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Structural feature of some copper mines in Bien Dong - Quy Son strip of An Chau structural zone

Thu Thi Le ^{1,*}, Nhuan Van Do ², Long Kim Nguyen ³

¹ Faculty of Geology Geosciences and Geoen지니어ing, Hanoi University of Mining and Geology, Vietnam

² Faculty of Environment, Hanoi University of Mining and Geology, Vietnam

³ General Geology of Vietnam, Vietnam

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ABSTRACT

Previously, copper mines and mineral occurrences in Bien Dong Bac Giang were believed to be formed from lithogenesis in sandstone of Mau formation (T_3cms_3). Recent studies by authors have identified precisely mineral composition, as well as morphology of ore body. These research results evidenced copper ores in Bien Dong Bac Giang to form original hydrothermal.

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1. Introduction

In the 1960s of previous century, in geological literature, Bien Dong area was known copper mines and mineral occurrences form deposit origin "mix of sandstone and copper" (Nguyen Tri Vat et al., 1997). Until now, this terminology exists in curriculum, lectures at universities and research institutes (Tran Binh Chu, Dinh Huu Minh et al., 2013). The study area has been surveyed by French geologists from beginning of the 20th century. Former Vietnam, Soviet Union and China geologists continued to study from the 60s to the 90s of previous century (Tran Van Tri, Vu Khuc et al., 2009). Since 2016, the author group have carried out a detailed and thorough study, combining traditional and

modern analyses, especially isotope geochemistry, to determine the geological structure of the area, the structure of copper mines being exploited, as well as the composition, origin and conditions of ore formation. Collected results of the research, initially confirmed that copper ore in the Bien Dong area has original hydrothermal. However, original copper and polymetallic accompanied with magma or sediment is an open question.

2. General geology of the Bien Dong - Quy Son zone

The North - East structure map of Vietnam showed that the stretch of Bien Dong - Quy Son belonged to *Mesozoi An Chau basin*. The geological formations in the study area included Mau Son Foration (T_3cms_3), Van Lang Foration ($T_{3n} - rvl$), Ha Coi Foration ($J_1 - 2hc$), Ban Hang Foration (Kbh),

*Corresponding author

E-mail: nguyenanhtuan@humg.edu.vn

Na Dương Formation (N_1nd) and the sedimentary formations of the Quaternary system were not divided. Copper ore bodies in the study area were mainly distributed in sandstone - siltstone, clay - siltstone in third assise of the Mau Son formation.

The structural geology activities occurred strongly in Mesozoic and Kainozoic were the main causes that generated the various fault systems with different level and direction. There included the North West - South Eastern fault system; East North - South Western and submeridian.

3. Structure of copper deposits

On the area of Thanh Moi (Chi Lang, Ban To, Chu, An Chau), showed that copper mineralizations have large distribution on the area about 750 km² in Luc Ngan and Son Dong districts of Bac Giang province (Đoan Ky Thuy et al., 1976). Structure of some typical mines in the study area will be described as following

3.1. Structure of Dong Bua mine

Dong Bua copper mine is managed and exploited by joint - stock company of A Cuong Mineral Group. Rocks of the mine were shale, shale - limestone, lime - claystone, interbedded with limestone, limestone - clay, dolomitic limestone belong to sub - formation of Upper Mau Son (T_3cms_3). The rocks are mainly grayish green,

gray ash, dark gray; weathering brownish yellow, purple violet, brown violet, having structure from medium to thin layers, and sometime foliation. The mine located in the south - eastern flank of Dong Bua syncline with with dip angle 20° - 30°, the more closer faults then layers were the more dip angle. In the area as well as in the mine found many fault systems, mainly two fault systems Northwest - Southeast and Northeast - Southwest. In which the North West - South Eastern fault system played role of controlling the ore body and the North East - Southwestern fault system played role of destroying the ore body (Figure 1).

The ore bodies developed rupture crumple zone of fault the northwest - southeast direction, with the length about 800m, the width of 20 - 80m, ramp angle of the ore body from 45° to 50° (Figure 4). In rupture crumple zone they was bent complex (Figure 1), the attitude was almost steep, and sliding, sometimes where had reverse attitude. Mineral ores such as tenatite, bornite, chalcocite (Figure 2, Figure 3) disseminated in quartz chips, white calcite (Figure 2) or in dolomitized strip, quartzite, sometimes distribute, veins intruded along layers cleavage, slaty cleavage.

3.2. Structure of Khuon Muoi mine

Khuon Muoi copper ore is managed and operated by Joint - stock company of A Cuong

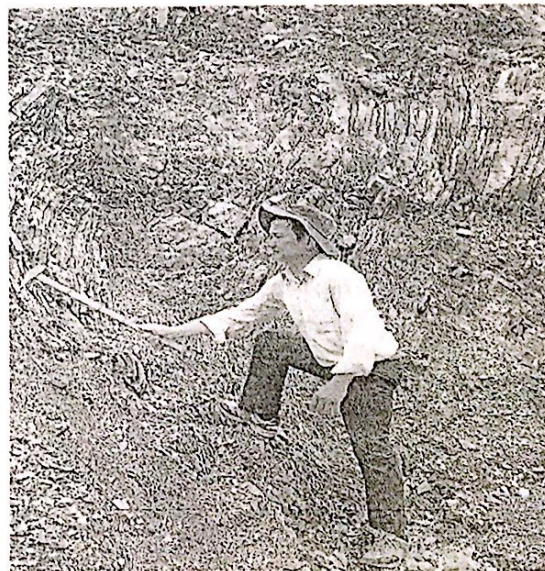


Figure 1. Fractured crumple zone containing Dong Bua copper mine. (Photo by Le Thi Thu).



Figure 2. Sulphides disseminated in broken quartz vein and in clay schist of Dong Bua copper mine.

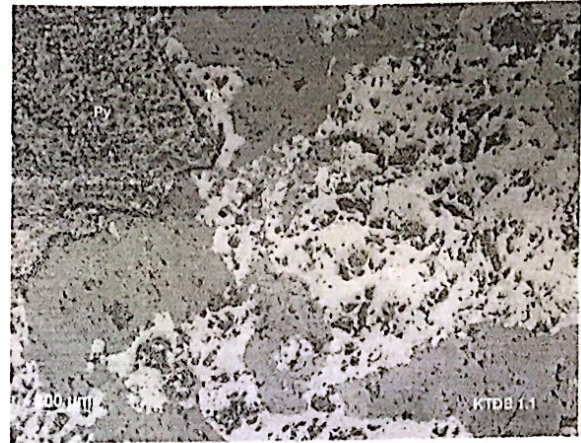


Figure 3. Tetraedite (Te), bornite(Bo) and pyrit (Py)) nest disseminated ores in host rocks of Dong Bua copper mine.

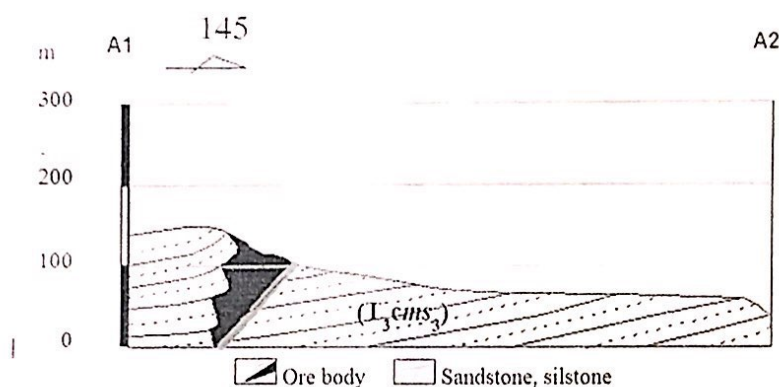


Figure 4. Schematic geological cross section according to open pit maining of Dong Bua copper mine..

Mineral Group. The rocks composed of the mine were mainly sandstone, siltstone, shale, shale - lime of Upper Mau Son horizon subsystem (T_3cms_3). The rocks were mainly gray, gray ash, dark gray, weathering was yellowish brown, purple pink, purple, having structure from medium to thin layers, sometimes foliation. The mine of the northwest flank of Khuon Muoi syncline with dip angle $20^\circ - 30^\circ$, the more closer faults then layers were the more dip angle. In the area as well as in the mine found many fault systems, there were mainly two fault systems northwest - southeast and northeastern southwest. Of which the North West - South East fault system played role of controlling the ore body and the North West - South East fault system played role of destroying the ore body.

The ore bodies developed rupture, crumple zone of fault northwest - southeast direction, with

the length about 700m, the width 10 - 70m, ramp angle of the main ore body from 75° to 80° (Figure 7). In rupture, crumple zone of stone was bent complex (Figure 5), the attitude was nearly escarpment, and having much more sliding. Mineral composition, included primary ore minerals tetraedite, bornite, chalcosine; secondary ore minerals malachite, azurite, covenlin (Figure 5, Figure 6). Copper Minerals disseminated in quartz chips, white calcite, sometimes distribute in veins intruded along layers cleavage, slaty cleavage. Particularly, the secondary copper minerals were deposited in sandstone and siltstone layers (Figure 5).

3.3. Structure of Goc Sau mine

Goc Sau copper mine was managed and exploited by Anh Phong joint - stock company.



Figure 5. Secondary copper minerals in siltstone smallgraine sandstone near to crumple 3 Kuon Muoi copper mine.



Figure 6. Tetraedite (Te), bornite(Bo) and chalcocine (Cc) nest disseminated ores in host rocks of Khuon Muoi copper mine.

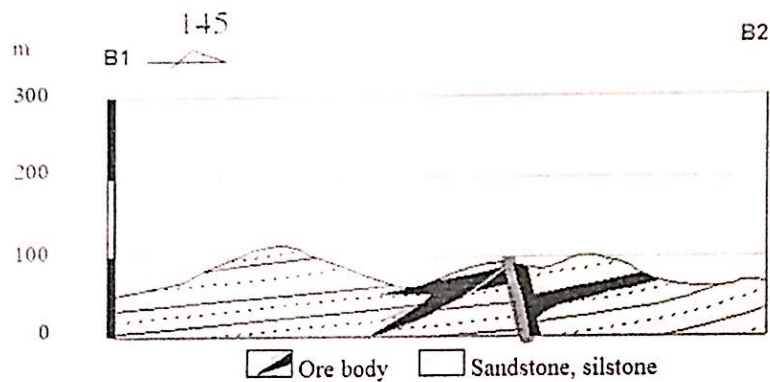


Figure 7. Schematic geological cross section according to open pit maining of Khuon Muoi copper mine by Nguyen Kim Long & LeThi Thu.

The rocks composed of the mine were shale, shale - limestone, lime - clay schist, interstratification of limestone layer, limestone - clay powder, dolomitic limestone, etc... belong to sub - formation of Mau Son upper (T_{3cms_3}). The rocks were mainly colours such as gray - green, gray ash, dark gray, dark gray, weathering yellowish brown, violet pink, violet brown, dark purple, medium to thin layer, sometimes foliation. The central mine of Giao Liem syncline, with two flanks of rip angle $30^\circ - 40^\circ$, the more closer faults then layers were the more dip angle. In the research area as well as in the mine developed many fault systems, mainly two fault systems northwest - southeastern and northeast - southwestern. In which the North West - South East fault system played role of controlling the ore

body and the North East - Southwestern fault system played role of destroying the ore body.

The ore bodies developed with crumpling zones, rupture of faults in the northwest - southeast direction, with the length of nearly 2000m, the width of 20 - 100m, dip angle of the ore body $85^\circ - 90^\circ$ (Figure 10). In the crumple zone, rumpure, stone layers were bent complex (Figure 8), attitude was almost escarpment, having much more sliding, sometimes where had reverse attitude. Ore minerals distribute in quartz chips, white calcite or in dolomitic, quartzitic zones; sometimes distribute, veins intruded along layers cleavage, slaty cleavage, fractures (Figure 9).

Other three mines presented above, the Bien Dong - Quy Son strip also contains tens of ore

occurrences and ore showing. Research results of all study area also found the same structure like these three mines.

4. Results and discussion

Copper mineral ores as well as morphology of the ore body in the study area was characterized of hydrothermal genesis. Shape of ore body was vein, vein net and layering. Mineral composition, structure texture of copper ore in Bien Dong - Quy Son stretch included primary ore minerals tetraedite, bornite, chalcocine, chalcopyrite and secondary ore minerals malachite, azurite, covelin, cuprit, etc. (Le Thi Thu, et al., 2018). The North - South - Western fault system in the depths plays a role in ore solution conduit, while its west upper part play a role in ore deposit, perhaps stones having fine particle size such as shale and shale - lime at the top as a barrier. The source supplies

material for mines and ore occurrence may be sedimentary, distributed in the terrigenous sediments of layer sub - system Mau Son (T_3cms_1).

5. Conclusion

Rocks involved in structure of copper mines of Quy Son - Bien Dong were mainly sandstone, siltstone, shale, shale - lime, slate - clay, intercalated with microgranular limestone, limestone - clay, dolomitic limestone, ect ... They were belong to sub - system of Mau Son upper (T_3cms_3). The ore bodies of vein, vein net, lenses, lobes were strictly controlled by the northwestern - southeastern fault system and the Northeast - Southwest fault system divided and destroyed. This conclusion combined with research results of mineral paragenesis assemblage, structure and texture of ore, isotopic geochemistry is more strongly support for genesis



Figure 8. Goc Sau open pit maining - crumbling ruptune zone (Photo by Do Van Nhuan).



Figure 9. Vein of chalcocine in shale lim (Photo by Do Van Nhuan).

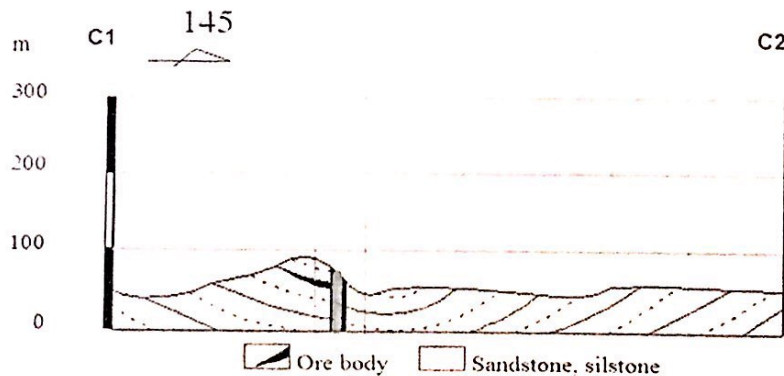


Figure 10. Schematic geological cross section according to open pit maining of Goc Sau copper mine by Nguyen Kim Long & Le Thi Thu.

of Bien Dong - Quy Son copper ore is hydrothermal. However, it is necessary to continue research on source providing primary material for formation ore to be magmatic sedimentary copper ores. The author group of the paper would like to thank director boards, experts and workers in Goc Sau, Khuon Muoi and Dong Bua mines, for their assistance in investigating, research and collecting samples.

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