

## Metallic mineralization and petrography of granitoids at the Phon Tiou - Boneng tin mining area, central Laos

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Recently demand and price of tin have been increasing because of development of lead-free solder alloy as a global industry standard. Indium tin oxide (ITO) is also known as a high technology material used for liquid crystal display and so on.

The Phon Tiou and Boneng deposits located in central Laos are medium-scale (>10,000 t Sn) residual and placer tin deposits with total reserves of 10,100 t and 11,600t Sn, respectively. The mining target is cassiterite (SnO<sub>2</sub>). Besides, there are several base metal and precious metal deposits and prospects in this area. Recently, Laotian, Thai, Chinese, Russian and North Korean companies are mining mainly tin and processing using shaking table method, in addition to small-scale miners. There are few studies that described metallic mineralization in this area. Objectives of this study are to elucidate petrographic and chemical characteristics of granitoids and metallic mineralization in the Phon Tiou - Boneng tin mining area, specially revealing a source rock of cassiterite, based on magnetic susceptibility, radioactivity, microscopic and EDS-SEM observation, bulk chemical compositions and sulfur isotopic compositions.

The Phon Tiou - Boneng tin mining area is located in Truong Son fold belt formed by Indosinian orogeny during Permian-Triassic period. Basement rock of the study area is Silurian-Devonian sandstone, mica schist and limestone. It is covered by Carboniferous and Jurassic sedimentary rocks, and Quaternary alluvial deposits. There are Triassic granitoids of the Say Phou Ngou and Phon Tiou complexess.

Magnetic susceptibility of the Say Phou Ngou and Phon Tiou granitoids complexes ranges from  $0.02 \times 10^{-3}$  to  $1.5 \times 10^{-3}$  SI and from  $0.02 \times 10^{-3}$  to  $0.15 \times 10^{-3}$  SI, respectively, indicating characteristics of almost ilmenite-series. The radio activity of granitoids ranges from 0.19 to  $0.34 \mu\text{S}$  and there is no distinct difference between the two complexes. Both the granitoids are composed mainly of quartz, K-feldspar, plagioclase, biotite of 300-700 $\mu\text{m}$  across and +/- zircon as primary minerals, showing equigranular texture. On the basis of the modal compositions, the Say Phou Ngou and Phon Tiou granitoid complexes are classified petrographically as syenogranite-monzogranite, and syenogranite, respectively. The granitoids of Say Phou Ngou complex (162-242 ppm Zr) contain relatively large amount of zircon included in biotite compared to those of the Phon Tiou complex (64-74 ppm Zr). The Phon Tiou complex (6-9 ppm Sn) is slightly enriched in tin compared to the Say Phou Ngou complex (2-3 ppm Sn).

Grain size of cassiterite contained in alluvial deposits and the concentrate after the table shaking separation ranges from 50 to 200 $\mu\text{m}$ . The SnO<sub>2</sub> concentrate is ca. 60 wt% and the concentrate contains magnetite, goethite, zircon (ca. 1,500 ppm Zr) and wolframite (ca. 450 ppm W). A sample of cassiterite-bearing alluvial deposits collected from a mining site contains ca. 1,000 ppm Sn and ca. 500 ppm Zr. The Sn content of a hard rock collected from the outcrop beside the mine is up to ca. 1,500 ppm, and we concluded that it is the source rock of cassiterite. The rock is composed mainly of equigranular quartz of 150-200 $\mu\text{m}$  across and their interstice is filled by goethite and cassiterite, implying that it is a hydrothermally altered and/or leached granitoid.

$\delta^{34}\text{S}_{\text{CDT}}$  of sulfides from sulfide veins in an outcrop and ores in a stockpile are negative suggesting that the sulfur was derived from biogenic sulfide of sedimentary rocks and/or from ilmenite-series granitoid magma into which biogenic sulfide of sedimentary rocks was incorporated.

Keywords: Laos, Phon Tiou - Boneng, residual and placer tin deposits, cassiterite, granitoids