University, Yogyakarta, Indonesia.

Results and Discussion

Geology of the Shwebontha Area

The Shwebontha area is divided into two parts including Shwebontha Hill and Shwebontha East. Both of these two parts are similar lithologic units, mineralization and alteration styles. The Shwebontha area is predominantly volcanic, volcaniclastic and sedimentary rocks including rhyolite, hydrothermal breccia, tuff breccia, tuff, tuffaceous sandstone as well as alluvium deposit (Figure 3). Stratigraphically, the hydrothermal breccia is the oldest rock unit in the research area, where it is distributed in the central part. The hydrothermal breccia unit is unconformably underlain by rhyolite rock unit which is the most dominant rock unit in the research area. Gold and base metals mineralization is mainly hosted by in rhyolite unit as well as hydrothermal breccias unit, as a member of Upper Oligocene-Middle Miocene Magyigon Formation. Most of mineralization veins are observed in the silicic alteration zone where gold (electrum) is associated with pyrite, galena, sphalerite and chalcopyrite. Their vein trends are generally followed the regional structural trend, probably related to be NE-ENE trending in direction that might be responsible for the formation of gold and base metals mineralization in the Shwebontha area.

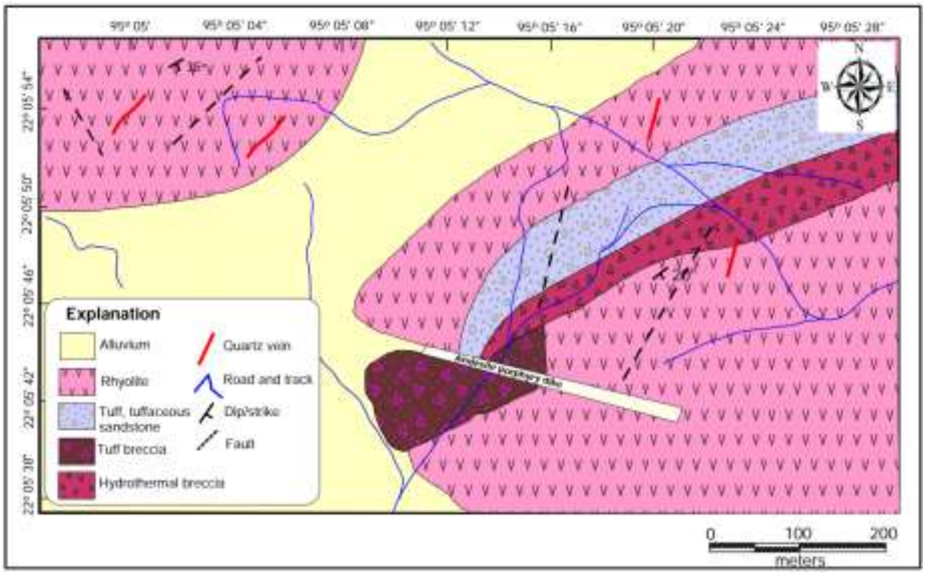


Figure 3. Simplified geological map of the Shwebontha area, Monywa district, central Myanmar (Win Min Htet, 2008).

Petrographic Characteristics

In the Shwebontha prospect, this unit is the most widespread and extensively covered rock unit. Based on the field investigation, variety of rhyolite is observed such as ash-white colour of rhyolite flow, pinkish colour of rhyolite flow and white/buff colour of rhyolite flow. Rhyolites are hard, compact, and moderately jointed. In some place, it shows faint flow structure and minerals are unidentifiable by naked eye in hand specimen. Rhyolite outcrops are generally grey colored on weathered surface (Figure 4).

Figure 4. (a) Field photographs of light to reddish brown color of weathered surface on flow banded rhyolite and (b) ash-white colour of faint flow structure of rhyolite, (c) an outcrop of planar flow banding in the rhyolite outcrop and (d) an exposure of strongly rhyolite flow fold in a rhyolite dyke.

Stratigraphically, hydrothermal breccia is the oldest rock unit. Ore mineralization mainly occurs in the rhyolite belonging to the Central Volcanic Belt in the study area. Mineralization is recognized by gold-bearing silicified massive ore and chalcedonic quartz veins in which sulfides are clustered and disseminated in the rhyolite host rocks. This mineralization vein is intimately associated with a silicic alteration zone characterized by the presence of pyrite, galena, sphalerite, chalcopyrite and gold. Their vein trends generally followed the regional structural trend, which might be related to NE-ENE trending in a direction that is probably considered to be responsible for the formation of ore mineralization in the Shwebontha prospect.

Petrography: Rhyolite is typically showing hypocrystalline and rhyotaxitic texture and composed of quartz, alkaline feldspar, minor plagioclase as well as trace amount of biotite and opaque minerals. It is grey to white and porphyritic with flow structures in a groundmass with a glassy or microcrystalline texture (Figure 5a,b). The main phenocrysts (~15% of the rock mass) are quartz, alkali feldspar and minor plagioclase. Biotite and opaque mineral occur in a lesser amount in this rock unit. The groundmass is dominated by aphanitic felsic minerals and glass. The size of the phenocrysts generally ranges from 0.2 mm to up to 2 mm and groundmass minerals are generally <0.1mm.

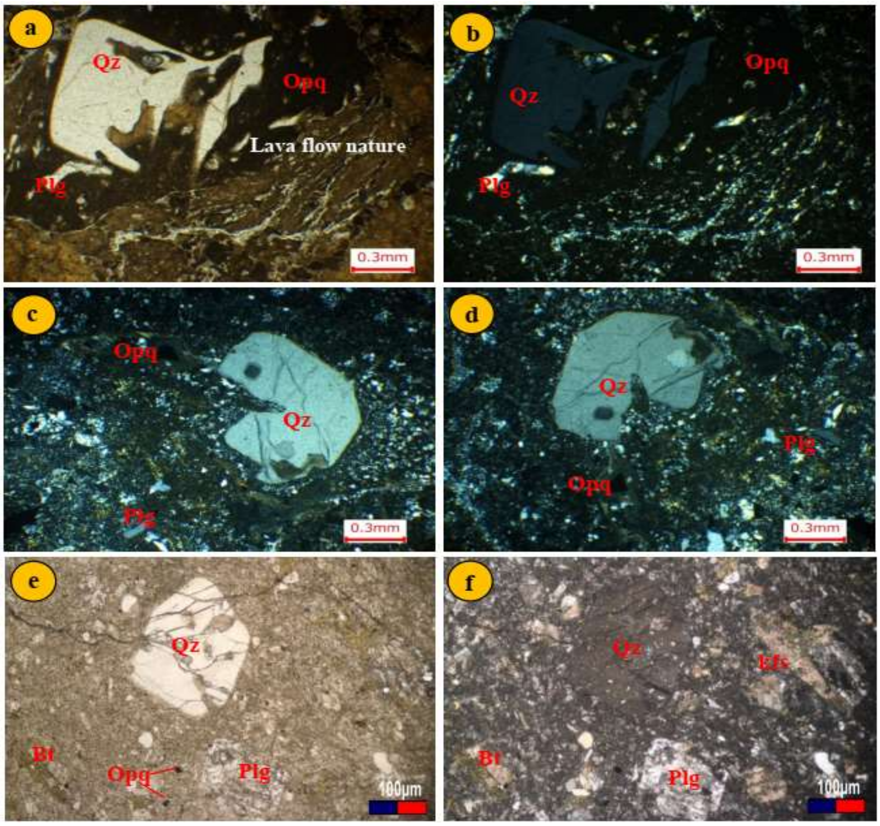


Figure 5. Photomicrograph of rhyolite. Abbr: Plg-Plagioclase; Qz-quartz; Kfs-K-feldspar; Bt-biotite; Opq-opaque.

The content of quartz is about 35 percent of total volume of the constituent minerals. It's size ranges from 0.5 mm to 2 mm. Most of quartz observes as phenocrysts as well as a groundmass. But, some quartz grains are deeply corroded by mesostasis and show a rhyolitic quartz aspect (Figure 5a,b). Quartz is deeply corroded by mesostasis. Some quartz phenocrysts display corroded outline and hexagonal outline and wavy extension as a result of strain (Figure 5c-f). Quartz grains observe as coarse-grained, euhedral to subhedral form where some coarse quartz grains occur as phenocrysts. Their characters of colorless, lack cleavage and wavy extinction are assisted to recognize well. It shows rounded to subrounded crystal shape with low relief.

Geochemistry of Host Rock

The volcanic rocks from the Shwebontha area mainly constitute rhyolite. These rhyolite rocks have been moderately affected by hydrothermal alteration processes and usually include secondary minerals of quartz, chlorite, sericite, and calcite. However, the analyzed samples were carefully selected and weathered surfaces were removed. Most of the rhyolite samples present a SiO_2 content higher than 75%, being classified as "high silica rhyolitic systems" according to Mahood and Hildreth (1983) and Metz and Mahood (1991). In general, rhyolite rocks with these characteristics have small ranges of SiO_2 variation, difficulting the classification based on geochemical parameters. The concentration of major (wt%), trace and rare earth element (ppm) of the rhyolite rocks from the Shwebontha prospect are displayed in Table 1. The rhyolite rocks show the SiO_2 contents ranged between (75.1-79.98%), Al_2O_3 (9.11-12.75%), FeO*(tot) (0.08-1.22%), TiO_2 (0.8-0.10%), MnO (0-0.1%), MgO (0.44-0.7%), CaO (0.14-0.21%), Na_2O (0.50-0.88%), and K_2O (6.43-9.73%) (Table 1). Based on the plotting result in the TAS (Total Alkali versus Silica) diagram of (Middlemost, 1994), (Figure 6a) can be confirmed that this unit is consisted of rhyolite. Volcanic rock compositions were also confirmed by immobile trace elemental plot (Figure 6b) by applying Zr/Ti and Nb/Y diagram (Pearce, 1996).

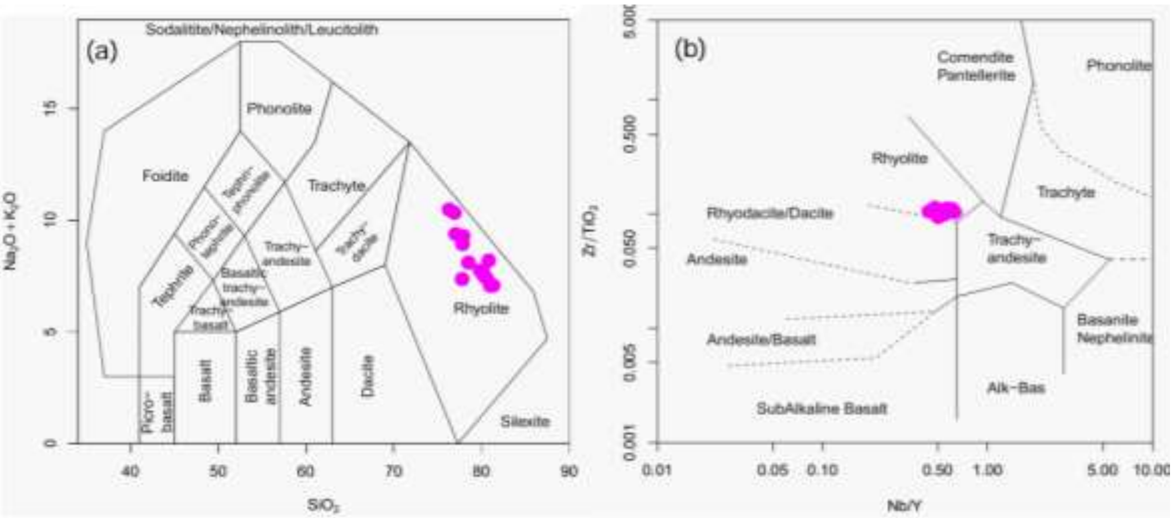


Figure 6. (a) TAS (total alkalis versus silica) classification diagram for volcanic rocks (Middlemost, 1994), (b) Nb/Y vs Zr/TiO_2 plot of volcanic rocks from the Shwebontha area (Pearce, 1996).

On the basis of binary plot diagram of SiO_2 versus Na_2O+K_2O Irvine and Baragar, 1971) volcanic rocks (rhyolites) of the Shwebontha area are displayed the nature of subalkaline to alkaline affinity (Figure 7a). AFM diagram is classified between tholeiitic and calc alkaline differentiation trends in the sub-alkaline magma series. Volcanic rocks (rhyolite) from the Shwebontha area are plotted on the AFM diagrams Irvine and Baragar, 1971). Triangular AFM plot shows that the rhyolite rocks are located in the field of the calc-alkaline series (Figure 7b). The SiO_2 and some of major oxide elements cannot be applied because of alteration product in the magmatic evolution processes. For this reason, incompatible element 'Zr' is used as a replacement for SiO_2. Trace element variation diagram in this study exhibits that Rb, Nb, Ba, Sr and Y versus Zr display positive correlation (Figure 8) which are recognized to be mobile with altered volcanic (rhyolite) rock during hydrothermal alteration.

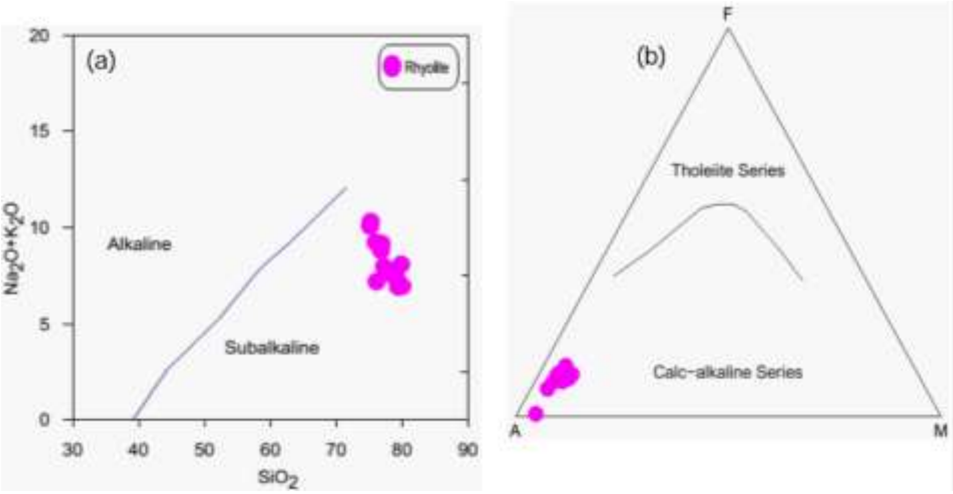


Figure 7. Subalkaline and alkaline classification plot diagram (SiO_2 vs Na_2O+K_2O) (Irvine and Baragar,197) and AFM classification diagram Irvine and Baragar, 1971) for rhyolite rocks of the Shwebontha area.

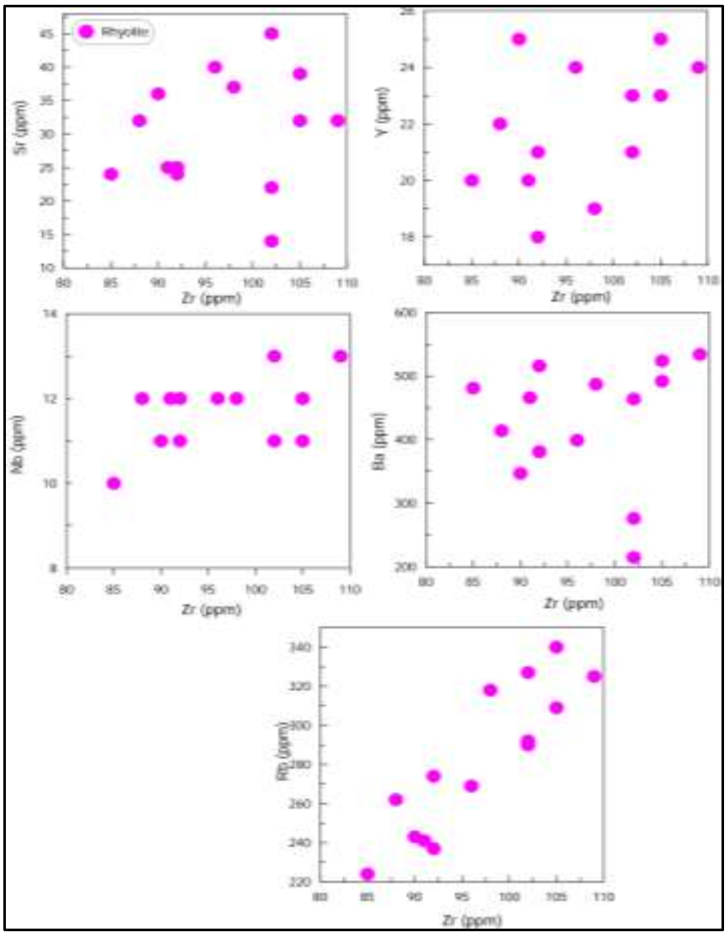


Figure 8. Binary plot diagrams of Rb, Nb, Sr, Ba, Y, and Zr (all in ppm) for rhyolite rocks at Shwebontha area.

Table 1. Whole-rock major- and trace-element concentrations of rhyolite rocks from the Shwebontha area.

Sample ID	S11	S9	S4	S1	S7	S2	S10	S3	S5	S12	S6	S14	S12	S8
Major elements (in wt%)														
SiO_2	76.1	77.1	75.2	79.2	78.9	78.4	79.9	78.9	75.9	76.8	79.8	79.4	75.1	76.8
TiO_2	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.08	0.09	0.09	0.09	0.08	0.10	0.09
Al_2O_3	12.8	11.3	11.5	10.2	10.4	10.3	9.56	10.0	11.5	10.9	9.11	10.0	11.7	11.08
FeO	0.99	1.12	0.84	0.86	0.80	0.92	0.93	1.22	1.16	0.96	1.07	0.82	0.08	1.19
MnO	0.01	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
MgO	0.54	0.53	0.45	0.55	0.57	0.70	0.67	0.49	0.48	0.46	0.44	0.58	0.47	0.50
CaO	0.14	0.17	0.14	0.17	0.17	0.17	0.16	0.16	0.19	0.21	0.16	0.18	0.14	0.19
Na_2O	0.52	0.56	0.60	0.51	0.52	0.52	0.51	0.64	0.80	0.88	0.62	0.50	0.58	0.77
K_2O	6.69	7.42	9.73	6.75	6.90	7.09	6.46	6.98	8.45	8.30	7.48	6.43	9.51	8.05
P_2O_5	n.d	n.d	n.d	n.d	n.d	0.01	0.01	n.d	0.01	0.01	n.d	n.d	0.01	0.01
H_2O	2.10	1.55	1.27	1.61	1.57	1.62	1.54	1.37	1.31	1.22	1.07	1.88	1.46	1.25
Total	**99.9**	**99.8**	**99.8**	**99.9**	**99.9**	**99.9**	**99.9**	**99.9**	**99.9**	**99.9**	**99.85**	**99.9**	**99.1**	**99.9**
Trace elements (in ppm)														
V	17	18	14	3	10	14	7	5	13	10	6	0	5	6
Cr	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
Co	30	36	42	45	50	27	30	55	50	40	34	36	23	25
Ni	11	13	8	8	8	7	12	9	8	9	13	7	6	11
Cu	2.01	23	31	22	41	24	30	78	49	25	19	31	5	3
Zn	46	50	n.d	26	9	3	n.d	47	18	33	7	12	10	20
Pb	5	9	8	11	22	17	6	n.d	6	23	31	41	23	45
As	13	7	8	6	8	31	43	9	10	12	19	9	7	11
Mo	13	11	11	11	9	11	7	7	10	10	9	8	9	10
Rb	292	290	340	237	241	269	243	274	318	327	262	224	325	309
Sr	14	22	32	24	25	40	36	25	37	45	32	24	32	39
Ba	215	276	524	516	466	399	347	381	487	464	414	481	534	492
Y	21	23	25	21	20	24	25	18	19	23	22	20	24	23
Zr	102	102	105	92	91	96	90	92	98	102	88	85	109	105
Ta	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
Nb	11	11	12	12	12	12	11	11	12	13	12	10	13	11

Hydrothermal Alteration

In the Shwebontha area, mineralization and hydrothermal alteration are observed in the rhyolite host rock unit. Alteration developed around open space mineralized vein at breccia zones. In the research area, there are three principal kinds of hydrothermal alteration zones that have evolved including silicic, argillic and propylitic alteration types. They are examined by optical petrographic observations (Figure 9). Silicification is also a common type of hydrothermal alteration in the Shwebontha area, and is closely related to ore mineralization. Silicified rock is characterized by equigranular microcrystalline quartz, hematite and sulfide minerals (Figure 9). This alteration is represented by chalcedony, disseminated pyrite with medium to coarse-grained quartz and quartz veinlets in the brecciated sulfide quartz vein and chalcedonic quartz vein (Figure 9). And, it also occurs as mineralized veins and is associated with breccias cements, vein-veinlet and stockwork (up to 2-3 cm width) quartz veins (Figure 9).

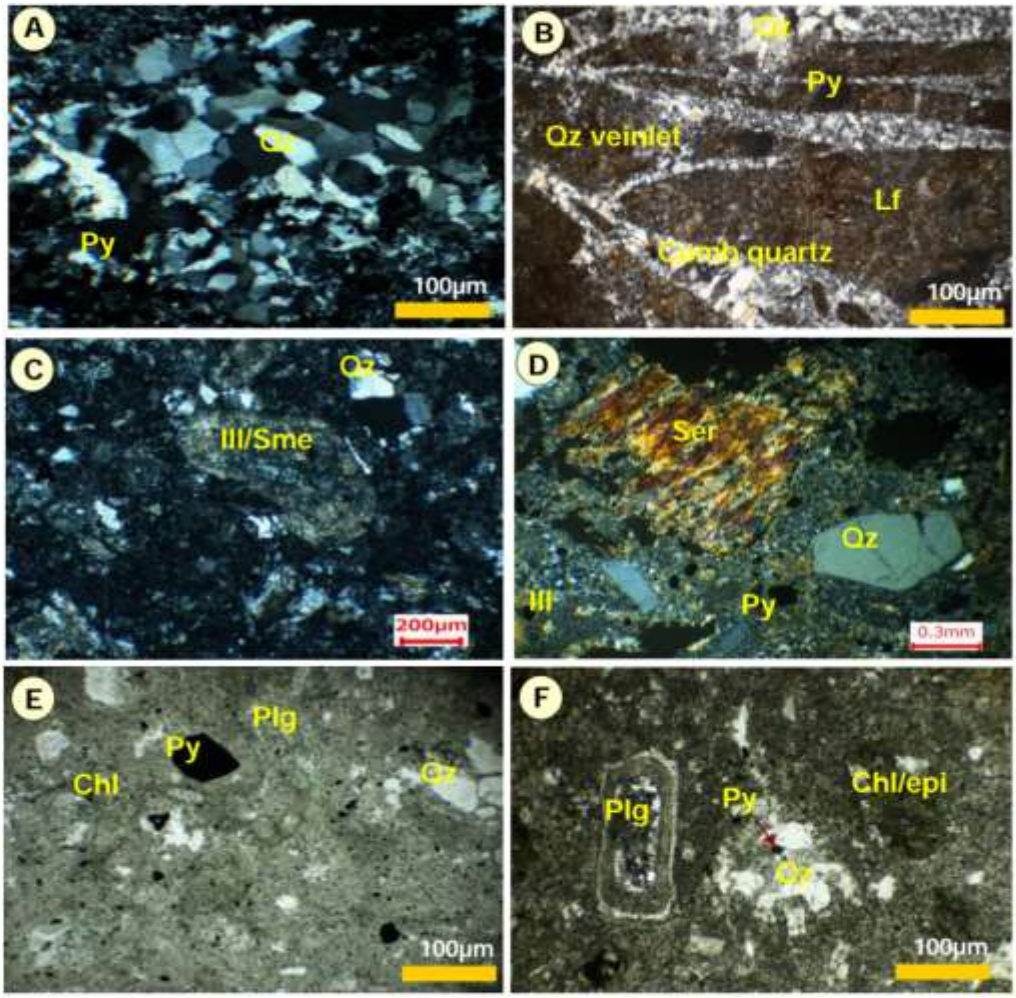


Figure 9. Photomicrographs showing hydrothermal alteration minerals at the Shwebontha area. (Qz-quartz, Ill-illite, Sme-smectite, Chl-Chlorite, Epi-Epidote, Py-Pyrite, Plg-Plagioclase, Lf-Lithic fragment).

Argillic alteration is characterized by variable amount of quartz, plagioclase, opaque mineral and clay minerals (sericite, illite, illite/smeciite, and kaolinite) (Figure 9 and 10a,b). Anhedral to subhedral quartz found as a phenocryst and fine-grained groundmass (Figure 9). Opaque minerals (pyrite) are occurred dissemination (Figure 9) which is associated with clay minerals (illite, smectite and quartz). Altered plagioclase replaced by yellowish brown colour of sercicite and kaolinite (Figure 9). In addition, plagioclase phenocrysts and groundmass partially replaced by illite, illite/smectite mixed layer mineral, pyrite and quartz minerals. Secondary quartz mainly replaced the groundmass or matrix of the rhyolites (Figure 10). According to the microscopic study and XRD analysis, the common propylitic alteration minerals are quartz, chlorite, epidote and pyrite (Figure 9 and 10c). The presence of chlorite and epidote can record the alteration type as propylitic alteration. Altered plagioclase is replaced by quartz, chlorite, epidote, and some clay minerals (Figure 9).

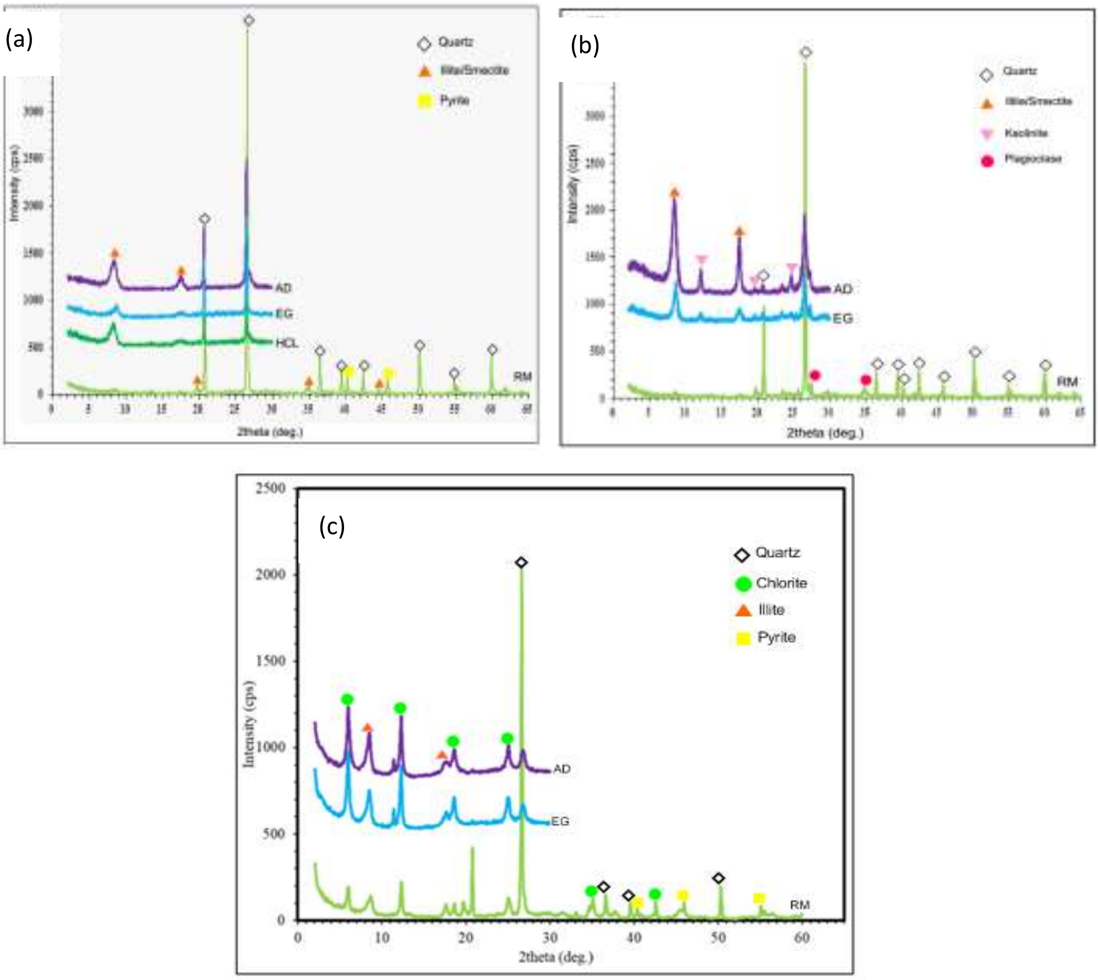


Figure 10. X-ray diffractograms (XRD) of argillic and propylitic alteration (AD-air-dried, RM-random mount, EG-ethylene glycolated).

Ore Mineralization

Ore mineralization is mainly hosted by rhyolite rock unit in the Shwebontha area, Monywa district. Massive orebody of gold-bearing silicified massive ore and chalcedonic quartz vein are concentrated on the foremost veins and in zones of argillic altered wall-rocks and oxidized zones (Figure 11). The veins belong to open-space filling and occasionally disseminated nature. Sulfide minerals are also occurred as in the chalcedonic quartz veins alternating with strongly silicified zones cut by cherty or sugary quartz vein in the rhyolite host rock as dissemination (Figure 11). Pyrite is the most common sulfide mineral. It is observed either as fine-grained disseminations and aggregates in quartz or as infillings in vugs. Primary (hypogene) ore minerals are pyrite, sphalerite, galena, chalcopyrite, and gold. Secondary (supergene) ore minerals include covellite whereas gangue minerals are mainly composed of quartz.

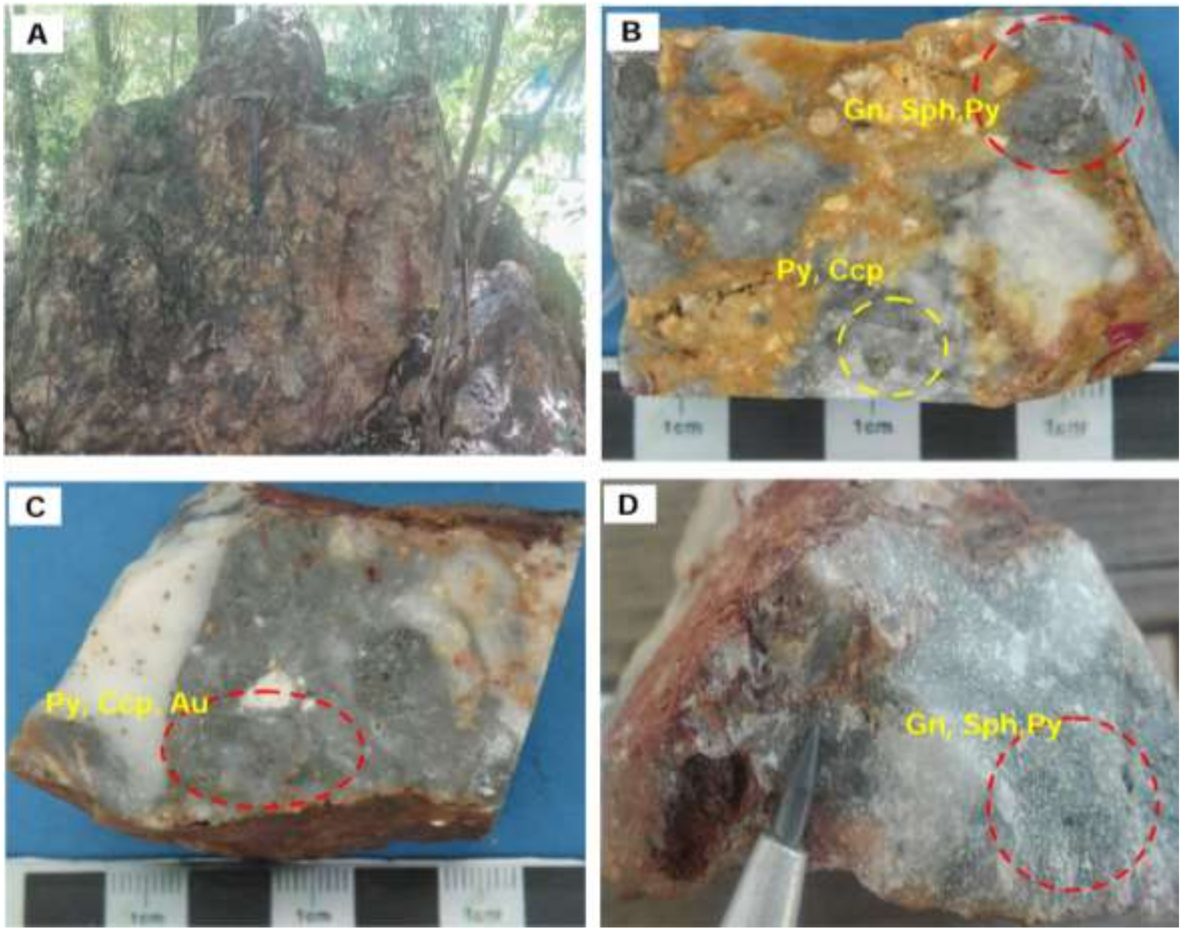


Figure 11. Outcrops and hand specimens showing (a) gold- base metal bearing silicified massive ore, (b,c) gold-bearing brecciated quartz veins and (d) chalcedonic quartz vein in the rhyolite host rock.

Pyrite is distributed and is the most abundant sulfides in the mineralized veins and host rocks. It shows anhedral to euhedral (Figure 12), pale yellow to yellowish white. On the other hand, irregular cracks and cataclastic deformation of pyrite are observed in gangue matrix. Most of pyrite were replaced by anhedral grains of galena, sphalerite, and chalcopyrite (Figure 12). Sphalerite is observed as anhedral grains. It is grey and displays internal reflection. Sphalerite appears to have replaced pyrite (Figure 12b). Galena exhibits light grey color and anhedral form. It occurs as a mineral that replaced pyrite (Figure 12c). Chalcopyrite displays yellow to brassy yellow in color and fairly high reflectance and weak anisotropism. It occurs as anhedral and irregular grain as well as enclosed in euhedral pyrite crystal (Figure 12d). Gold which is significant occurs as native gold or electrum granular grains in euhedral pyrite crystal (Figure 12e). It is very fine-grained (1–2µm), occasionally up to 200 µm. Covellite occurs as a secondary mineral and is generally found as fine-grained disseminated crystals replacing in pyrite (Figure 12f).

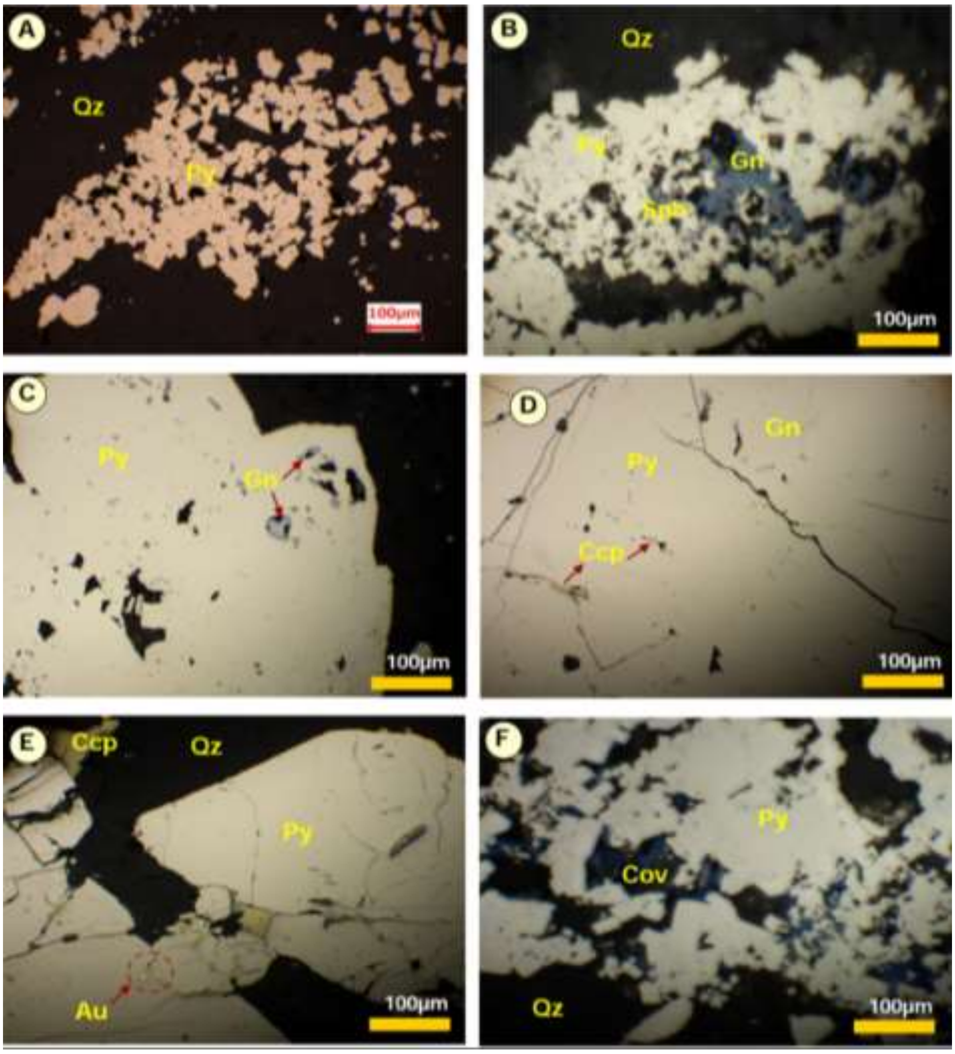


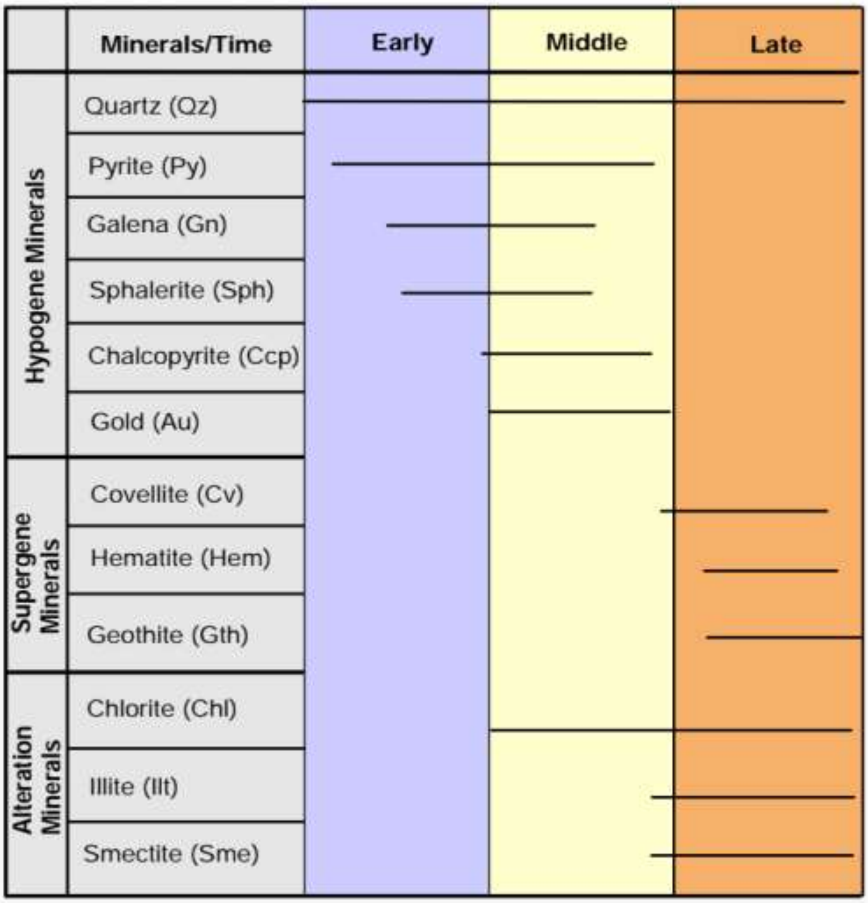
Figure 12. Reflected light photomicrographs of ore mineral assemblages from the Shwebontha prospect. (Py-Pyrite, Gn-Galena, Sph-Sphalerite, Au-Gold, Ccp-Chalcopyrite, Cov-Covellite, Qz-quartz).

Ore-Gangue Minerals Paragenesis

Textures of minerals such as banded, exsolution and replacement, distribution have been interpreted to correspond to the order of deposition. According to ore textures, the early formed quartz and pyrite, minerals are found while late phase sulfide and quartz are seen in the center of vein. In fact, early formed pyrite and quartz minerals showed their euhedral crystal forms that indicated anhedral sphalerite is younger than quartz and pyrite in order of deposition. Generally, crystals of quartz and pyrite were formed during the entire period of mineralization. Some anhedral sphalerites are replaced by galena along the boundary. Some small grain of chalcopyrite occurs as exsolution in sphalerite. It means that sphalerite is earlier in deposition than chalcopyrite and galena. And chalcopyrite crystal also occurred in euhedral pyrite crystal. In addition, covellite replaces along the margin of pyite crystals.

Based on the textural characteristics, order of deposition can be divided into two main stages (stage I and stage II) and oxidation stage. Quartz, pyrite, galena, sphalerite, chalcopyrite and gold/electrum were formed in early stage of deposition as primary hypogene ore minerals whereas covellite, hematite, and goethite were formed as secondary supergene minerals. Supergene minerals occurrences reflect the oxidation of primary sulfides such as pyrite and chalcopyrite by surficial water. The generalized paragenesis of the ore and gangue minerals of the research area are shown in Table 2.

Table 2. Generalized paragenesis sequence of Shwebontha area.



Ore Geochemistry

In general, ore mineralogy and metal occurrences in hydrothermal deposits are commonly controlled by the composition of the ore fluids. The chloride (Cl^-) and sulphide (specifically, HS^-) are regarded as being essential in order to solubilize gold and base metals in aqueous solutions (Seward and Barnes, 1997). Moreover, the redox states of the fluid and sulfur activity affect the mineralogy (Einaudi et al., 2003). Selected ore samples from mineralization veins were conducted in chemical analyses. Based on the AAS measurement of eight (8) mineralized quartz vein samples, the concentration of Au and Ag, Cu, As, Pb, Zn and Sb were performed by AAS technique. The composition of selected ore samples is shown in (Table 3). Chemical analyses of ore samples from mineralization veins are shown as the significant concentration of Cu, Zn, Pb, Ag, Sb, As and Au constructed to know the variation among these elements (Figure 13). Accordingly, plots of gold (Au) versus silver (Ag), copper (Cu), lead (Pb), zinc (Zn), tin (Sn) and antimony (Sb) were constructed to determine their correlation. The relation of gold (Au) versus silver (Ag), and copper (Cu) showed a positive correlation with Au. The Au versus zinc (Zn), lead (Pb), and antimony (Sb), arsenic (As) are shown negative in correlations (Figure 15). The analyzed mineralized samples concentration of gold ranges from 0.19 ppm to 7.25 ppm, silver 15 ppm to 75.5 ppm, copper 33 ppm to 170 ppm, lead 14 ppm to 163 ppm, zinc 6 ppm to 82 ppm, arsenic 126 ppm to 1030 ppm and stibnite 27 ppm to 2013 ppm is respectively shown in (Table 3).

Table 3. Ore chemistry of some selected ore samples by AAS analyzed at Shwebontha area

Sample	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)
SBV-4	0.81	20	93	19	18	252	68
SBV-7	7.25	70	122	105	6	517	72
SBV-5	4.21	60	165	14	33	126	27
SBV-6	0.89	30	52	53	11	174	49
SBV-3	0.23	19	49	71	30	354	51
SBV-1	0.32	21	43	77	10	647	50
SBV-8	0.37	34	170	163	82	1020	203
SBV-2	0.19	18	33	28	13	1030	55

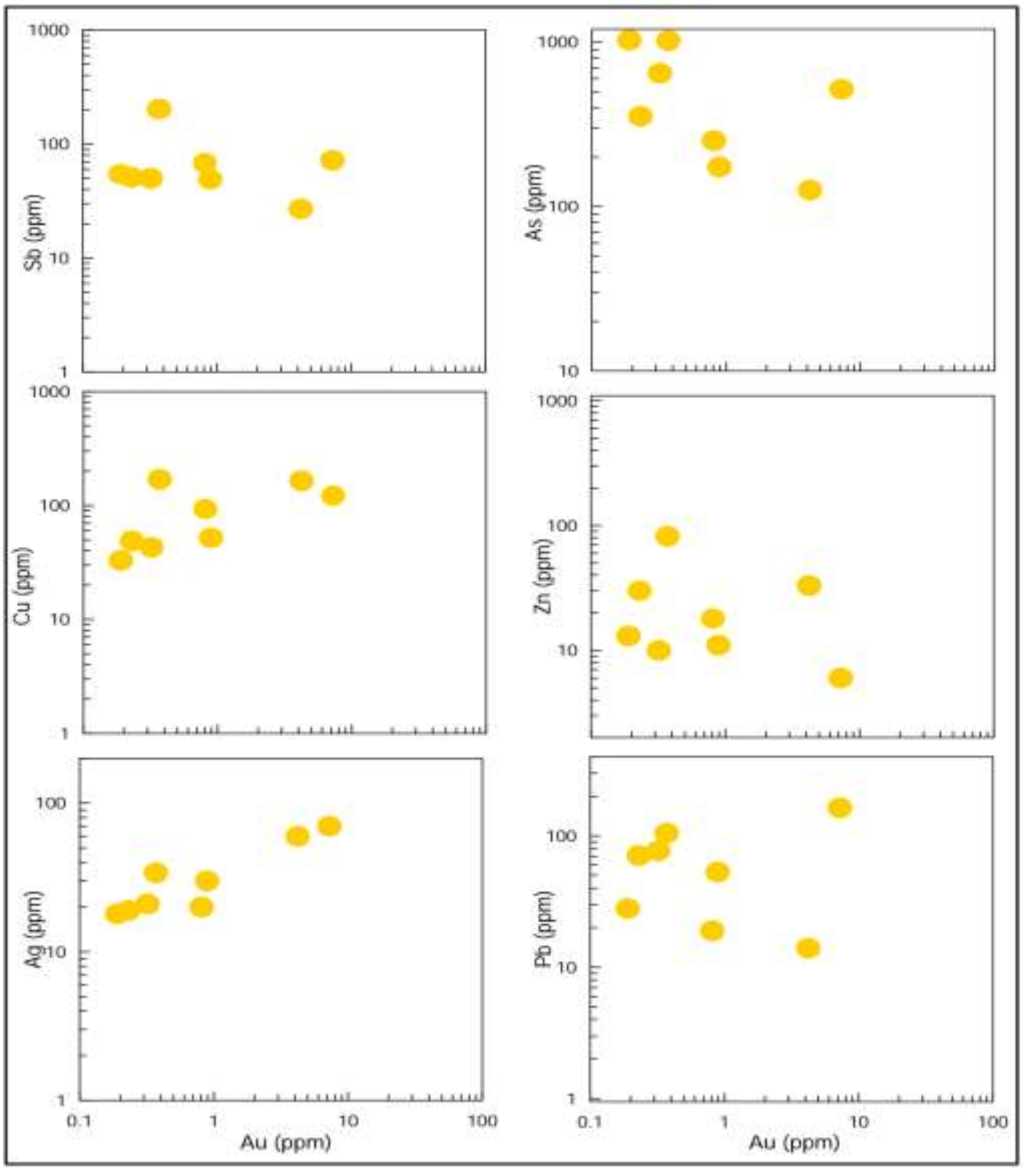


Figure 13. Multi-element plots of gold versus Ag, Cu, As, Sb, Sn, Zn and Pb showing their relation at Shwebontha area.

Conclusions

The Shwebontha area is located west of the Chindwin river and Monywa City in Central Myanmar. Geologically, the Shwebontha prospect area is characterized by magmatic extrusion that occurred during the Upper Oligocene to Middle Miocene of Magyigon Formation which led to the outcrops of rhyolite rocks. According to the geochemical data, rhyolite rocks from the Shwebontha area are plotted in the rhyolite/dacite field and calc-alkaline area. Rhyolite rocks are also classified using major element (TiO_2) and trace elements (Zr, Nb, and Y), showing that all host rocks fall in the fields of rhyolite. In addition, SiO_2 vs Na_2O+K_2O plot diagram as well as AFM diagram indicate that most of rock samples are classified in the field of the calc-alkaline series. The rhyolite rocks surrounding the mineralized veins are commonly extensively altered. The mineral assemblages show that the types of alteration include silicification as well as argillic and propylitic alteration. The alteration mineral assemblages include quartz, adularia, calcite, chlorite, epidote, kaolinite, sericite, illite and illite/smectite. Most of the ore mineralization is in open-space filling veins with lesser amounts in replacement and disseminated ore minerals in the volcanic and volcaniclastic host rock. The mineralized rocks contain gold-bearing brecciated quartz vein and chalcedonic quartz vein from the Shwebontha prospect. The most common primary ore minerals in the mineralized veins at the Shwebontha area include pyrite, galena, sphalerite, chalcopyrite, and gold/electrum. Covellite, goethite, and hematite occur as late supergene minerals in the shallow portions of the veins. The ore minerals occur as replacements, disseminations, and massive accumulations in the mineralized veins. On the basis of precious data and current understanding from the all available data including hydrothermal alteration, mineralized quartz veins and ore mineral assemblages, the Shwebontha area is considered to be epithermal type deposit.

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