



## New constrains on lithology and sulphide mineralizations in Pha Khieng-Nam Bo area, Muang Long district, Laos PDR

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### ABSTRACT

The Pha Khieng-Nam Bo area is located in the Muang Long District, Luong Nam Tha Province, Laos PDR. It comprises the Sukhothai fold belt, which is located in Northwest central Indochina. The area is underlain by predominant volcanic rocks and subordinate siliciclastic and carbonate sedimentary sequences. All rocks in the area have variable affected by several phases of deformation, including regional penetrative ductile shearing and folding as well as local brittle faulting and fracturing. Within the Pakieng-Nam Bo area, numerous sulphide occurrences have been discovered, which comprises mostly Cu and Mo ( $\pm$ Au) mineralizations. New geochemical data have demonstrated that the volcanic rocks in the Pha Khieng-Nam Bo area are part of high calc-alkaline series, which has been formed in a subduction environment as a part of the Sukhothai-Bokeo Island Arc system during the Late-Permian to Early-Jurassic. On the basis of ore microscopic and EPMA analyses, these mineralizations can be divided in to two groups including Mo-Pb-Au ( $\pm$ Cu) and Cu-Pb ( $\pm$ Mo) mineralizations. The Mo-Pb-Au ( $\pm$ Cu) mineralization is characterized by very fine-grained of sulfur mineral, which are filled pore spaces of the fracture/breccia systems. Cu-Pb ( $\pm$ Mo) mineralizations are occurred along high strain zones and are more abundant in the Nam Bo area. The presence of epithermal breccia with fine-grained sulfide minerals including pyrite is good indicators for low sulfidation epithermal environment for the Cu-Au mineralization in the Pha Khieng-Nam Bo area.

### 1. Introduction

The Pha Khieng-Nam Bo area is located in the Muang Long District, Luang Nam Tha Province, Laos PDR (Figure 1). The environment of the rocks forming in The Pha Khieng-Nam Bo has presented their characteristics via their own physical-chemical properties, by lava and sill-dike. The Pha Khieng-Nam Bo area is a part of the Sukhothai

fold belt, West of the Nan-Luongnamtha Suture zone, which was derived from the collision of Sibumasu and Indochina plates (Metcalf, 2000; Phommakaysone, 2011; Sone and Metcalfe, 2008). Sukhothai fold belt comprises of granite pluton from early Permian to end-Triassic (Sone and Metcalfe, 2008), it is the volcanic arc margin as well as the Pha Khieng-Nam Bo (Metcalf, 2011; Sone and Metcalfe, 2008; Ueno and Hisada, 1999), volcanic arc is the best environment to create epithermal

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system. According to rock physical and bulk rock chemical classification diagram of (Cox et al., 1979), the area comprises of a variety of volcanic rocks such as basalt, amygdule basalt, andesite, dacite and rhyolite, gabbro is the plutonic rock in the area.

## **2. General geological features**

### **2.1. Tectonics setting**

The Pha Khieng-Nam Bo area (Sukhothai belt) has been formed as an island arc in Early-Permian, resulted from subduction of Sibumasu oceanic formation, volcanic activity had created characteristics of the Pha Khieng-Nam Bo lithology, such as lava and dike-sill, those formed I-type magma (Sone and Metcalfe, 2008). The seamount had been subducted to Sukhothai arc (Figure 2), that is the source of plutonic granite in Sukhothai belt (Figure 1). Seamount is related to earthquake and plutonic granite, which had the potential to give ore mineralization. Ore mineralizations formed in Late-Permian to Early-Jurassic (Sone and Metcalfe, 2008). The tectonics of Sukhothai including in The Pha Khieng-Nam Bo are on active, presented by the Num Ma fault, Mengxing fault (Lacassin et al., 1998). Pailoplee et al, (2010 (Streckeisen, 1979) had divided this area to zone F and E of active fault in Southeast Asia.

### **2.2. Volcanic Lithotectonics**

The Pha Khieng-Nam Bo areas comprise of various volcanic rock types such as basalt, amygdule basalt, andesite, dacite, and rhyolite. Most of the areas are underlain by basalt. The basalt characterized by dark greyed color, it composes mainly of plagioclase and some of pyroxene. The andesite is grey in color; it composes mainly of plagioclase and less of quartz. The dacite is white-grey and contains more quartz and feldspar. Quartz size range from 1 mm to fine grained size. The rhyolite is white-grey and contains more quartz, feldspar and k- feldspar. Grain size ranges from 3mm to fine grained. Plutonic rocks are rarely exposed and where exposed, they commonly form small bodies, dikes, and sills of gabbro in composition. Gabbro presents as grey dark color, showing crystal of olivine with size of

25 $\mu$ m (Figure 3).

#### *a. Rocks petrography*

The studies of rocks properties by thin section allow classify rocks by mineral component and rock texture such as: basalt, amygdule basalt, andesite, dacite, rhyolite, and gabbro (Figure 3, 4), the mineral identification had been improved by x-ray definition (XRD).

#### *b. Rocks chemistry*

The rock classifications have been proven by data from X-ray fluorescence wavelength dispersive spectro-meters (XRF-WDS), through major element component in the rocks. The compounds  $\text{Na}_2\text{O}+\text{K}_2\text{O}$  and  $\text{SiO}_2$  are showing patterns in alkali with silica diagram (Cox et al., 1979) (Figure 5), indicated that rocks chemical composition are characterized as basalt, amygdule basalt, dacite, and rhyolite. The  $\text{FeO}^*/\text{MgO}$  ratio with  $\text{SiO}_2$  diagrams suggest the volcanic rocks in Pha Khieng-Nam Bo origin is from source magma which represented in the subduction zone (Figure 6) (Winter, 2001). The compounds  $\text{K}_2\text{O}$  and  $\text{SiO}_2$  show the patterns of fresh rock are the calc-alkaline series (Figure 7), which indicates that the rock in Pha Khieng-Nam Bo areas are formed as island arc composition.

## **3. Ore mineralization**

Mineralizations in the Pha Khieng-Nam Bo can be divided into two groups including molybdenum-lead-gold and copper-lead metal mineralizations.

The Mo-Pb and Au mineralizations occur in the Northern part of the Pha Khieng area. The Mo-Pb and Au mineralizations are formed in epithermal breccia which developed from the high-strained of brittle-ductile shear (Tran, 2011s), it is present by fine grain in the matrix of epithermal breccia, so the ore microscope and EPMA (Electron Probe Micro-Analysis, Figure 8) analytical methods have been applied to study the character of ore deposits.

Molybdenum is difficult to interpret under microscopes because it is really fine grained and formed as wulfenite [ $\text{PbMoO}_4$ ] (Figure 8. C), the EPMA can present the shape of wulfenite. They form in matrixes and in fracture of breccia. Some of the galena are formed in the

fracture (Figure 8A). The Au is hosted by pyrite [FeS<sub>2</sub>] (Figure 8F), and chalcopyrite.

Copper-Lead mineralizations distributed along high strain zone, distributed widely in the Pha Khieng-Nam Bo. The Cu are formed as chalcopyrite [CuFeS<sub>2</sub>], bornite [Cu<sub>5</sub>FeS<sub>4</sub>],

covelite [CuS], chalcocite [Cu<sub>2</sub>S] and tarkianite [(Cu,Fe)(Re,Mo)<sub>4</sub>S<sub>8</sub>] (Figure 8B). Tarkianite is exhibited in the East of Nam Bo, it associated with galena and goethite. The ore concentrated in NB core show high content of Cu and Mo, with less of Pb.

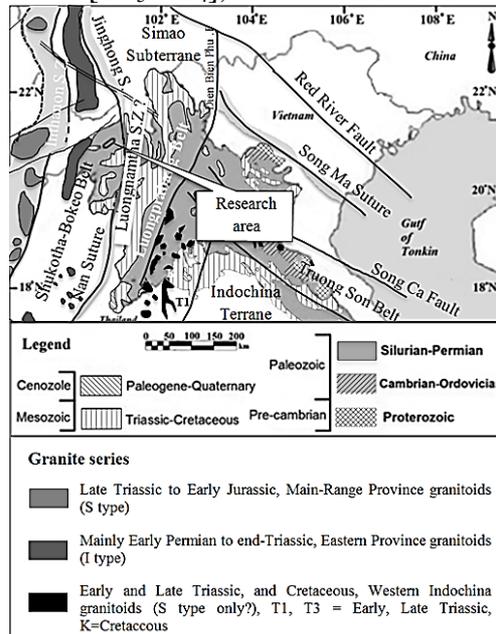


Figure 1. Location of Pha Khieng- Nam Bo area in Muang Long district, Luang Nam Tha province, Northwest of Laos PDR, The area locates within the Sukhothai-Bokeo fold belt (after (Metcalf, 2011; Phommakaysone, 2011; Sone and Metcalfe, 2008; Tate, 2005))

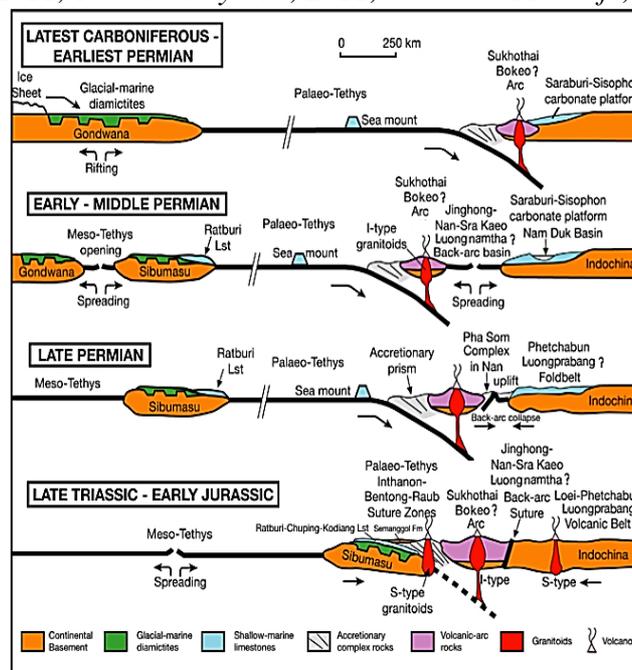


Figure 2. The tectonic evolution of Sibumasu, Palaeo-Tethys-Inthanon Suture zone, Sukhothai Belt, Jinghong – Nan – Srakaeo - Luongnamtha Back - arc Suture and Loi- Phetchabun - Luongprabang Volcanic Belt during Late Carboniferous–Early Jurassic times (after (Metcalf, 2011; Sone and Metcalfe, 2008; Ueno and Hisada, 1999))

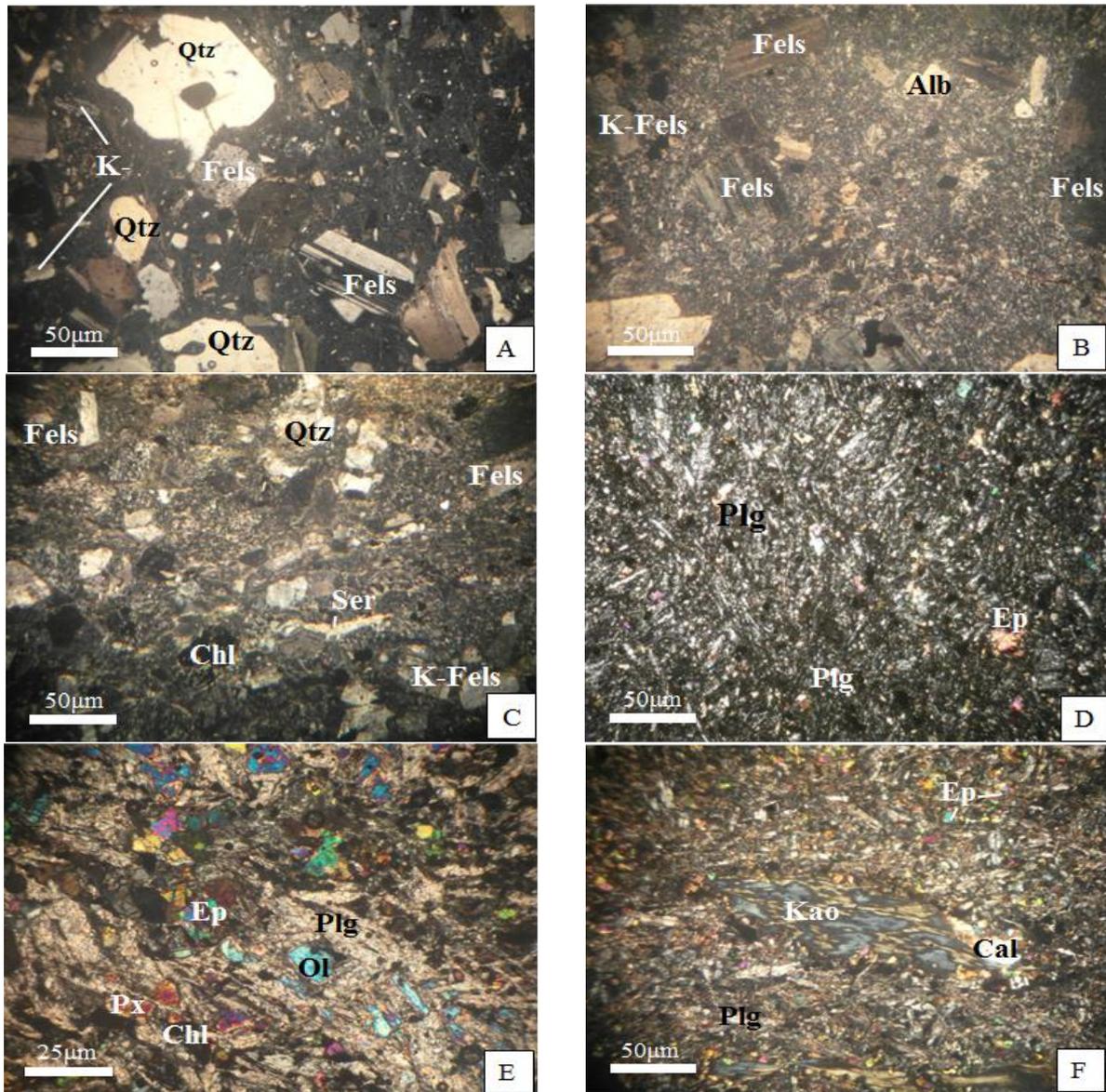


Figure 3. Micro-photos

A. The rhyolite presents big grains of quartz ranging from 10-100  $\mu\text{m}$ , feldspars crystal sizes range from 5  $\mu\text{m}$  to 70  $\mu\text{m}$ ; K-feldspars commonly are grains of 25  $\mu\text{m}$  (sample K076);

B. The andesite had presented mainly by feldspar with sizes ranging from 80  $\mu\text{m}$  to fine grained, there is a little quartz grain as 10  $\mu\text{m}$  size, and there are some albite with sizes 20  $\mu\text{m}$  (sample K100);

C. The dacite comprise of feldspar as 10-25  $\mu\text{m}$  sizes and quartz with sizes ranging is from 5-20  $\mu\text{m}$ , and there are some secondary minerals such as sericite, chlorite;

D. The basalt is composed mainly of feldspar which is colorless with some epidote being colorful (sample K097);

E. The grabbo is composed mainly of plagioclase, with some pyroxene, and less of olivine, the secondary minerals such as epidote, chlorite are formed, at out crop K094;

F. The amygdule basalt exhibits the amygdule structure in hand specimens as well as under microscopes. The rock is composed mainly of plagioclase. The amygdule textures are filled by kaolinite and calcite, with epidote and chlorite as the secondary minerals.

Abbreviation: Alb=Albite; Cal=Calcite; Chl=Chlorite; Ep=epidote; Fels=Feldspar; K-Fels=Alkaline feldspar; kao=kaolinite.

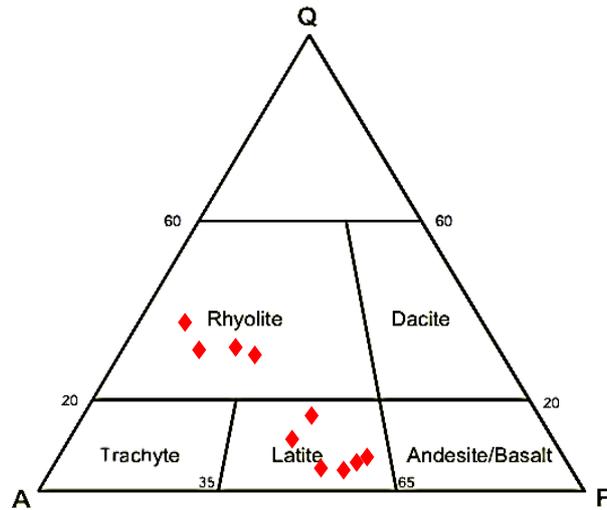


Figure 4. Petrography diagram of the sample in Pha Kiang-Nam Bo, classification of the volcanic rock in research area (Streckeisen, 1979)

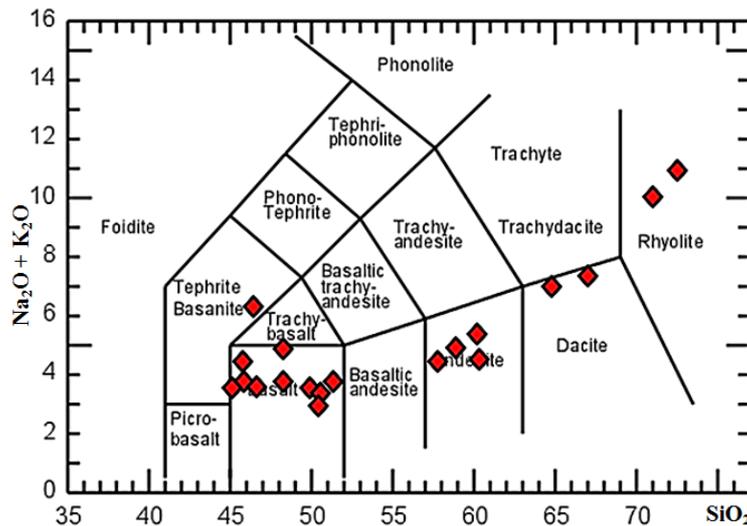


Figure 5. The diagram of (Cox et al., 1979) show the rocks in Pha Kiang-Nam Bo areas

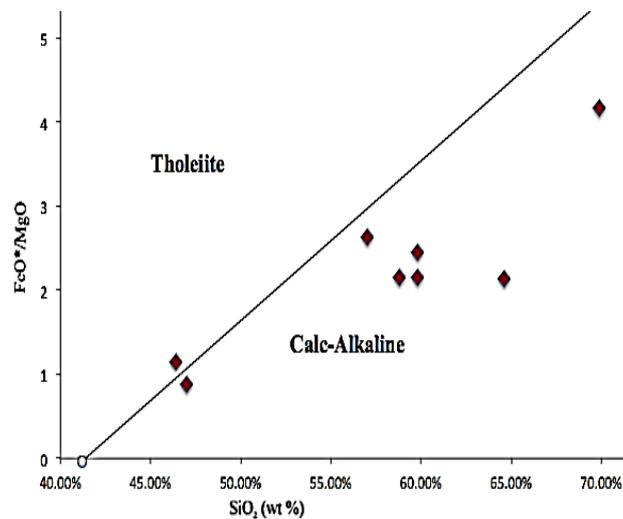


Figure 6. The Pha Kiang-Nam Bo volcanic rock plotted in the diagram of tholeiitic and alkaline

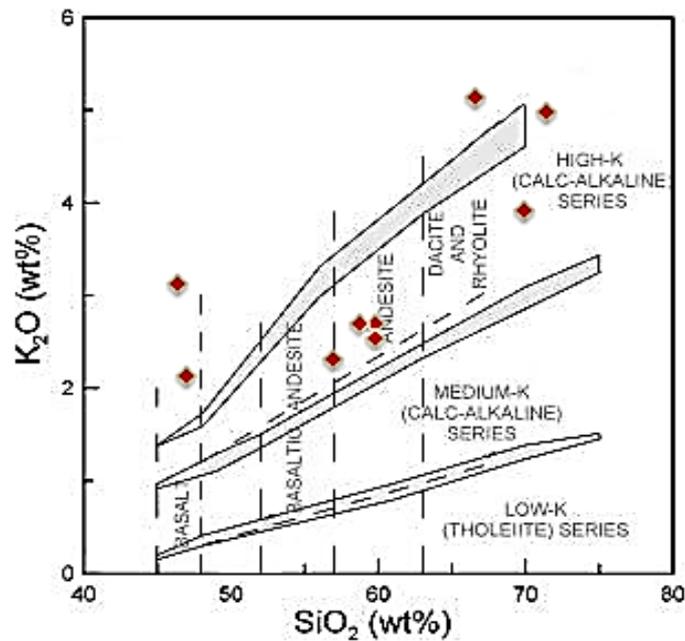


Figure 7. The subdivision of subalkaline rock using the  $K_2O$  with  $SiO_2$  (Le Maitre et al., 1989), the plot of rock shows patterns, Pha Kieng-Nam Bo areas are related with high calc-alkaline series

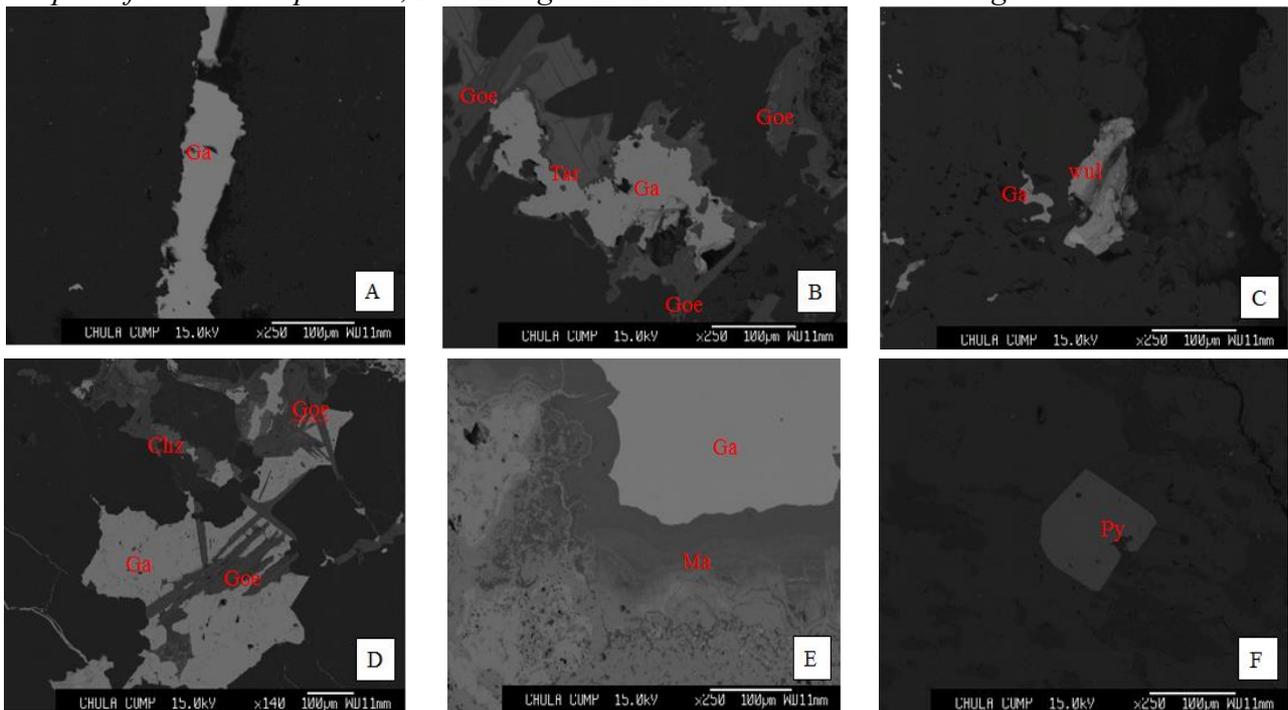


Figure 8. Photos of the electron probe micro analysis (EPMA)

A. The photo of sample Pk17-183.4 exhibits the single shape of galena with 86.98% of Pb in the fracture of breccia; B. The photo of sample K064 shows the tarkianite cut by galena, tarkianite and galena had been cut by goethite; C. The photo of sample K001 shows wulfenite (56.95% of Pb, 20.82% of Mo) in matrix of epithermal breccia and fracture; D. The photo of sample L10046 shows chalcocite with galena and goethite; E. The photo of sample L10046 shows galena rounded by malachite as buffering zone; F. The photo of sample Pk17-159.6 presents pyrite mineral is contains gold in the grain; Abbreviation: Bor: bornite; Cp: chalcopyrite; Cov: coveline; Chz: chalcocite; Geo: goethite; Ga: galena; Ma: malachite; Py: pyrite; tarkianite; Tent: tennantite; Wul: wulfenite

#### 4. Conclusion

The rocks in Pha Khieng-Nam Bo such as basalt, amygdule basalt, andesite, dacite and rhyolite, represent volcanic environment as calc-alkaline series.

The samples in Pha Khieng drill core as well as in the breccia show that molybdenum presents as molybdenite and the surface is the Mo-Pb oxidation minerals such as wulfenite, Nam Bo is form as tarkianite.

Mineralizations in Pha Khieng-Nam Bo can be separated into two groups including Mo-Pb-Au ( $\pm$ Cu) and Cu-Pb ( $\pm$ Mo). Pha Khieng's Epithermal mineralization of Mo-Pb-Au ( $\pm$ Cu) is present Au in pyrite.

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