Title	Precious and Base Metal Mineralization in Kwinthonze-Nweyon area, Singu and Thabeikkyin Townships, Mandalay Region, Myanmar
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Keywords	Mogok Metamorphic Belt (MMB), gold-silver, adularia, epithermal, Myanmar
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Precious and Base Metal Mineralization in Kwinthonze-Nweyon area, Singu and Thabeikkyin Townships, Mandalay Region, Myanmar

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ABSTRACT

Gold-silver and associated base metal mineralization occurs in the Kwinthonze-Nweyon area within the Mogok Metamorphic Belt (MMB) in Myanmar. The area is mainly underlain by high-grade metamorphic units and intrusive rocks. Gold-sulphide bearing quartz veins are predominantly hosted in gneisses and marbles. Numerous faults striking N, NNE, ENE and E to ESE with moderate to steep dips occurred in the area. The veins are characterized by banded, colloform, cockcade, breccia and some vuggy textures. The vein-related alteration is characterized by silicification, sericitization and chloritization from the inner to the outer zones. Principal metallic minerals are pyrite, chalcopyrite, sphalerite, galena, arsenopyrite in addition to electrum. The mineralogy of the vein is recognized into three paragenetic stages. Stage 1 is pre-mineralization stage. Stage 2 is main mineralization stage and stage 3 is post-ore carbonate stage. Quartz with minor sulfide, mainly pyrite was deposited during stage 1. Precious and base metals were precipitated during stage 2. In this stage, adularia is common. Gold and silver are more enriched in the veins containing abundant adularia than virtually quartz rich veins. In stage 3, the veins are barren. Bullion fineness data of the whole area display a wide range of fineness (416-875). Garnet and wollastonite minerals are found in the west of Chaunggyi, Kabani and Bwettaw indicating that skarn assemblages formed in the area. In comparison, the eastern part of the system displays an epithermal character as evidenced by the mineral texture and the presence of adularia. Metamorphic belts such as MMB are complex tectonic regions in which diverse types of gold deposit can be formed. Therefore, the mineralization of the Kwinthonze-Nweyon area can be consisted of epithermal to mesothermal (orogenic) and skarn mineralization genetically linked with calc-alkaline, peraluminous magmatism.

Keywords: Mogok Metamorphic Belt (MMB), gold-silver, adularia, epithermal, Myanmar

INTRODUCTION

The Kwinthonze-Nweyon area is well known in Myanmar due to local gold rush and abundant artisanal workings in the last three decades. The area is located about 96km north of Mandalay and is underlain by high-grade metamorphic rocks and intrusive bodies within the northern part of the Mogok Metamorphic Belt (MMB) of Searle and Haq (1964) (Figures 1 and 2). Gold-silver and associated base metal mineralization is mainly hosted in gneisses and marbles of MMB. The present paper will focus on the geological, structural and geochemical controls on the mineralization and their relation to tectonic setting.

REGIONAL GEOLOGIC SETTING

The regional geological setting of MMB is shown in Figure 2. To the north, the MMB is bounded by left lateral Momeik fault (also called Nanting Fault in Western Yunnan, China, Socquet and Pubellier, 2005). To the west, the MMB is separated by the Irrawaddy Formation and the right lateral strike slip fault (Sagaing Fault of Win Swe, 1972). The general structural trend of the area is nearly N-S. The structures of

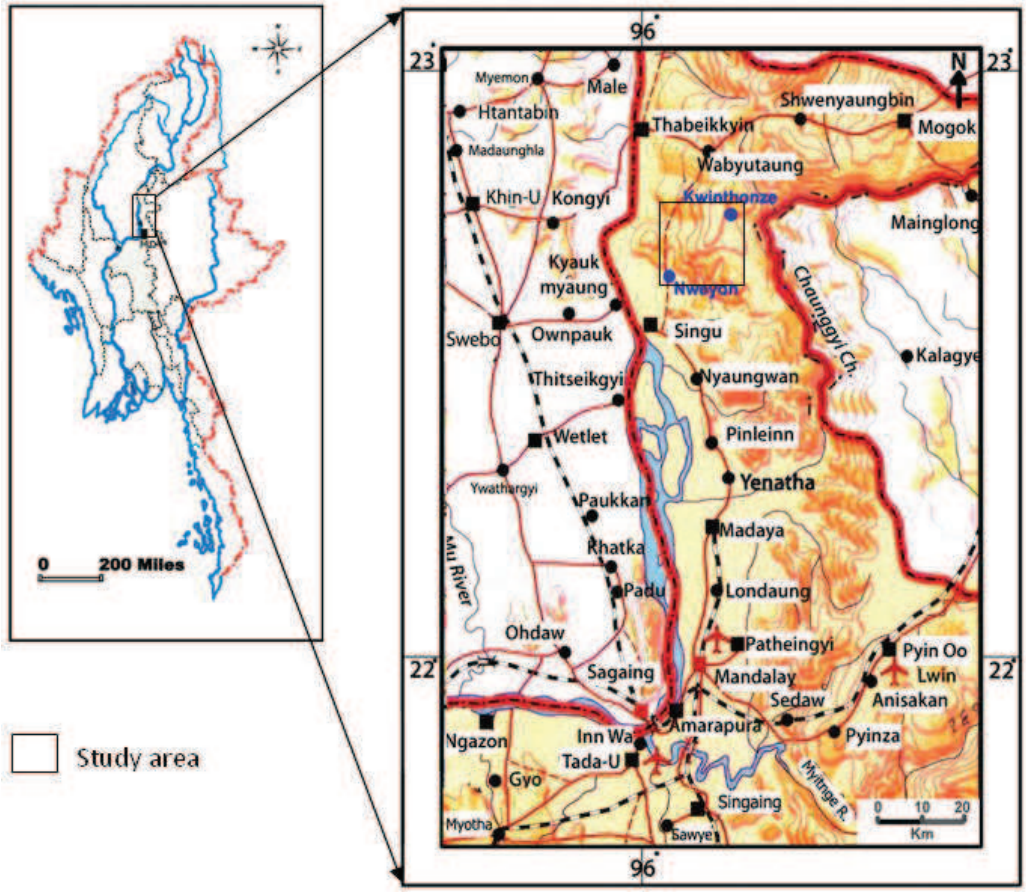


Figure 1. Location map of the Kwinthonze-Nweyon area, north of Mandalay, Myanmar

the metamorphic rocks are homoclinally dipping to the east. To the north and south, rock units of MMB were intruded by igneous rocks (Figure 2).

The main igneous unit in the area is biotite microgranite (Kabaing granite) (Figure 3). The emplacement age of Kabaing granite is Miocene (Khin Zaw et al., 2014a). Potential mineralization of the area is gold associated with base–metals found in Thabeikkyin through Kwinthonze, Chaunggyi to Nweyon from north to south. Although Singu Lava field is situated west of the area, no genetic relationship to mineralization has been found.

METHOD OF STUDY

More than sixty rock and ore samples were made polished and thin sections. Some ore and silicate samples were also analyzed using electron microprobe analyzer at the Department of Earth and Planetary Sciences, Nagoya University, Nagoya, Japan and other analyses were performed using AAS, WDXRF and X-ray Analytical Microscope (XGT) at the Mandalay University Research Centre to document the geochemical characteristics.

MINERALIZATION CHARACTERISTICS

The geometry of ore bodies and the nature of alteration are shown in Figure 4. Gold mineralization principally occurs in quartz veins, replacements in marbles and in the wall rock alteration zone. In general, the veins are controlled by north-, northeast-, and northwest-striking faults with varying attitudes.

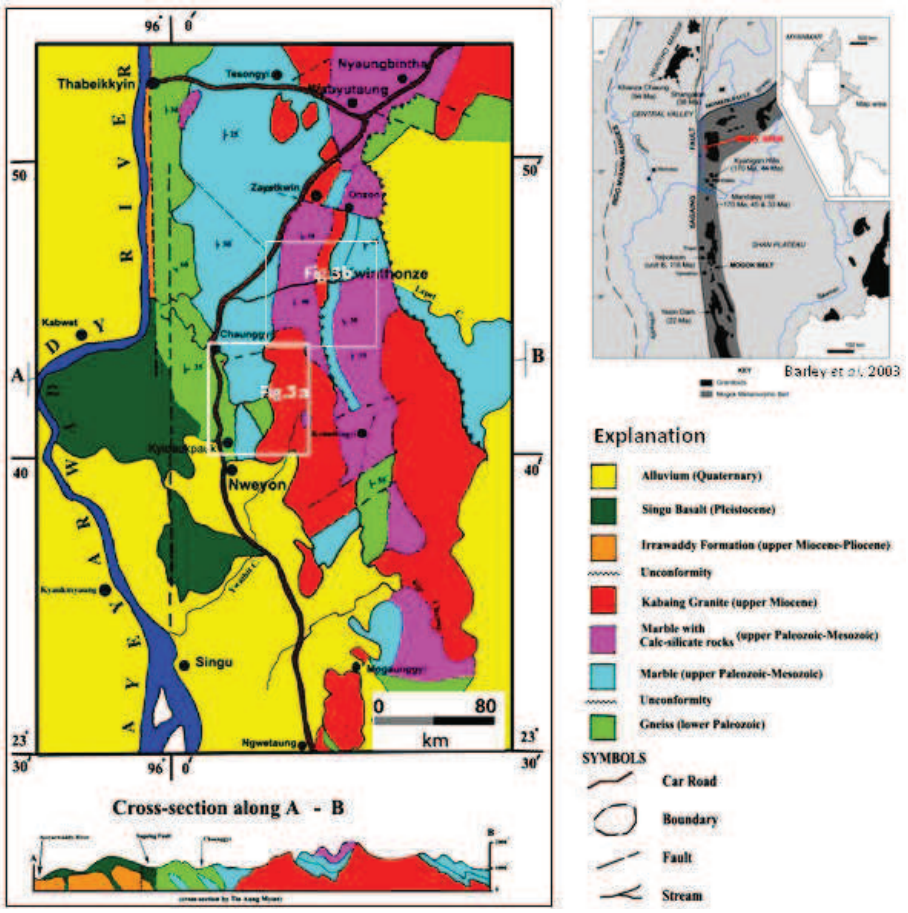


Figure 2. Regional geological map of the Mogok Metamorphic Belt (MMB) between Singu and Thabeikkyin Towns (Modified from Myint Lwin Thein et al., 1990; Barley et al., 2003; Tin Aung Myint et al., 2009). Note the geological maps of the rectangle area are shown in Figures 3a and 3b.

Gold veins in gneisses are observed as fissure filling type, whereas more replacement nature occurs in marbles. This is probably due to the intensity of hydrothermal fluid that may have dissolved the marble more than the gneiss. As a result, mineral deposits of economic importance are more common in the marble than in the gneiss. Gold and silver are associated with Zn and Pb and sometimes Cu, and are almost invariably hosted in the marble. Coarse visible gold are sometimes found, but overall grades are around 5 ppm Au. At Bwettaw, the Au-Ag mineralization occurs near the contact between granite and marble probably suggesting that mineralization appears to be related to the granitic intrusion. Wollastonite and garnet are common in the marbles near the stock. Similar local skarn assemblages occur in the areas, west of Chaunggyi and Kabani (Figure 3).

ORE AND GANGUE MINERALOGY

The gold-bearing quartz veins are characterized by banded, colloform, cockscade, breccia and some vuggy textures. The vein-related alteration is characterized by silicification, sericitization and chloritizaion from the inner to the outermost zones. Studies on the paragenetic sequence of mineralization have shown that pyrite occurs over the entire period of mineralization. Coarse pyrite is commonly fractured and cemented by gangue quartz and some sulfides such as galena (Figure 5a). In some places, pyrite relic crystals occur in quartz. Oriented small grains and rods of chalcopyrite

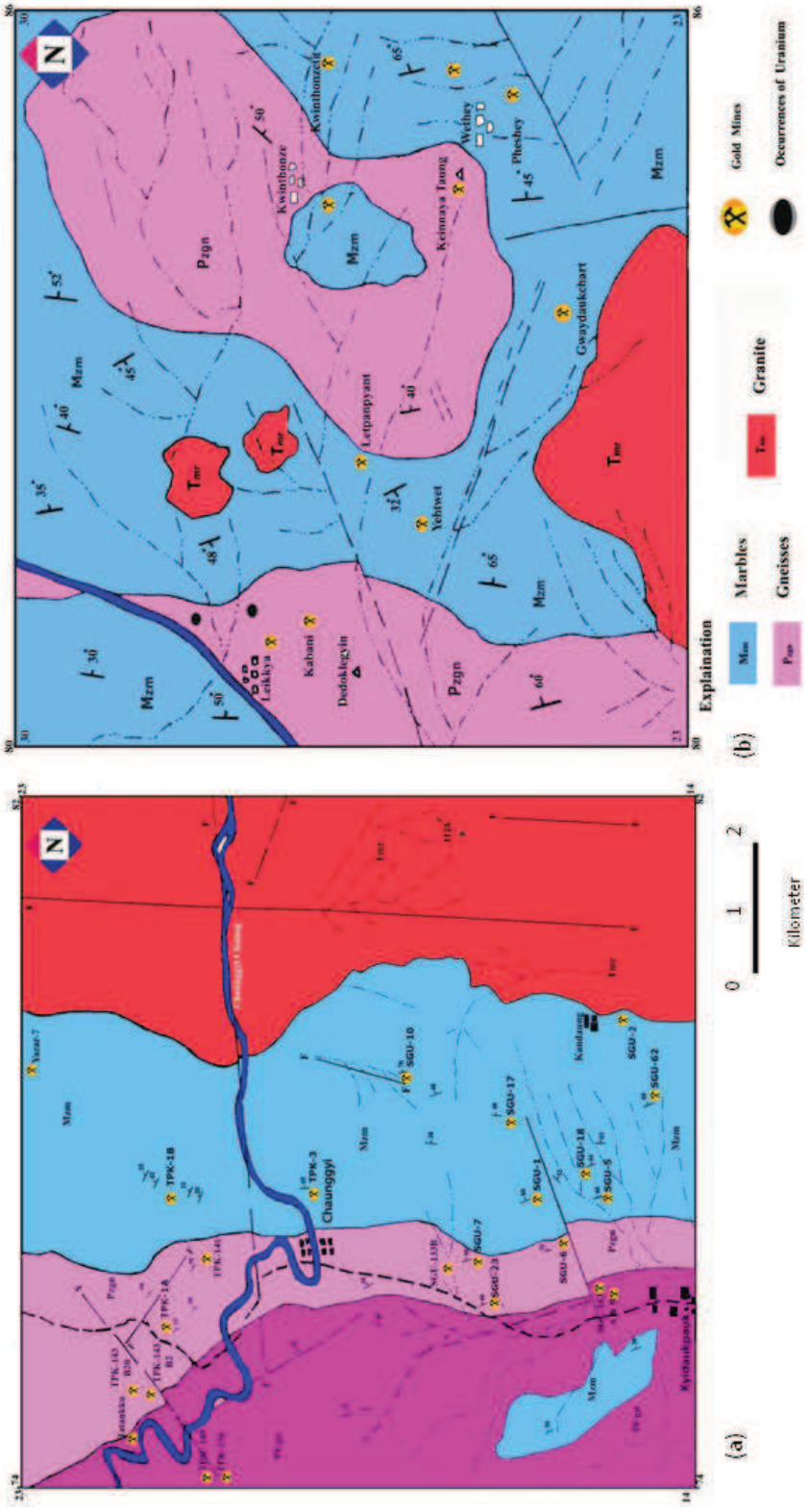


Figure 3. (a) Simplified geological map of Nweyon area and (b) Geological map of Kwinthonze area (Modified from Myint Naing, 1987; Tin Aung Myint et al., 2010)

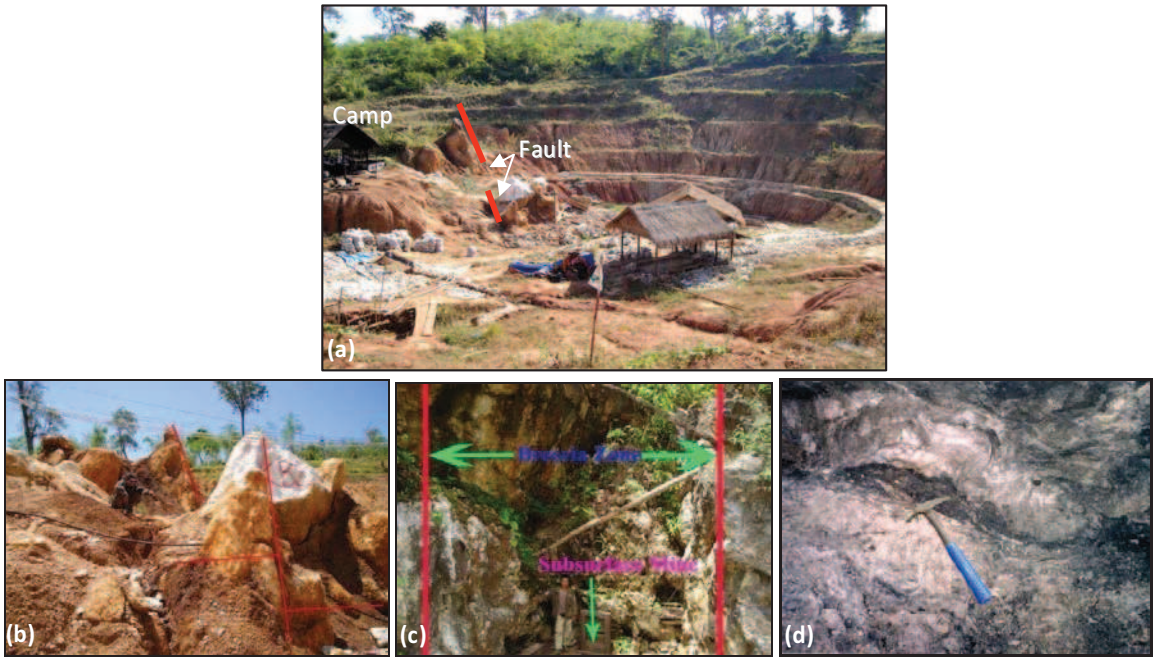


Figure 4. **(a)** Open-pit mine, **(b)** Close-up view of Figure (a) and **(c)** Underground mine within fault zone in marble at the east of Kwinthonze village and **(d)** Auriferous vein hosted in biotite gneiss with wall rock alteration (mainly silicification) at TPK-1A Mine near Chaunggyi village.

(chalcopyrite diseases) (Oeisner, 1966) are sometimes found in sphalerite (Figure 5b). This is due to the occurrence of chalcopyrite resulted either by epitaxic growth (overgrowth) during sphalerite formation or by replacement of copper rich fluid reacting with the pre-existing sphalerite (Craig and Vaughan, 1981). Galena sometimes encloses earlier-formed sphalerite (Figure 5c). The perfect cleavage of galena is usually visible and characterizes triangular pits (Figure 5d). Electrum is essentially observed as disseminated specks within pyrite, chalcopyrite, sphalerite and galena groundmass (Figure 5e).

Adularia and sericite are rare in the northern part of the system. In comparison, occurrences of adularia is commonly associated with minor sericite in the eastern part of the system indicate that the pH of the fluid during mineral deposition was nearly neutral condition (Dong and Morrison, 1995).

The mineralogy of the vein can be recognized into three paragenetic stages (Table 1). Stages 1 and 2 are main mineralization stages, and stage 3 is post-ore carbonate stage. Quartz together with minor sulfide, mainly pyrite was deposited during stage 1. Precious and base metals were precipitated during stage 2. Vein adularia, one of the mineralogical indicators for boiling (Henley, 1985), is common in this stage. Because of boiling, gold and silver are more enriched in the veins containing abundant adularia than virtually quartz rich veins. In stage 3, the veins are barren. Principal metallic minerals are pyrite, chalcopyrite, sphalerite, galena, arsenopyrite in addition to electrum. The veins can be classified according to the dominant ore minerals as pyrite, pyrite-gold, pyrite- lead- zinc- copper (± gold) and barren quartz-carbonate types. Quartz is the dominant gangue mineral and carbonate mineral mainly calcite is locally present.

GEOCHEMISTRY

Ten ore samples from mineralized veins and ten rock samples from adjacent altered phlogophite marble were analyzed in order to determine the

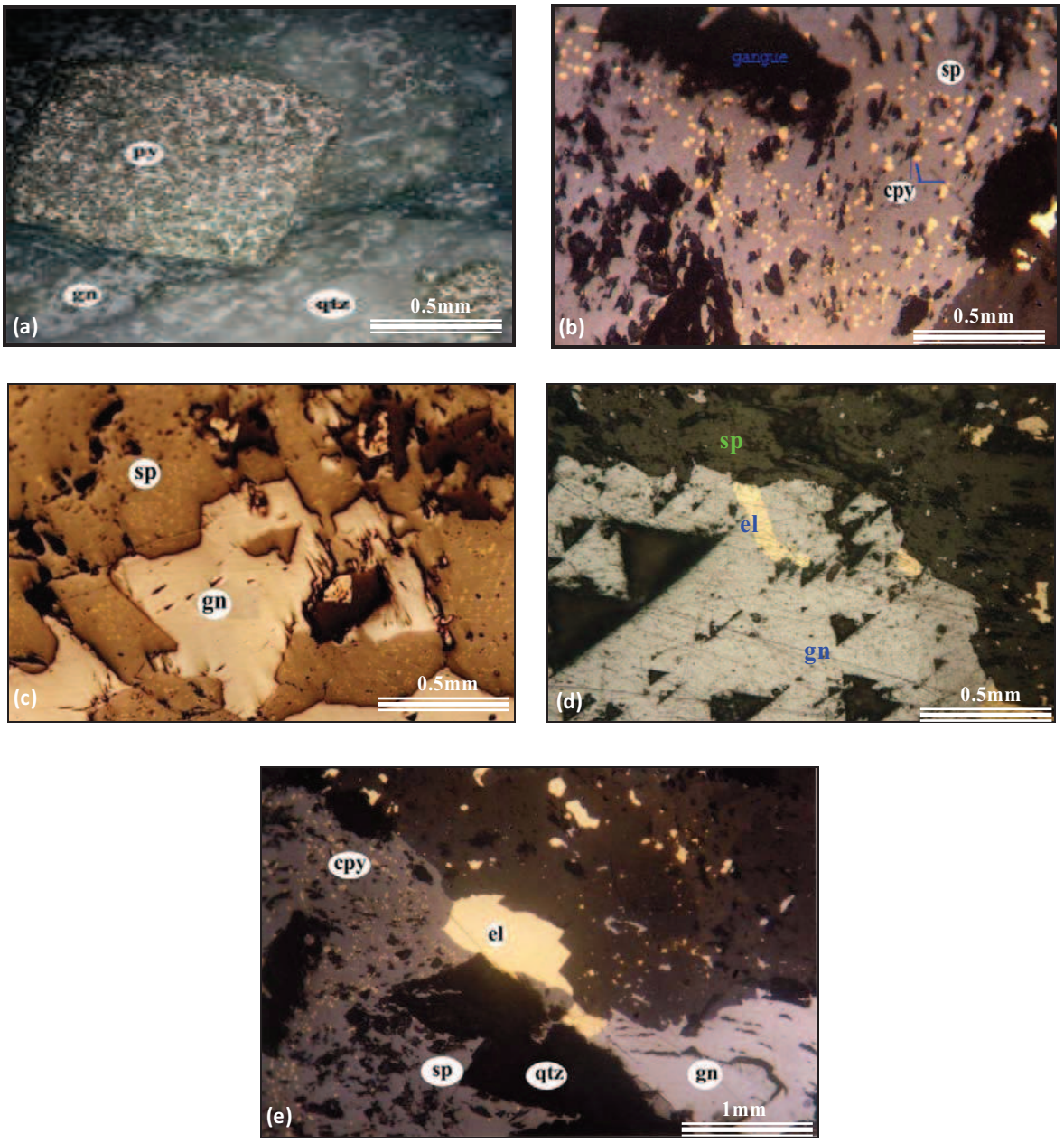
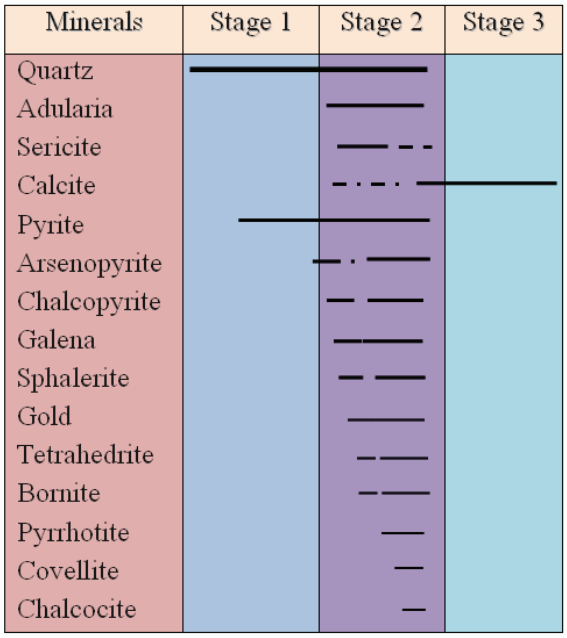


Figure (5) **(a)** Euhedral pyrite (py) is commonly fractured and cemented by gangue quartz and galena (gn), **(b)** Oriented small grains and rods of chalcopyrite (chalcopyrite diseases) found in sphalerite (sp), **(c)** Anhedral sphalerite (sp) replaced along the boundary by galena (gn), **(d)** Galena (gn) encloses in sphalerite (sp) and electrum (el) also replaces the galena and **(e)** Disseminated specks of electrum (el) within chalcopyrite (cpy), sphalerite (sp) and galena (gn) groundmass.

Table 1. Generalized paragenetic sequence of the vein minerals (width of lines corresponds to abundance)



geochemical characteristics of the gold mineralization and enrichment level of the anomalous elements. The result indicates that concentrations of gold, silver and copper are common in fracture vein system rather than in disseminated pattern (Figures 6 and 7). Judging from this, the concentrations of gold and copper show very close relationship. Gold and silver also show some sympathetic relationship in their concentration (Figure 8).

The sample MN-I is taken from mineralized vein hosted in marble at SGU-1, Kandaung (Figure 9). Under XGT microscopic study, it contains the equal amount of S and Fe content indicating pyrite. Interpretation of the X-ray map shows that minor amount of gold is observed. Gold together with other metals occupied after pyrite. The cross-cutting nature of calcite does not carry metals and is formed in late stage, supporting the three paragenesis stages of the area.

In microprobe images of TAM-01 (Figure 10) taken from the eastern part of the system at Kwinthonsettit (east of Kwinthonze), the points 01-01 and 01-02 are (Au- Ag) alloy, point 01-03, quartz and point 01-04 is quartz and adularia. Adularia is typical of low-temperature, hydrothermal environments (Dong and Morrison, 1995). The mineral typically occurs as distinctive gangue phase of the so- called adularia–sericite type deposit of Heald et al. (1987) or low sulfidation type but other category of same epithermal deposit known as the acid- sulfate (Kaolinite – alunite) or high sulfidation type is not found. Fineness of gold (458-850) in the whole area indicates high fineness– Cu-Au Systems (Chaunggyi area), intermediate values base metals + Au (Kandaung) and lowest values Au+Ag (Doenwe area) causing T and distance from source region (Figure 11).

Geodynamic setting of Myanmar is shown in Figure 12. It has traditionally been divided into three Terranes, the India plate to the west, the Burma microplate to the west of the Sagaing fault and the Shan-Thai (Sibumasu)Terrane to the east of the Sagaing Fault. The so-called Mogok Metamorphic Belt (MMB) lies along the western margin of the Shan-Thai Terrane. The MMB formed as a tectonic collage due multiple magmatic and metamorphic processes (e.g., Khin Zaw et al., 2014a, b) and the mineralization of the Kwinthonze-Nweyon area is confined to MMB and it was likely associated with the orogenic evolution of MMB. Further work is warranted to document timing of orogeny and mineralization episode in MMB.

DISCUSSION AND CONCLUSIONS

The structural setting of the area is related to the movement of the Sagaing Fault and Momeik Fault. Thus, N-, NE- and NW-trending fracture zones related to these two faults appear to be major controlling structures for hydrothermal fluid acting as the channel ways. The mineralization is mainly characterized by Au–Ag bearing pyrite–chalcopyrite dominant sulfide assemblage along with gangue mineral assemblage consisting mainly of quartz, adularia, sericite and calcite. Adularia is typical for epithermal mineralization in the eastern

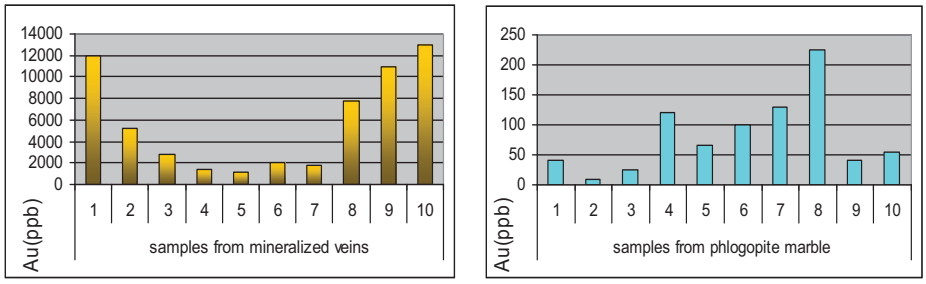


Figure 6. The Au content (ppb) in mineralized veins as compared to ambient wall rocks

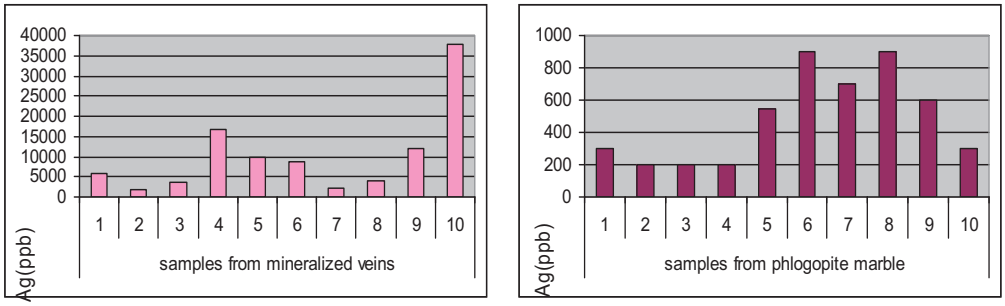


Figure 7.The Ag content (ppm) in mineralized veins as compared to those in wall rocks

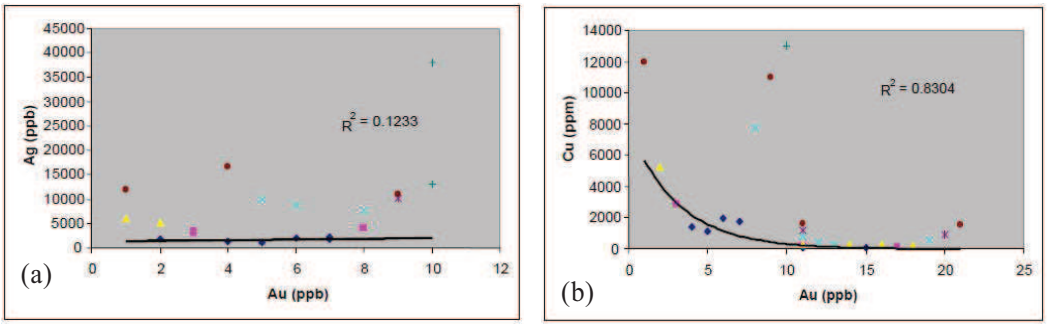


Figure 8. The relationship between the concentration of gold to silver (a) and gold to copper (b)

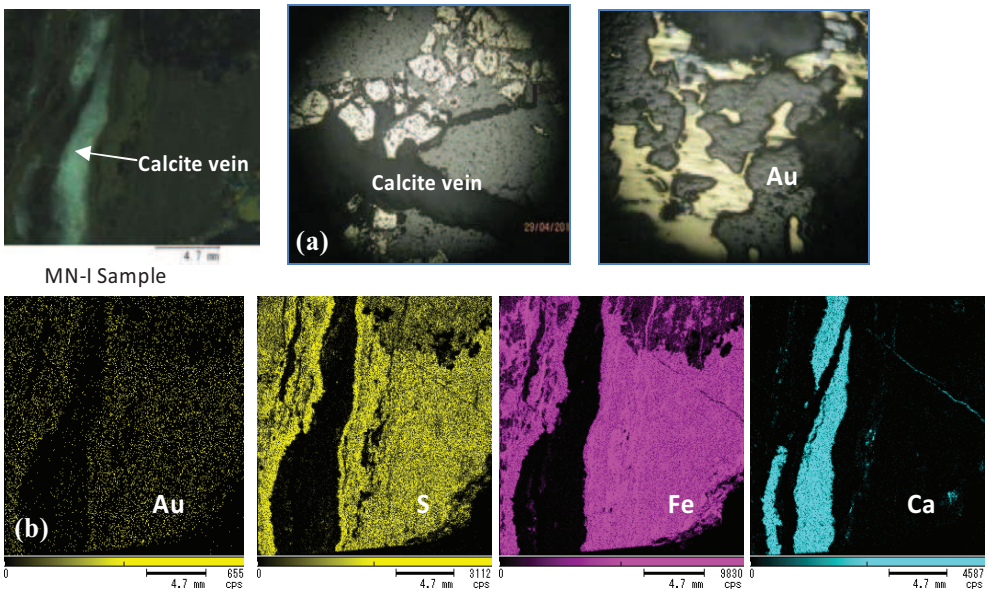


Figure 9. Photomicrographs and X-ray maps of MN-I sample collected from SGU-1 mine at Kandaung (a) under ore microscope and (b) under XGT microscopic views of Au, S, Fe and Ca.

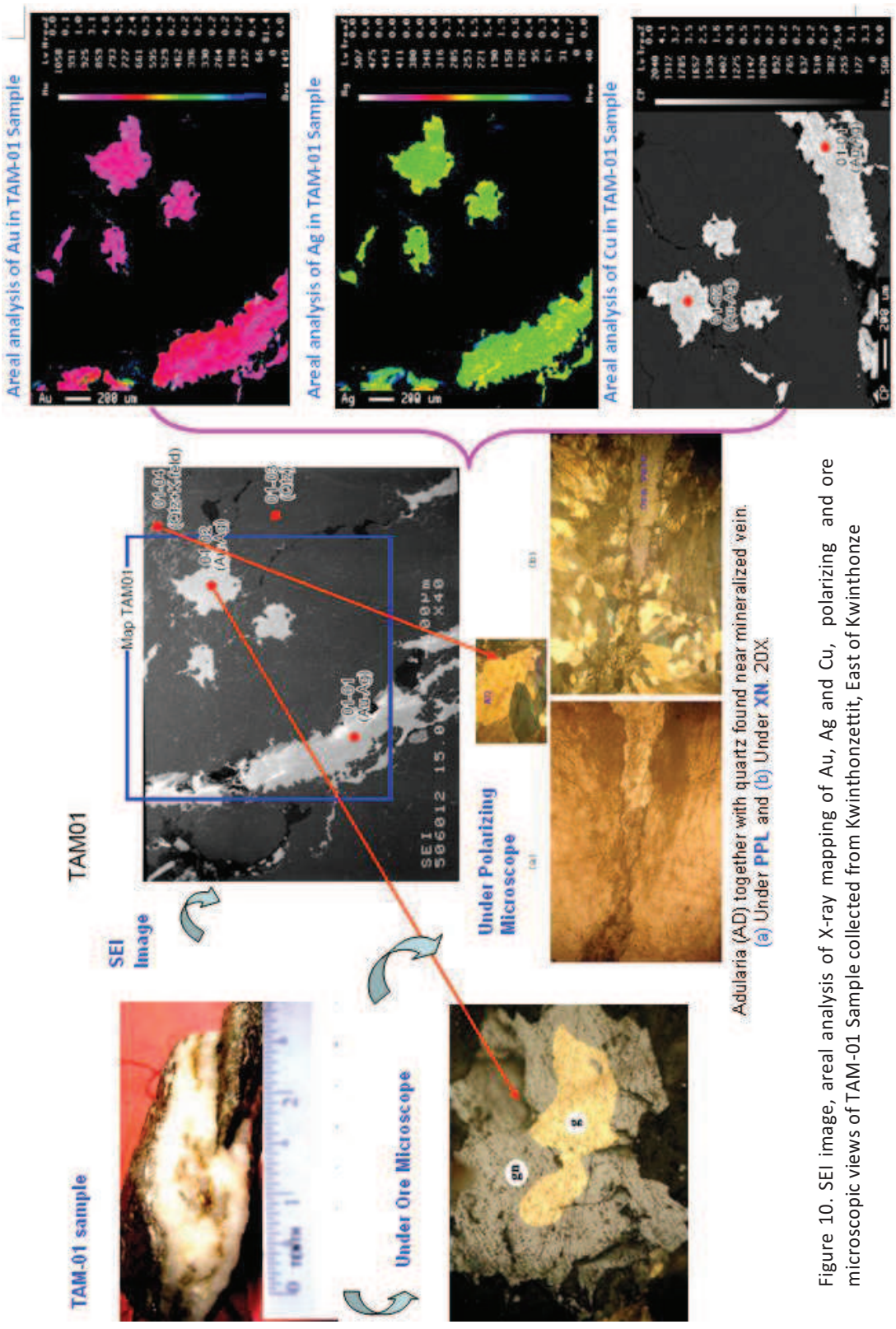


Figure 10. SEI image, areal analysis of X-ray mapping of Au, Ag and Cu, polarizing and ore microscopic views of TAM-01 Sample collected from Kwinthonzettit, East of Kwinthonze

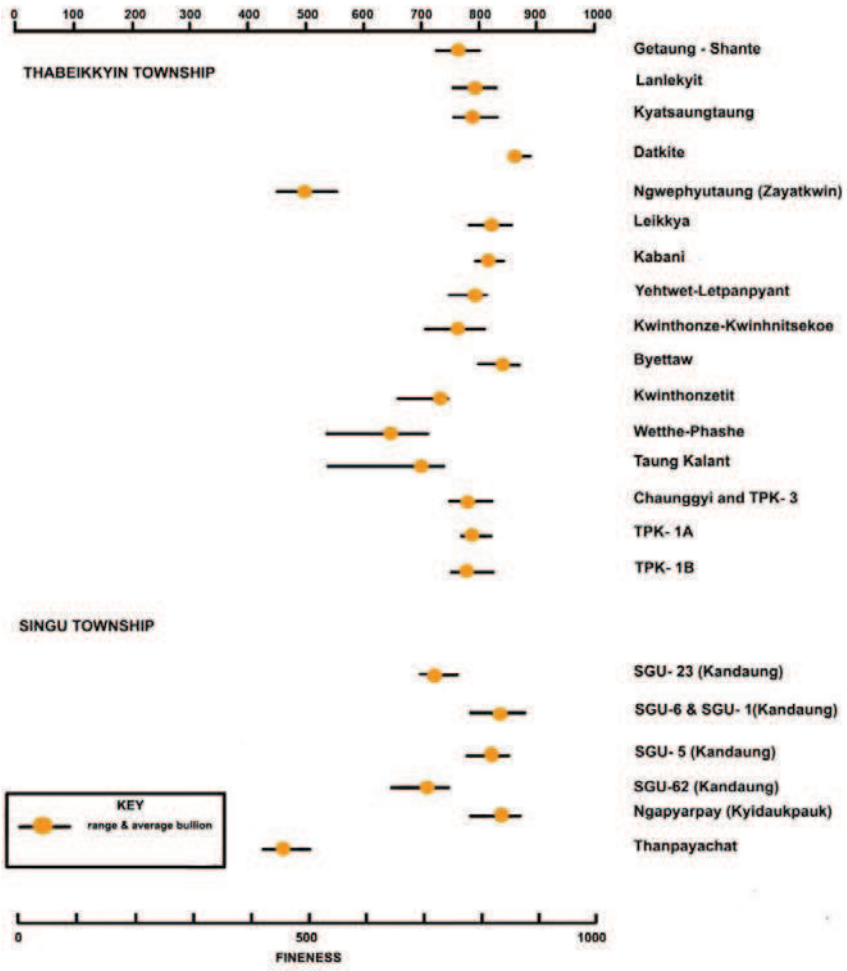
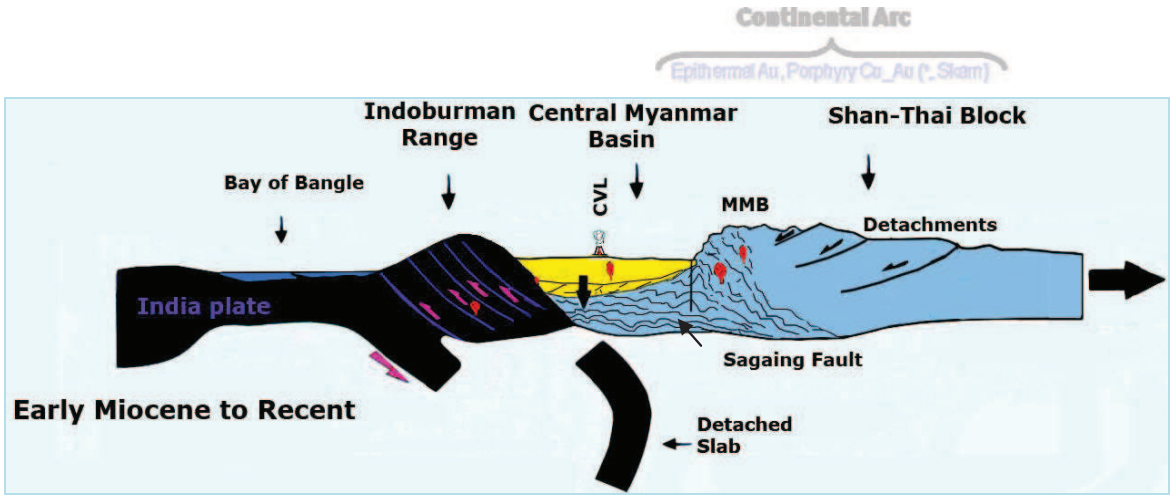


Figure 11. Bullion fineness data of gold deposits in Thabeikkyin and Singu Townships (Tin Aung Myint et al., 2009)



CVL – Central Volcanic Line **MMB –** Mogok Metamorphic Belt

Figure 12. Geodynamic setting of Myanmar including Tectonic settings of gold-forming environment in MMB at the margin of Shan-Thai (sibumasu) Terrane (Modified from GIAC, 1999)

part of the system. Besides, porphyry system was possible to occur near the intrusion or at depth of certain crustal level. Skarn assemblages such as garnet and wollastonite minerals are also found in the area. Metamorphic belts such as MMB are complex tectonic regions where accretion or collision has added to or thickened the continental crust. Thus, gold deposits can be formed at all stages of orogenic evolution so that evolving metamorphic belts may contain diverse types of gold deposit. Therefore, the mineralization of the Kwinthonze-Nweyon area would be of epithermal to mesothermal (orogenic) with local skarn assemblages and hydrology of the ore fluid is considered to be genetically linked with calc-alkaline, peraluminous S-type magma during the evolution of MMB.

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