CHARACTERISTICS OF GOLD DEPOSITS FROM MOGOK BELT: CASE STUDIES ON ZAYETKWIN-KWINTHONSE AND PHAYAUNG TAUNG AREAS, MANDALAY REGION, MYANMAR

Aung Tay Zar[1], Win Phyo[2]

Abstract

Mogok Belt is the one of metallogenic province in Myanmar. This belt has two sub-belts such as Mogok Metamorphic Belt and Slate Belt. Along these two sub-belts, gold deposits are difference characteristics and features. Zayetkwin-Kwinthonse gold deposit from Mogok Metamorphic Belt is mainly hosted in marble unit as fracture-filling vein with silicification, sericitization and propylitization alteration. Gold occurs in quartz vein as disseminated specks in pyrite, sphalerite and galena. The diagnostic quartz vein textures, coexistence of vapor-rich and liquid-rich fluid inclusions and the presence of adularia and calcite in the vein mineralogy are distinct characteristics features. In place, fluid inclusion homogenization temperature '*Th*' and salinity from Zayetkwin-Kwinthonse deposit are 159-315°C and 0.88-12.51 wt%NaCl equivalent respectively. Alternatively, Phayaung Taung gold deposit from Slate Belt is hosted in phyllite, schist and quartzite. The mineralization is associated with stockwork quartz vein system. Wall-rocks silicic alteration by cryptocrystalline quartz or amorphous silica is dominant; phyllic alteration is expressed by sericite, quartz, chlorite and pyrite with disseminated hematite. Gold occurs as small spots in tourmaline-quartz vein and sulfide bearing quartz vein. It is associated with pyrite and chalcopyrite as well as Au-Ag-Bi-Te ore assemblages. Fluid inclusion homogenization '*Th*' in quartz fall within the range of 234-426°C and salinities ranging from 0.35-8.41 wt%NaCl equivalent. In fact, Zayetkwin-Kwinthonse gold deposit represents the epithermal expression whereas Phayaung Taung gold deposit shows typical mesothermal characters.

***Keywords*:** Mogok Belt, Mogok Metamorphic Belt, Slate Belt

1. Assistant Lecturer, Department of Geology, Pyay University

2. Department of Geological Survey and Mineral Exploration, Ministry of Natural Resources and Environmental Conservation, Myanmar

Introduction

Myanmar is rich in natural resources and largest country in mainland of Southeast Asia. Mineralization in Myanmar is basically related with tectonic events of subduction, collision and other related processes such as faulting and accretion. Recently, primary gold deposits are extracted from porphyry, epithermal, mesothermal (orogenic) and local skarn types. Mogok Belt (Searle and Haq, 1964) is one of prominent metallogenic and geological province in Myanmar, along this belt variety of mineral deposits are observed including gold-silver, tin-tungsten and precious stones of ruby and sapphire. Basically, primary gold deposits along Mogok Belt are inferred as orogenic gold (Mitchell et al., 2004) but it would belong epithermal and locally skarn gold deposits. Mogok Belt is divided into two sub-units; Mogok Metamorphic Belts and Slate Belt. Gold mineralization from both of sub-units are possessed different characteristics features. In this paper, authors describe the regional tectonic setting, deposit geology and characteristics of gold deposits from these sub-units of Mogok Belt where we selected one deposit from each sub-units: 'Zayetkwin-Kwinthonse gold deposit' from Mogok Metamorphic Belt and 'Phayaung Taung gold deposit' from Slate Belt.

Research Methods

This research paper writing has been done through various steps such as studying literatures, field works and laboratory analyses. Actually, there is very few previous research and publication related to gold mineralization of Mogok Belt. Moreover, no one is focused the comparison and studying difference characteristics of gold mineralization from sub-units of Mogok Belt. Some of publications related with gold mineralization from Mogok Belt such as Mitchell et al., (1999 & 2004) and Cho Cho Aye and Ye Myint Swe (2014) were reviewed at the beginning of this research. Subsequently, altered rock samples and mineralization ore samples were collected and conducted for petrology study by microscopy and X-ray diffraction (XRD). In place, the kind of ore minerals and their chemical composition were measured by scanning electron microscope with energy dispersive X-ray (SEM-EDX). Furthermore, quartz veins samples from different generation were prepared for fluid inclusion study and conducted by LinkanSG600 combined heating and freezing stage. All of these laboratory analyses were performed at Department of Earth Resource Engineering, Mineral Resource lab and Center for Advanced Instrumental Analysis, Kyushu University, Japan.

Regional Tectonic Setting

Myanmar region is composed with micro plates such as (1) the India plate to the west, (2) Burma microplate (West Burma) in central part and (3) Shan-Thai block (Sibumasu) east of the Sagaing Fault (Figure 1). These plates are created to Myanmar landform by Mesozoic-Cenozoic subduction and collision of a series of plates during the closing of Tethys Ocean. The collision of Sibumasu terrane with Indochina at late Triassic describes the closure of Paleo-Tethys (Wakita and Metcalfe, 2008; Sone and Metcalfe, 2008; Metcalfe, 2002. The collision suture observed along through western Thailand and central Malaysia (Sone and Metcalfe, 2008; Hutchison, 1973). Sibumasu terrane can be split into two distinct geological provinces in Myanmar such as Shan Plateau in east and Mogok Belt to the west (Gardiner, 2015). Mogok Belt is one of the distinct geological suture zone and metallogenic province in Myanmar which located between Central low-land (West Burma) and Shan-Thai block (Sibumasu). It is believed that southern continuation of Himalaya (Searle and Haq, 1964) and formed by collision (Mitchell, 1979) of India plate (the later closure of Neo-Tethys). In fact, the suture of Neo-Tethys extends from the Himalayas south through western Myanmar 'Mt. Victoria Belt'(Mitchell, 1979) and link up with Andaman Island and Wolya suture zone in Sumatra (Barber and Crow, 2009). In place, Mogok Belt is shifted to recent place relatively northwards motion of the India plate (including West Burma microplate) by Neogene strike-slip movement (Metcalfe, 2009), along the major right lateral Sagaing Fault (Win Swe, 1972). The Mogok Belt can be subdivided into two sub-units; 'Slate Belt' (Mitchell et al., 2004) eastern part of Mogok Belt and 'Mogok Metamorphic Belt' (Searle and Haq, 1964) western part of Mogok Belt (Figure 3). The Slate Belt is generally N-S direction from Mandalay to lower Myanmar till Myeik and composed of Carboniferous to early Permian interbedded slaty mudstone and pebbly wack, with rare quartzite and calcareous beds (Mitchell et al., 2012). Locally low-grade metamorphic rocks of schists and phyllite are also observed. Alternatively, Mogok Metamorphic

Belt is composed of Paleozoic to Mesozoic, high-temperature Kyanite-sillimanite grade metamorphic rocks dominated by meta-carbonate rocks of phlogopite- and diopside- marble but peletic rocks of gneiss, schist and quartzite are also observed occasionally. Moreover, a variety of I-type and S-type two-mica granite (Cretaceous-Paleogene) are intruded into Mogok Belt (Gardiner et al., 2015; Mitchell et al., 2012; Barley et al., 2003). I-type granitoids in Mogok Belt (Cretaceous to early Eocene) confirmed that prior to collision of India. This was followed by emplacement of syenites and leucogranite (S-type) between 35 and 23 Ma (Eocene-Oligocene) after initial collision of India and Eurasia (Barley et al., 2003). In place, Slate Belt hosted S-type granites are associated with tin-tungsten mineralization (Gardiner et al., 2015; Khin Zaw, 1990). This S-type granites from Slate Belt represent a northward extension of Central Granitoid Belt of Myanmar (Khin Zaw, 1990). With regard to Mogok Metamorphic Belt, another igneous activity is biotite granite (Kabaing granite) which emplaced by process of faulting and overthrusting in Miocene (Bertrand et al., 2001). Kabaing granite is the youngest as emplacement time and set at post tectonism.

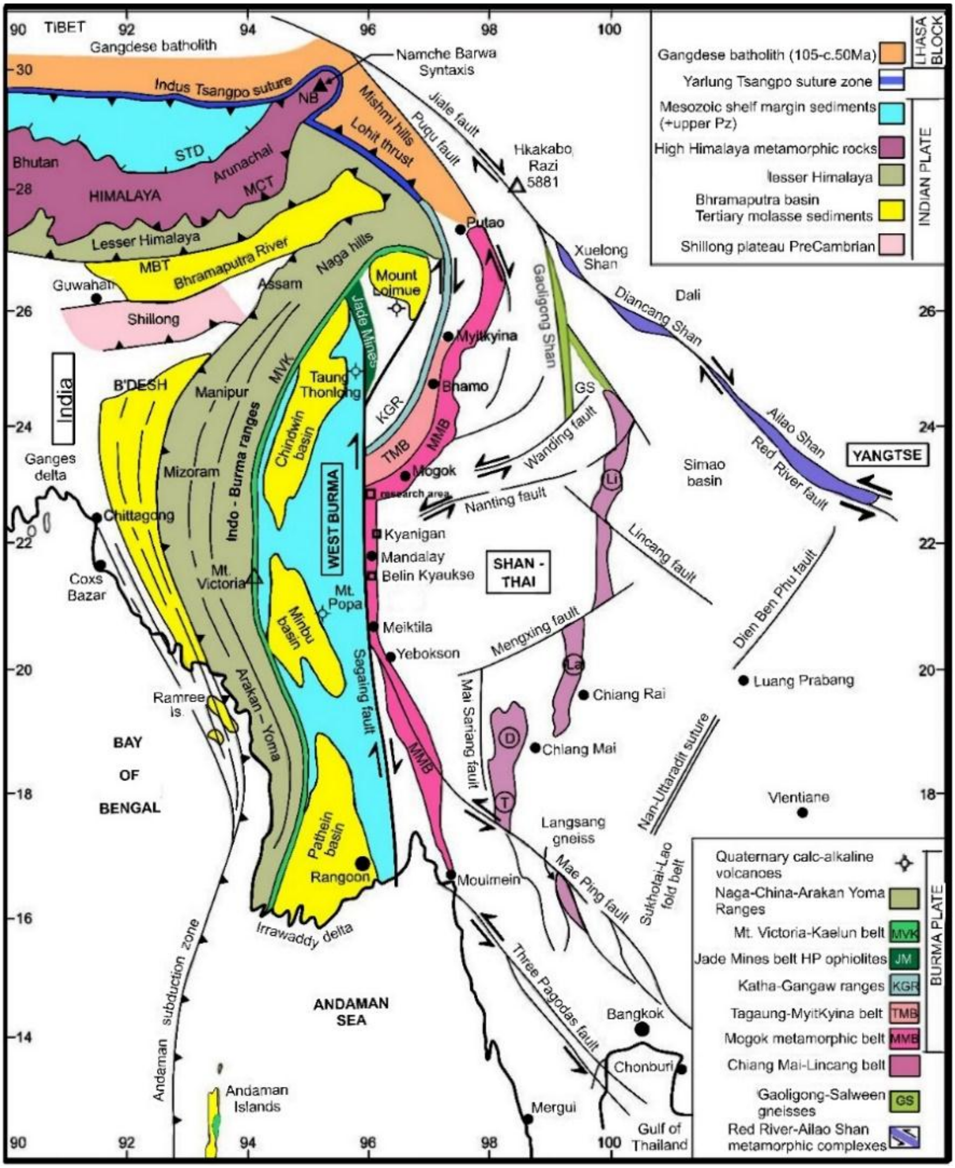

Figure 1: Regional Geological Map of Myanmar showing the principal tectonic units. (Searle et al., 2007)

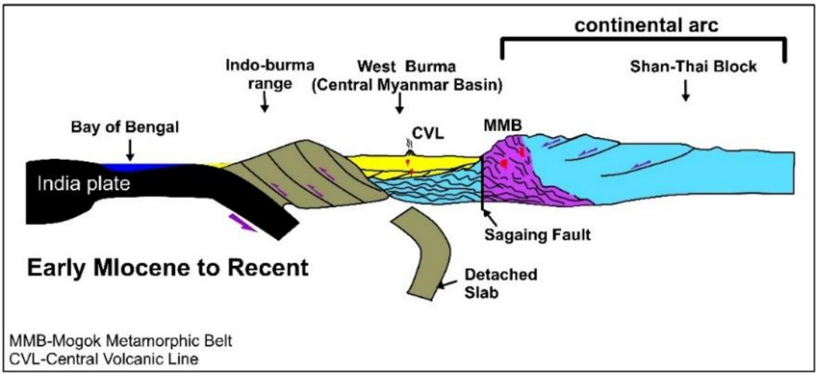

Figure 2: Principal tectonic units and their tectonic evolution setting of Myanmar (modify after G.I.A.C)

Gold Mineralization from Mogok Belt

According to tectonic emplacement, Mogok Belt is sited on continental arc setting "Fig. 2". Normally, continental arc setting are location of primary porphyry, epithermal and localized skarn gold deposits (Mitchell et al., 1999). Moreover, it would be hosted mesothermal (orogenic) gold deposits because Mogok Belt is a part of Himalayan orogeny that related with collision process of India and Eurasia plate. Generally, Gold deposits from Mogok Belt are considered as orogenic-type (mesothermal) gold deposit (Mitchell et al., 1999) but epithermal and locally skarn gold deposits could be observed. In Slate Belt (eastern part of Mogok Belt), gold mineralization has been recognized at numerous localities(Mitchell et al., 1999) such as Moditaung, Shwekyin, Meyongyi and Phayaungtaung. Mineralization occurred within quartz-pyrite stringer and veinlets whereas gold mineralization are not really associated with Cretaceous-Eocene granite intrusions, mineralization predates granite intrusions (Mitchell et al., 2004). Otherwise, gold deposits along Mogok Metamorphic Belt (western part of Mogok Belt) such as Zayetkwin-Kwinthonse, Thabeikkyin-5mile and Nweyon are mostly hosted in marble and associated with the intrusion of Createaceous I-type granite (Gardiner et al., 2015). Mineralization veins are observed as fracture filling veins and occasionally disseminated in marble where gold are associated with base metal sulfides. Some of gold deposits from Mogok Belt are shown in figure "Fig. 3".

Deposit Geology of Zayetkwin-Kwinthonse Area

Zayetkwin-Kwinthonse area is belonged by Mogok Metamorphic Belt, composed with metamorphic rocks of marble, gneiss and calc-silicate rocks where meta-carbonate rocks of marble and calc-silicate rocks (Upper Paleozoic to Mesozoic) are unconformably overlain by older gneiss unit (Lower Paleozoic). A variety of igneous rocks such as leucogranite, syenite and biotite granite (Kabaing granite) are intruded to older metamorphic rocks. The well-known N-S trending Sagaing Fault serves as western margin of research area. Interpretative NE-SW trending faults from research area are relatively parallel to the foliation of metamorphic rocks. It is probably related with Sagaing Fault system. Mineralization is hosted in marble unit and occasionally observed in gneiss which apparently acts as mineralization-hosting fracture/shear zones. Petrographically, meta-carbonate rocks are abundantly composed with calcite, phlogopite and diopsite where tremolite and diopside are common in marbles near the stocks. Small amount of actinolite, forsterite, apatite, epidote and sericite are also observed. Diopside calc-silicate occurs along the margin of igneous intrusion. The contact of intrusion is nearly parallel to the strike of this unit. Therefore, both of regional and contact metamorphism are happened in this area. Based on mineral assemblages of metamorphic rocks, it is considered that the metamorphism of research area is characterized into greenschist to upper amphibolite facies (Winkler, 1979). The geological map of Zayetkwin-Kwinthonse area is shown in Figure (4).

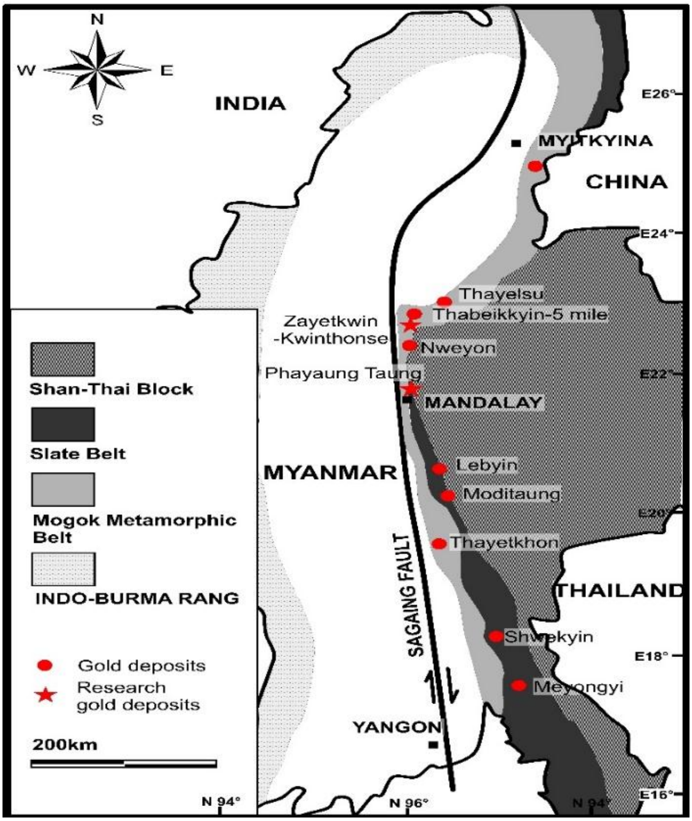

Figure 3: Some of gold deposits along Mogok Metamorphic Belt and Slate Belt

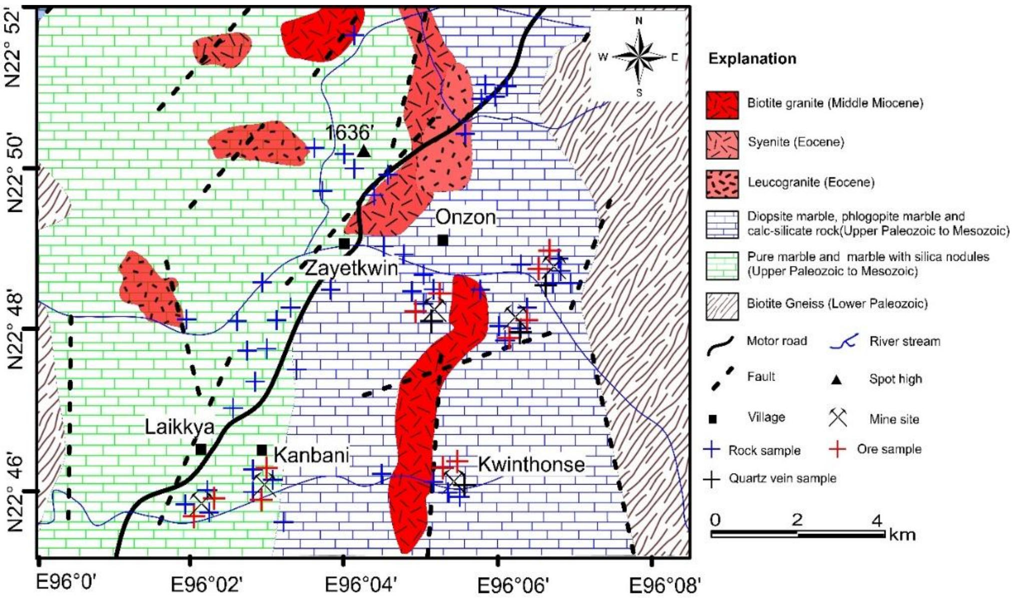

Figure 4: Simply geological map of Zayetkwin-Kwinthonse area (modify after Thein et al., 1990)

Mineralization and Ore Mineralogy

Zayetkwin-Kwinthonse area is a part of Mogok Metamorphic Belt where gold mineralization veins are mostly hosted in marbles and occasionally observed in gneiss as fracture filling veins related with fracture and shear zones. Occasionally, disseminated nature of mineralization also developed in marble. This is probably due to interaction of hydrothermal fluid and wall-rock ‘marbles’. In fact, vein trends are followed the regional structural controls, mostly NE-SW in direction with steep slope (Dip= 55° to nearly vertical)where the width of veins are 0.5 to 3 meters (Figure 5). A variety of quartz vein textures such as banded, crustiform, bladed calcite, lattice, comb and cockade are observed in mineralization quartz veins especially in shallow depth of mineralization quartz veins. Banded vein nature is a common characteristic of both quartz vein and quartz carbonate vein ‘Fig. 5”. Banded quartz–calcite± adularia veins are also found in marble unit. In this case, gold bearing quartz veins are observed at shallow level fracture zone. Occasionally, fissure filled visible gold are observed in quartz vein.

Alteration halos are observed around the hydrothermal fracture-filling veins as laterally outgoing such as silicification, sericitization, and propylitization. Silica occurs as cryptocrystalline groundmass as well as openspace filling in vugs and veinlets. Moreover, chalcedony and amorphous silica are observed locally along the fractures. Adularia are also frequently observed as banded nature as well as cavity filling in mineralization veins.Beside silicification, narrow zone of sericitization is observed where fine-grained sericite are widely spread like dusty. But in deeper portion, this alteration zone is not developed. Propylitization zone is the outermost zone of alteration halos. In fact, some parts of propylitic alteration are not really related with hydrothermal alteration, prior to the ore deposit. It is the product of regional metamorphism (Evans, 1987) and overlapped with hydrothermal alteration.

The common ore minerals in mineralization are pyrite, galena, sphalerite, chalcopyrite, marcasite and minor arsenopyrite, native gold and electrum. Sometime more than 30% of base metal sulfides are observed in mineralization veins. Pyrite is observed as most common sulfide.In place, native gold are observed in base metal quartz-carbonate veins as fine-grained specks (< 100 µm in size) within pyrite, galena and sphalerite. Otherwise, large grained electrum (< 100 µm in size) are associated with quartz gangue and ore minerals pyrite and sphalerite in gold bearing quartz vein (Figure 6).

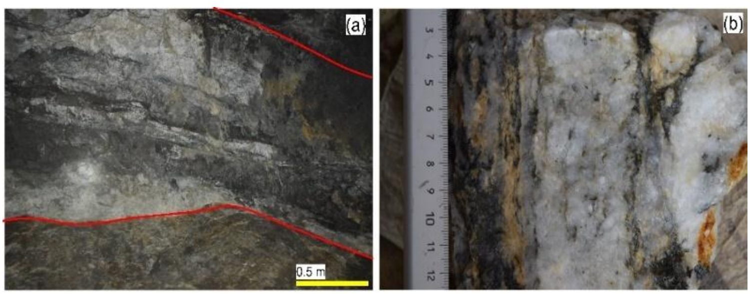

Figure 5: Photos showing fracture filling banded quartz vein(quartz-calcite ± adularia)

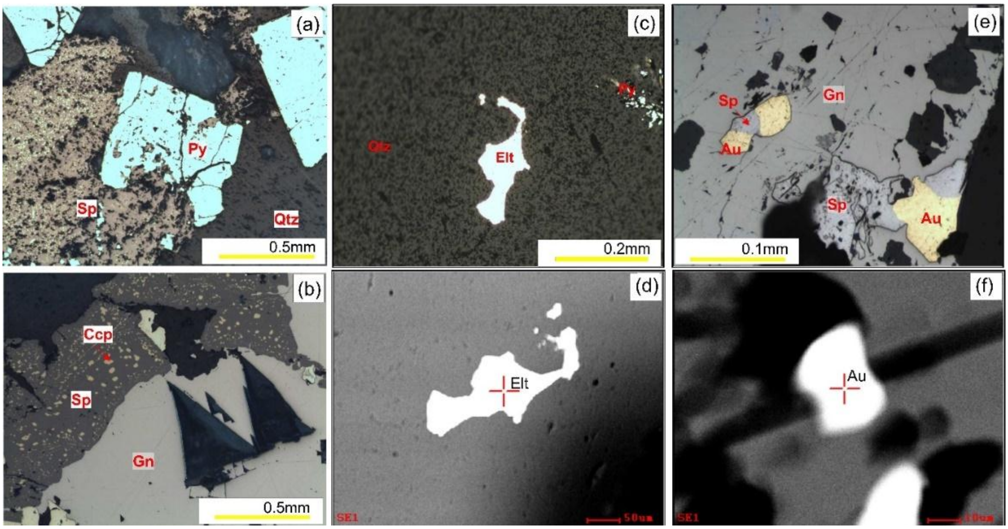

Figure 6: Photomicrographs showing (a) Euhedral pyrite (Py) replaced by sphalerite (Sp), (b) Galena (Gn) with triangular pits nature and chalcopyrite (Ccp) specks in sphalerite (Sp), (c & d) large electrum (Elt) grains in gold bearing quartz vein, and (e & f) fine grained native gold (Au) specks in base metals quartz carbonate vein.

Fluid inclusions study and interpretation

Seven of quartz vein samples were conducted for fluid inclusion study where four from quartz vein and three from quartz-carbonate vein. According to fluid inclusion petrography, there are three types of fluid inclusions are categorized based on their phase relation (1) Two-phase liquid-rich inclusion, (2) Two-phase coexisting liquid-rich and vapor-rich inclusions, and (3) Two-phase vapor-rich inclusions (Aung Tay Zar et al., 2017)(Figure 7). Most of fluid inclusions are observed in growth zones as individual inclusions or small clusters with dispersed arrays. The size range is 5 to 50 µm. In fact, two-phase fluid inclusions with coexisting liquid-rich and vapor-rich inclusions in samples are indicated that inclusions are trapped in boiling or immiscible fluid system (Bodnar, 1993). Moreover, only vapor-rich fluid inclusions are also indicator of boiling in hydrothermal system. This vapor-rich fluid inclusions assemblage indicates the intense boiling or flashing condition (Moncada et al., 2012). The temperature ranges of homogenization (*Th*) and salinity of fluid are 159 to 315°C and 0.88 to 12.73 wt% NaCl equivalent respectively. In place, salinity of fluid inclusions were calculated from (*Tm*) by using Bodnar's equation (Bodnar, 1993). According to Bodnar et al. (1985), the formation temperature of vein refers to the first peak of histogram distribution of *Th* under boiling condition. Therefore, the formation temperature of quartz vein and quartz carbonate vein are 165°C and 175 °C respectively. The formation temperature (first peak of *Th*) and salinity differences between gold bearing quartz vein and base metal quartz-carbonate vein are not too much different (Figure 8) and (Table1). It means both of these two veins are properly the same generation of vein system. A compilation of homogenization temperature (*Th*) and salinity from Zayetkwin-Kwinthonse deposit is displayed that fluid inclusions with the wide range variation of salinities and homogenization temperature. In place, the trend of increasing salinity with decrease temperature indicates boiling condition. Moreover, fluid mixing also could be happen by adding or mixing with a more or less saline solutions. On the other side, the ranges of homogenization temperature and salinity of fluid inclusions from Zayetkwin-Kwinthonse deposit are assigned to epithermal system (Figure 9).

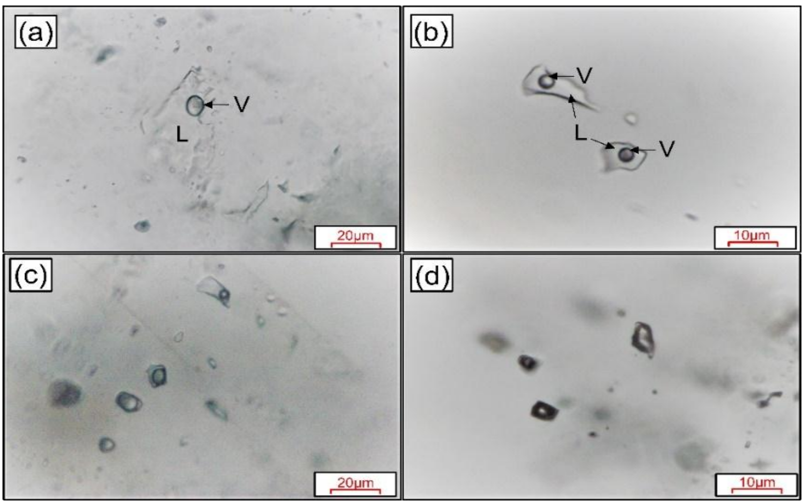

Figure 7: (a) Giant primary two-phase fluid inclusion with negative shapes, (b) two-phase fluid inclusion with consistent liquid-vapor ratio, (c) two-phase coexisting liquid-rich and vapor-rich fluid inclusion, and (d) two-phase vapor-rich fluid inclusion from Zayetkwin-Kwinthonse deposit

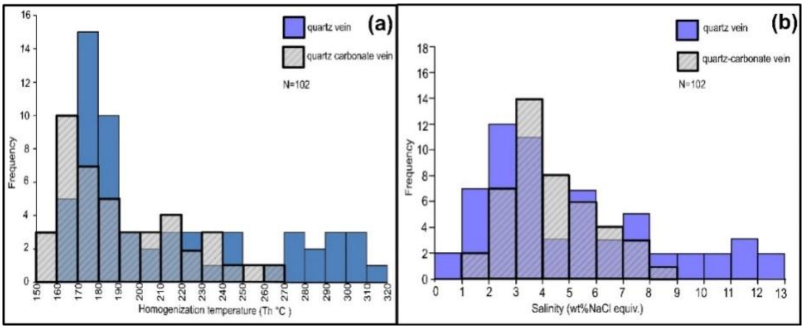

Figure 8: Histograms showing (a) homogenization temperature *Th* (°C), and (b) salinity (wt%NaCl equiv.) of fluid inclusion from Zayetkwin-Kwinthonse deposit

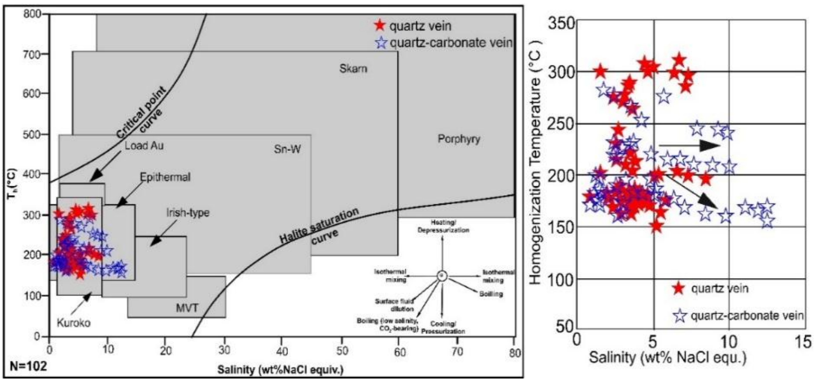

Figure 9: Homogenization temperature (*Th*)-Salinity diagram illustrating typical range for fluid inclusions from different deposit types (Wilkinson, 2001). Stars are microthermometric result of fluid inclusions from Zayetkwin-Kwinthonse deposit where *Th*-salinity space due to various fluid evolution process.

Table 1: Fluid inclusion microthermometric data of selected samples from Zayetkwin-Kwinthonse deposit

Sample ID	**Vein type**	**Inclusion type**	**Homogenization Temperature (°C)**	**Ice melting Temperature (°C)**	**Salinity (wt%NaCl eqiv.)**
GF-1VA, 1VB, GY-2 and 7	Quartz vein	L+V	168-315	-0.5 to -5.5	0.88-8.55
GK-F, 3, 9	Quartz-carbonate vein	L+V	159-267	-0.5 to -8.9	0.88-12.73

Deposit Geology of Phayaung Taung Area

Phayaung Taung area is the northernmost extension of the Slate Belt which is mainly composed by metasedimentary rocks such as phyllite, schist, quartzite and slightly metamorphosed limestone (Figure 10). Western part of this area is an eastern flank of Mogok Metamorphic Belt (Paleozoic to Mesozoic), consisting of mica schist and calc-silicate rock where small bodies of diorite and pegmatite intruded to mica schist. The Chaungmagyi Group (Precambrian age) occupies about half part of the research area and mainly composed with quartzite, phyllite and slate. Upper Plateau limestone of bluish grey to dark grey limestone (Carboniferous- Permian) is unconformably overlain by older Chaungmagyi Group. Gold mineralization is mainly hosted in quartzite and phyllite of the Changmagyi Group which are strongly deformed and brecciated. In fact, these rocks might be consist of interbedded sandstone and shale or mudstone beds in paleo-stratigraphy that were metamorphosed to recent metamorphic rocks during regional metamorphism. Recently, the thickness of hosted rocks ranged from 0.15 to 3 m. Phyllite, quartzite and schist were composed of low to medium grade temperature and metamorphic index minerals such as chlorite, epidote, muscovite, biotite and minor amount of garnet, staurolite and silliminite. These minerals indicate low to medium grade temperature as greenschist to amphibolite facies condition. According to deposit profile, mineralization might be related orogeny because of strong compressional and transpressional (shear) environment were clearly developed. Generally, mineralization vein trend is NE-SW in direction.

Beside the veins cut by post-mineralized E-W structures as well as normal and reverse faulting. Therefore, mineralization is strongly controlled by structures.

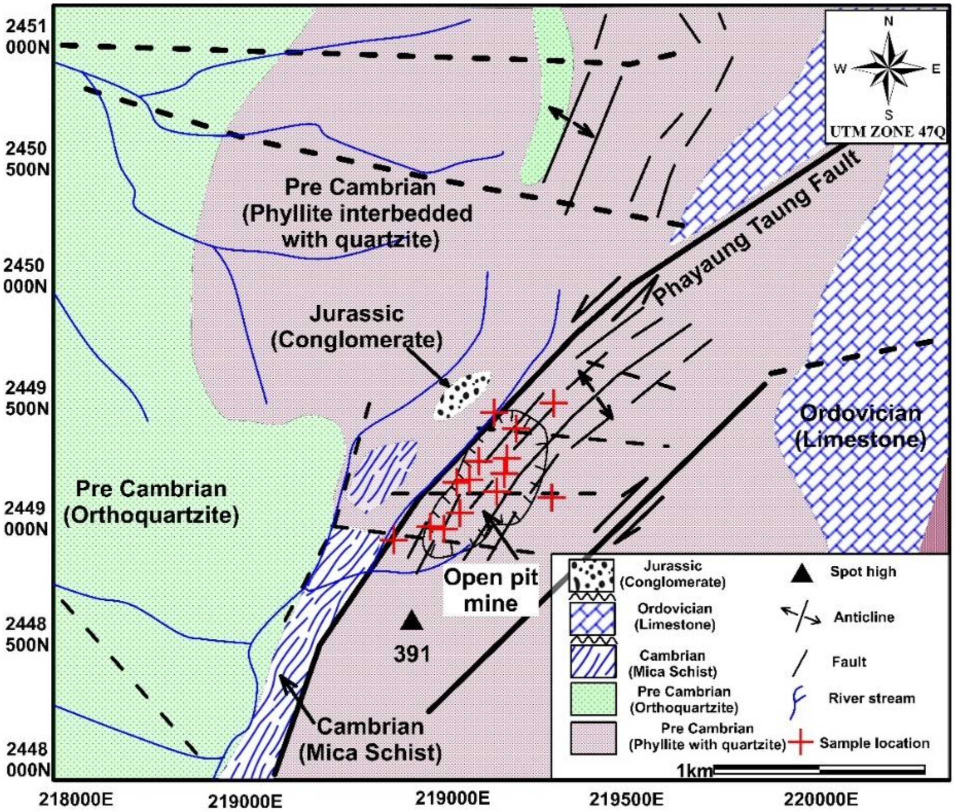

Figure 10: Geological map of Phayaung Taung gold deposit (modify after Htay et al., 1991)

Mineralization and Ore Mineralogy

The vein system of Phayaung Taung gold deposit is complicated and difficult to identify due to the strongly deformed, brecciated, and sometimes cutting by faults. The gold mineralization occurred within quartz-pyrite stringer and quartz vein/veinlets (1cm to 0.15m) which are filled along the NE-SW structural lineaments of dilational fault zone and brecciated zone. The main auriferous zones is about nearly 20 m wide and 100 m long. Two generations of vein are categorized based on structural cross-cutting and mineral content: first generation quartz vein (± black tourmaline) and late generation of disseminated sulfide (pyrite and chalcopyrite) quartz vein (Figure 11). Generally, mineralized tourmaline bearing quartz veins in the hosted rock could be seen clearly but sulfide bearing quartz veins were a rare case to find. However, it was found some kind of visible sulfides such as pyrite and chalcopyrite on the wall of some places in open pit mine. Moreover, secondary remobilized veins are frequently occurred in strongly brecciated/oxidized zone with higher Au content. It can suggest that intense supergene oxidation extend to quite depth of vein system. Mostly, vein structures are like veinlet and stringer which forming stockwork as well as some laminated nature with tourmaline. The vein mineral quartz is well developed as elongate blocky crystal/ fibrous texture in tourmaline bearing quartz vein. Moreover, the lateral breakdown of wall rock to accommodate rapidly growing crystals are observed in sulfide quartz vein. Mosaic, feathery and comb quartz textures are also observed together with open spaces filled pyrite aggregates. Boiling diagnostic vein textures of lattice, bladed, crustiform and colloform textures are absent in quartz vein.

Within and alongside the mineralized brecciated-zone, destruction of primary minerals and the wall-rock textures is incomplete. Generally, wall-rock silicic alteration by cryptocrystalline quartz or amorphous silica is dominant. In place, phyllic alteration is expressed by sericite, quartz, chlorite and pyrite with disseminated hematite. Plagioclase feldspar from bleached and silicified wall-rocks are altered to white mica (sericite) and chlorite with finely crystalline quartz. The white mica is disseminated in chlorite groundmass of strongly deformed phyllitic wall-rock which is district as micro fold texture. Fine-brecciated with disseminated calcite and pyrite next to micro-cracks filled with Fe-oxide. In outermost alteration, the original texture of host rocks has been preserved and still have to phenocryst phases. In place, white mica (sericite) and biotite flakes are partially to chlorite.

Gold occurs as small spots in tourmaline bearing quartz vein as well as sulfide bearing quartz vein in which it is associated with sulfides (pyrite and chalcopyrite) and Au-Ag-Bi-Te ore assemblages of petzite, hessite and tellurobismuth (Figure 12). Scanning electron microscopy with energy-dispersive X-ray (SEM-EDX) analyses revealed the average gold content of electrum grains, it is 75.1 at% Au and grains size range from 3-40µm. Moreover, secondary formed native gold grains were formed with hematite and iron oxides in secondary remobilized/deformed veins at strongly brecciated/oxidized zone. The association of gold and altered sulphides are suggested that gold was refractory in sulphides. It can regard that supergene oxidation extend to quite depth of mineralization veins. The Au content of such gold grains has the highest Au content; it has often almost pure condition.

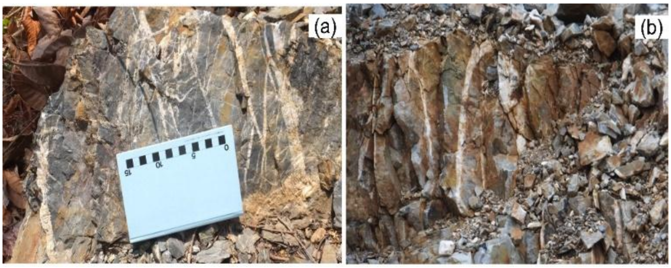

Figure 11: Photos showing (a) stockworks auriferous quartz veinlet and (b) tourmaline bearing gold- quartz veinlet

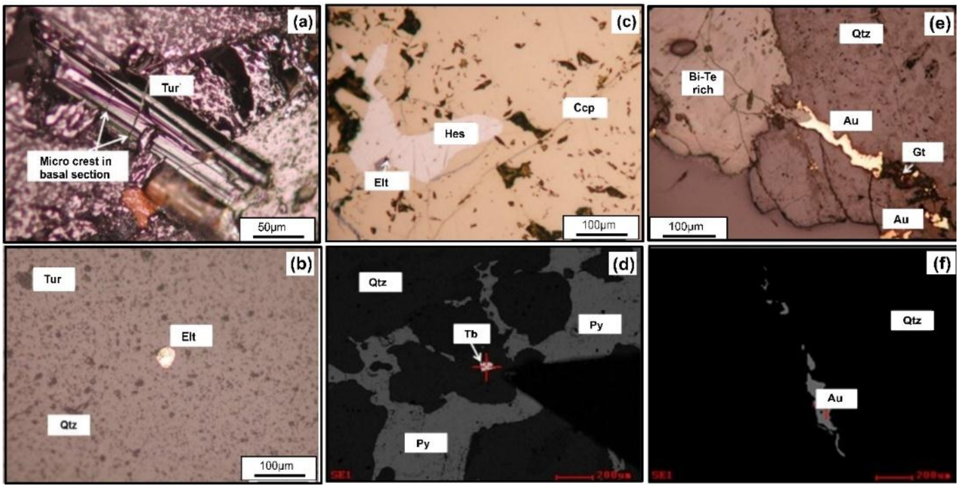

Figure 12: Photomicrographs showing (a & b) small electrum spot in tourmaline bearing quartz vein, (c & d)sulphide minerals from sulphide bearing quartz vein, and (e & f) remobilized large grains native gold in oxidized vein (Qtz=quartz, Tur=tourmaline, Au=native gold, Elt=electrum, Py=pyrite, Ccp=chalcopyrite, Hes=hessite, Tb=tellurobismuth, Bi=bismuth, Te=tellurite)

Fluid inclusions study and interpretation

A total of 4 quartz vein samples from different generation were prepared and conducted to fluid inclusion study. Basically, there are two phase fluid inclusions (liquid+vapor) are observed in both tourmaline bearing quartz veins (early stage) and sulfide bearing quartz veins (late stage) at room temperature (Figure 13). Mostly, fluid inclusions are small in size 4 to 7 µm with sub-rounded shape. The homogenization occurred into liquid dominant two-phase fluid inclusions varies from 234 to 426°C and temperatures of ice melting range between -0.2 to -5.4°C. In place, corresponding salinity range of fluid inclusions is 0.35 to 8.41wt.% NaCl equivalent [24]. The homogenization temperature of the first generation (early stage) tourmaline bearing quartz vein varies from 292-426°C. This temperature range is higher than second generation of sulfide bearing quartz vein (234-332°) but salinity ranges is not too much differences (Table 2). In nature, the second generation (late stage) of sulfide bearing quartz veins that cross-cut the first generation veins and have higher gold content. The *Th* and salinity diagram for these two generation veins is indicated that the first generation vein of tourmaline bearing quartz vein underwent 'an isothermal mixing with slightly variation salinity fluid'. Alternatively, the late generation vein is properly formed by boiling and mixing with cool low saline meteoric water. Despite the lack of fluid boiling evidence, abundant occurrence of muscovite and illite assemblage within the proximal alteration zones suggest that boiling has happen in hydrothermal system of Phayaung Taung. Therefore, we assumed the formation temperature of quartz veins as the first peaks of homogenization temperature histograms where tourmaline bearing quartz vein (370°C) and sulfide bearing quartz vein (270°C) respectively (Figure 14). In order to homogenization temperature and low to moderate saline fluid, it was possibly responsible for the development of gold ore that indicates of hydrothermal activities in mesothermal system (Figure 15).

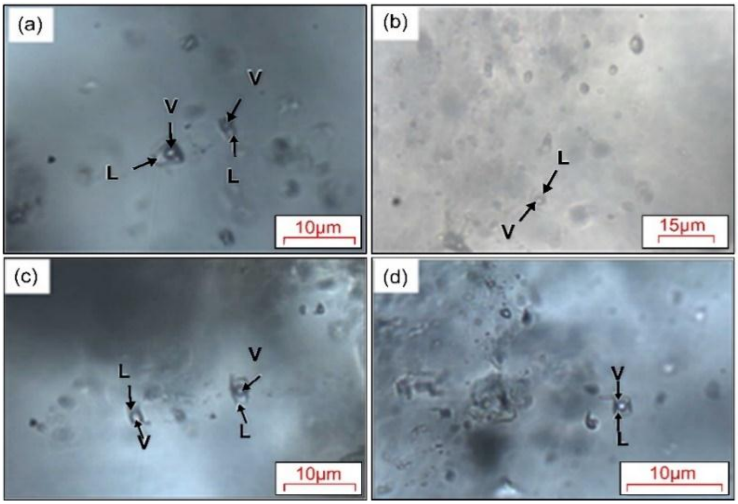

Figure 13: Photomicrographs showing two-phase fluid inclusions from Phayaung Taung deposit

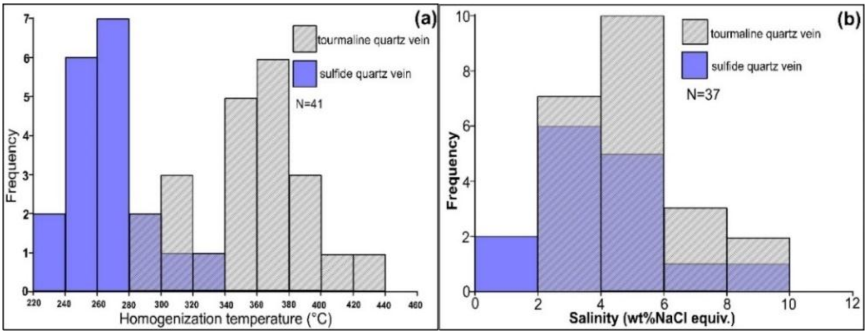

Figure 14: Histograms showing (a) homogenization temperature *Th* (°C), and (b) salinity (wt%NaCl equiv.) of fluid inclusions from Phayaung Taung deposit

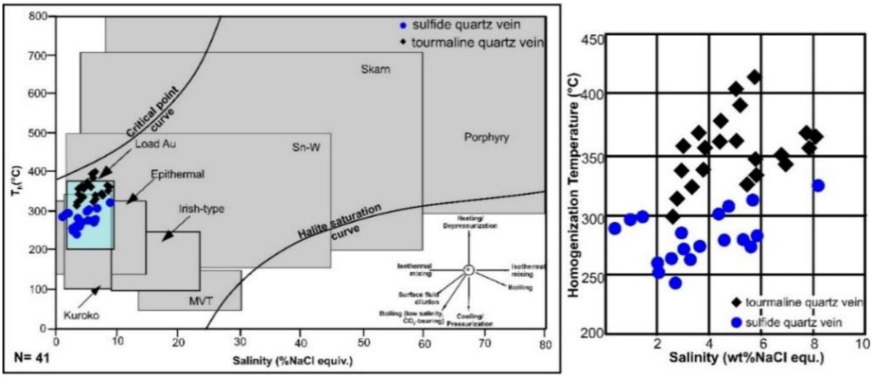

Figure 15: Homogenization temperature (*Th*)-Salinity diagram illustrating typical range for fluid inclusions from different deposit types (Wilkinson, 2001). Circles and diamonds are microthermometric result of fluid inclusions from Phayaung Taung deposit where *Th*-salinity space due to various fluid evolution process.

Table 2: Fluid inclusion microthermometric data of selected samples from Phayaung Taung deposit

Sample ID	Vein type	Inclusion type	Homogenization Temperature (°C)	Ice melting Temperature (°C)	Salinity (wt%NaCl eqiv.)
PYT Q-7,10	Sulfide quartz	L+V	234-332	-0.2 to -5.4	0.35-8.41
PYT Q-2,3	Tourmaline quartz	L+V	292-426	-2.1 to -5.3	3.55-8.28

Discussion

Although the gold deposits from Mogok Belt are considered as mesothermal (orogenic) deposits, its sub-units of Mogok Metamorphic Belt and Slate Belts have different characteristics in gold deposits. Gold mineralization from both of subunits are generally influenced by regional structural controls of faults and fractures. In place, mineralization veins from Zayetkwin-Kwinthonse gold deposit (Mogok Metamorphic Belt) are observed as fracture filling with numerous quartz vein textures. Some of vein textures such as banded, crustiform, lattice and bladed are diagnostic textures of fluid boiling (Simmons and Christenson, 1994). Moreover, hydrothermal alteration styles and mineral assemblages of quartz, calcite, adularia, sericite, illite and chlorite are look similarity of epithermal mineralization whereas calcite and adularia are characteristics of the boiling in hydrothermal system. Boiling in the conduits causes CO_2 and H_2S loss and consequent increase in pH, this condition is favored to precipitation of adularia and calcite mineral. Petrographically, coexisting of liquid-rich and vapor-rich of fluid inclusions in quartz veins are also one of indicators that happen in boiling condition of hydrothermal fluid. Furthermore, the homogenization temperature (159-315°C) and salinity (0.88 to 12.73 wt% NaCl equiv.) are also reliable that the hydrothermal system in Zayetkwin-Kwinthonse gold deposit (Mogok Metamorphic Belt) is epithermal system. Alternatively, mineralization veins from Phayaung Taung gold deposit of Slate Belt are occupied in fracture and shear zones as stockwork vein system. Gold are observed in tourmaline bearing quartz vein and sulfide bearing quartz vein. The presence of vein structure and microstructures of ductile deformation in quartz veins are indicated multiple episodes of fracturing and filling process in shear zone. It is also inferred that mineralization veins might have developed in a progressive deformation environment of ductile-brittle regime. In place, low-sulfide nature of quartz tourmaline vein and vein mineralogy of quartz, calcite, tourmaline, sericite, chlorite and sulfide minerals (pyrite, chalcopyrite) are inferred to typical of mesothermal (orogenic) gold deposit. Moreover, mineralization style and associated altered mineral assemblages of quartz, sericite (white mica), calcite, and epidote are also reliable to mesothermal (orogenic) gold deposit. Additionally, the homogenization temperature of fluid inclusions from Phayaung Taung are quite high (234-426°) that is probably deposited in mesothermal (orogenic) system.

Conclusion

Mogok Belt is one of major metallogenic belts in Myanmar with north-south general trend. It have two sub-belts from west to east (1) Mogok Metamorphic Belt and (2) Slate Belt. Both of belts are significant in gold mineralization and possess different characteristics. Case studies of each specific gold deposit from both sub-units are shown their different characteristics and natures of gold deposits. Based on available data of each gold deposits, the following conclusion can be made. In Mogok Metamorphic Belt 'Zayetkwin-Kwinthonse gold deposit', gold mineralization mainly hosted in marble units as fracture filling veins as well as disseminated in nature. A variety of quartz vein textures are observed such as banded, crustiform, bladed, lattice, comb and cockade textures. Mineralizations are controlled by regional fault system. Gold mineralization observed as large grains of electrum gold in gold bearing quartz vein and fine grains of native gold in base metal quartz-carbonate veins. Gold mineralization are basically associated with base metal sulfides of pyrite, sphalerite and galena. Hydrothermal alteration halos are also develop around narrowing zone of mineralization veins. It is overlapped to regional metamorphism of Mogok Metamorphic Belt. According to alteration minerals such as adularia, calcite, sericite, chlorite and epidote, it can conclude that it is deposited in near neutral condition of hydrothermal fluid. Vein textures of banded, lattice and bladed as well as fluid petrography of coexisting liquid-rich and vapor-rich fluid inclusions are indicated that boiling and mixing are possibly responsible for gold deposition. Moreover, microthermometric data of homogenization temperature (*Th*) 159 to 315°C and salinity 0.88 to 12.51 wt% NaCl equivalents are compatible to say deposited in epithermal system. But in Slate Belt, mineralization occurred within quartz-pyrite stringers and veinlets which forming stockwork veins. Primary gold occurs as small electrum spots in tourmaline bearing vein and sulfide bearing quartz vein. Tourmaline bearing quartz veins are the characteristics of Phayaung Taung gold deposit. Gold mineralization is associated with pyrite, chalcopyrite, petzite, hessite and tellurobismuth. Large grains secondary native gold are also formed in oxidized zone associated with hematite and iron oxide. The wall-rocks alteration are observed as silicic and phyllic with localized chloritization. There is no evidence of boiling characters within mineralization quartz vein. Microthermometric measurement of homogenization temperature and salinity range of 234 to 426°C and 0.35 to 8.41wt% NaCl equivalent are possibly responsible for the development of gold deposit from Phayaung Taung that indicates mesothermal system. Accordingly, Zayetkwin-Kwinthonse gold deposit from Mogok Metamorphic Belt shows near neutral condition of hydrothermal system with shallow level epithermal characters (possibly epithermal to mesothermal) but Phayaung Taung gold deposit of Slate Belt shows typical mesothermal characters. Such kinds of mesothermal system are elsewhere in Mogok Belt, but is not developed typical characters in Mogok Metamorphic Belt where it would be epithermal to mesothermal style.

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