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## Study on Iron-Copper-Gold Mineralization in the Truong Son Metallogenic Belt, Laos-Vietnam

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### 1 Introduction

The Truong son fold belt, located in the Truong son Range and in central Vietnam and eastern Laos, an elongate northwest trending belt, is dominated by a system of strike-slip faults, which forms part of the Indochina block. Rocks in the belt are metamorphosed up to the amphibolite facies grade, predominantly Early to Mid Paleozoic. The tectonic boundaries of the Truong son fold belt, Song Ma suture zone, Dien Bien Phu Fault, Khorat Basin and Tamky-Phuoc Son fault lies to north, west and south of the belt respectively (Fig. 1). The Truong son tectonic magmatic belt, the same position with fold belt, composed of volcanic rock and granite, which was formed in Caledonian, Variscan and Indosinian periods. Due to the particular geological background, the Truongson metallogenic belt has experienced complex diagenesis and mineralization, and rich mineral resources were formed. There are more than 70 gold, copper, iron, tin, lead and zinc deposits, including some large to super-large-scale deposits, such as Sepon copper-gold deposit, Phu Kham gold-copper deposit in Laos, and Thach Khe iron deposit in Vietnam.

### 2 Geological Characters of Typical Deposits

Phalek iron deposit is located in northwest of the Truong son metallogenic belt. The deposit mainly relates to monzonitic granite and Devonian carbonatite. Three main ore types are recognized in Phalek mine district, i.e., massive magnetite ore, pore-shaped hematite ore and gravel-earthly ore. The ores appear both characteristics of volcanism and deposition mineralization, and have suffered weathering and leaching later. Therefore, the mineralization stages of Phalek deposit can be divided into three stages. Firstly, the Variscan intrusive magmatism activity led to contact metasomatic mineralization, forming skarn type iron deposit. Secondly, volcanic

eruption resulted in hole-shaped lava type hematite ore depositing in continental rift basins during continental folding orogenesis. Finally, owing to crustal uplift in Cenozoic, supergene physical and chemical weathering mineralization happened, which formed the gravel-earthly type iron ore on the surface.

Sepon copper and gold mine is a largest copper and gold production base in Laos, with annual output of approximately 7 tons of gold and 100 000 tons of copper in recently years. Copper mineralization is mainly related to the porphyry system, which including three mineralization types, i.e., porphyry copper-molybdenum-bismuth mineralization, proximal skarn copper mineralization, and secondary copper mineralization. Gold mineralization mainly occurs on the interface of different lithologies. The orebodies are controlled by the lithologic interfaces, faults, folds and porphyry, etc. Accordingly, five major mineralization types can be divided: porphyry Cu(-Mo-Au) mineralization, proximal skarn Cu mineralization, secondary Cu mineralization, sediments-hosted Au mineralization, and carbonatite metasomatic Pb-Zn-Ag mineralization. Metallogenic model of the former three types is similar to "normal magmatic mode" associated with the porphyry systems. The mineralization related to magmatic fluids of granodiorite porphyries and dikes. The micro disseminated sediment-hosted gold shear much similarities to the Carlin Tredn, Nevada. The deep porphyry magmatic fluids with circulating evolved meteoric fluids probably provided the heat source necessary to drive the hydrothermal system and associated trace elements from sedimentary rocks for the gold deposits.

The Phu Kham copper-gold deposit occurs near to Phalek iron mine. The resources of copper-gold ore are about 400 million tons. There are three mineralization types, including porphyry Cu (-Au) mineralization, skarn Cu (-Fe-Au) mineralization, and hydrothermal Cu (-Au) mineralization. Nameung copper polymetallic deposits occurs in the contact zone of biotite granite and carbonatite,

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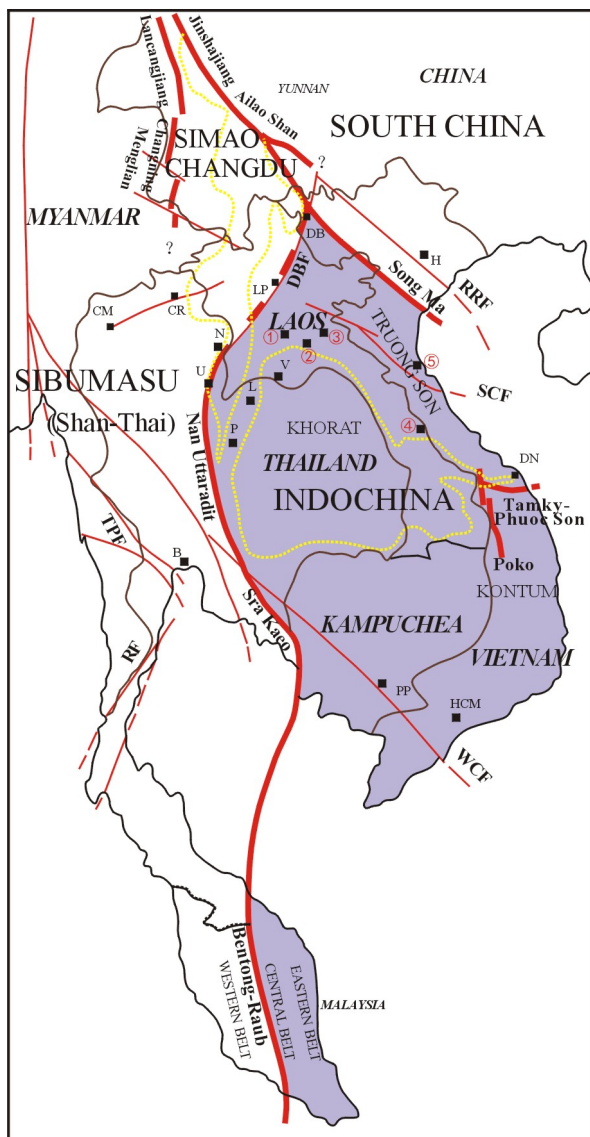


Fig. 1. The tectonic map of Indochina and adjacent regions  
①:Phalek iron deposit;②:Phu Kham copper-gold deposit; ③:Nameung copper polymetallic deposit;④:Sepon copper and gold deposit;⑤:Thach Khe iron deposit.

which shows to be a typical skarn type deposit. The reserves of iron ore is about 600 million tons in Thach Khe deposits in Vietnam. The deposits within the contact zone of biotite granite, granodiorite and Devonian-Triassic carbonatite, clastic rock formation.

### 3 Geochronological Data

Recently, many geochronological datas are obtained about granitoids associated with Fe-Cu-Au minerlization in the Truong Son belt, with multimethod dating combinig Ar-Ar and U-Pb techniques. In Phalek iron deposits, U-Pb zircon dating on a monzogranite intrusion yields a  $(280.3 \pm 2.9)$  Ma age emplacement. the younger ages are encountered in the eastern 40km Palek, in the Namueng copper polymetal deposits, displaying U-Pb biotite

monzogranite ages of  $(254.2 \pm 4.1)$  Ma, similar to a SHRIMP age of  $(257.8 \pm 2.2)$  Ma in Thach Khe iron deposits. Other data such as  $(290 \pm 5)$  Ma in Sepon and  $(300-310)$  Ma in Phu Kham were reported by other authors. In the Truongson metallogenic belt, Fe-Cu-Au metallogenic ages are mainly concentrated in two stage, one from Late Carboniferous to Permian  $(280-310)$  Ma, and the other from Late Permian to Early Triassic  $(250-260)$  Ma.

### 4 Metallogenic Geodynamic Setting

The Truong son fold belt might have underwent three tectonic evolution stages: (1) the formation of the Truong son continental and crystalline basement evolution stage in Precambrian, no significant mineralization known, possibly formed primary metal material source. (2) Song Ma oceanic basin opening- development-subduction-closing tectonic evolution stage from Early Paleozoic to Triassic, forming mineralization in the subduction boundary. porphy-sharn-hydrothermal Au-Cu-Fe mineralization form during subduction stage, and skarn Cu-Fe mineralization during post-Collisional orogenic. (3) Late Triassic - Cenozoic intracontinental evolution stage, mineralization is not obvious.

### 5 Conclusion

(1) From Late Carboniferous to Early Permian, porphyry - skarn type copper and gold deposits, hydrothermal type gold deposits and skarn type iron deposits are mainly deposits types in the Truong son metallogenic belt. Study on typical deposits of Sepon copper-gold deposit, Phu Kham copper-gold deposit and Phalek iron deposit have been carried out by the authors. These deposits are suggested to have formed in volcanic arc tectonic setting.

(2) From Late Permian to Early Triassic, the skarn type copper polymetallic deposits and skarn type iron deposits are the most important deposit types within the Truong son metallogenic belt. The tectonic setting is supposed to be post-collision. The typical deposits of Namueng copper polymetallic deposit and Thach Khe iron deposits have been summarized.

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