タイ国チャットリー金鉱床Q探鉱地区の金鉱化作用

Ladda Tangwattananukul[1]、石山大三[1]、松葉谷　治[1]、

水田敏夫[2]、Punya Charusiri[3]、世良耕一郎[4]

[1]秋田大学大学院工学資源学研究科環境資源学研究センター
010-8502 秋田市手形学園町1-1

[2]秋田大学国際資源学教育研究センター
010-8502 秋田市手形学園町1-1

[3]チュラロンコン大学理学部地質学科
タイ国バンコック市

[4]岩手医科大学サイクロトロンセンター
020-0173 岩手県岩手郡滝沢村滝沢字留が森 348-58

要旨

チャットリー金鉱床は、低硫化型金鉱床として分類されている。Q探鉱地区の金鉱化作用は、安山岩質火山砕屑岩の中に鉱脈または網状鉱脈として存在する。金鉱化作用は、4つの鉱化段階に区別される。鉱化段階 I：貴金属・卑金属鉱化作用、極細粒の石英と少量の樹枝状黄鉄鉱、黄銅鉱、カリ長石、方解石；鉱化段階 II：不毛粗粒櫛歯状石英；鉱化段階 III：不毛中粒モザイク状石英と少量の黄鉄鉱；鉱化段階 IV：貴金属・卑金属鉱化作用（網状鉱脈）、フランボイヤント組織を示す細粒から粗粒石英と細粒黄鉄鉱、黄銅鉱。鉱化段階 IとIVは、急速成長を示す樹枝状とフランボイヤント組織、高いAu、K_2O、CaO含有量で特徴づけられる。これらの鉱物組織と鉱物組合せに基づくと、鉱化段階 IとIVは、沸騰による過飽和熱水溶液から形成されたと思われる。

Gold mineralization of Q prospect at Chatree deposit, central Thailand

Ladda Tangwattananukul[1], Diazo Ishiyama[1], Osamu Matsubaya[1],
Toshio Mizuta[2], Punya Charusiri[3] and Kouichiro Sera[4]

[1]Graduate School of Engineering and Resource Science, Center for Geo-Environmental Science,
Akita University, 1-1 Gakuen-Machi, Akita 010-8502, Japan

[2]International Center for Research and Education on Mineral and Energy Resource,
Akita University, 1-1 Gakuen-Machi, Akita 010-8502, Japan

[3]Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok Thailand

[4]Cyclotron Research Center, Iwate Medical University
348-58 Tomegamori, Takizawa, Iwate 020-0173, Japan

Abstract

The Chatree gold deposit is classified as a low sulfidation epithermal deposit. Gold mineralization at Q prospect occurs as veins and stockworks in andesitic volcanic-clastic and volcano-sedimentary rocks. Gold mineralization of the deposit is divided into four stages; Stage I: precious and base metal mineralization, microcrystalline quartz with minor dendritic pyrite, chalcopyrite, K-feldspar and calcite; Stage II: barren coarse-grained comb quartz; Stage III: barren medium-grained mosaic quartz with minor pyrite; Stage IV: precious and base metal mineralization (stockwork), fine to coarse-grained quartz showing flamboyant texture, K-feldspar, calcite, fine-grained pyrite and chalcopyrite. Stages I and IV are characterized by dendritic and flamboyant textures suggesting rapid crystal growth, higher gold, K_2O and CaO contents. Stages I and IV are thought to be formed under highly supersaturated hydrothermal solutions caused by boiling based on the texture and mineral assemblage of ores.

1 Introduction

The Chatree deposit is located about 300km north of Bangkok (Fig. 1). The deposit is in the central part of the Loei-Phechabun-Nakhon Nayok Permo-Triassic volcanic belt (LPN). This belt extends from western Lao along the western edge of Khorat plateau to the Cambodian central plain (Bunopas and Vella, 1983, 1992; Charusiri et al., 2002). The Chatree gold deposit consists of several prospect areas. The deposit has an estimated total gold production of about 5 million ounces and 35 million ounces of silver, with an average ore grade 1.07 g/t of gold and 7.5 g/t of silver (personal communication). Gold occurs in quartz-carbonate-sulfide veins and stockworks in a sequence of volcanic rocks (Jame and Cumming, 2007; Salam et al., 2006).

The Hishikari epithermal Au-Ag deposit is located in Japan. It is one of the richest gold veins in the world. Gold reserves are estimated to be 150 metric tons at an average grade of 80 g/t with ore produced at a rate of 350~400 metric ton/day (Ibaraki et al., 1991). The veins in Hishikari deposit are mainly quartz, adularia and smectite showing banded structure. In comparison with Q prospect at the Chatree and the Hishikari deposit, the characteristics of width of veins, ore grade and mineral assemblage of Q prospect are different from those of typical epithermal quartz veins such as the Hishikari deposit.

The aim of this study is to clarify confirm that the gold mineralization of Q prospect is epithermal-type mineralization based on data of textures of quartz and chemical compositions of ores.

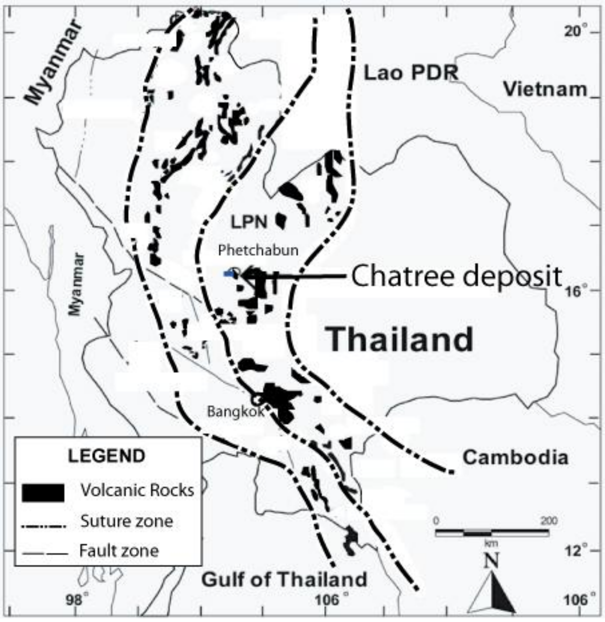

Fig. 1 Map showing the location of the Chatree deposit in Loei-Phetchabun-NakhonNayok Volcanic belt (LPN) (partly modified from Charusiri et al., 2002: Cumming et al., 2007).

2 Outline of geology and ore deposit

Geology of the Chatree deposit is composed of oceanic and continental arc complexes that developed before and during the suturing of the Shan-Thai and Indochina Terranes (Charusiri et al., 2002). The geology of LPN volcanic belt including of the Chatree deposit is composed of conglomerate, sandstone, shale and limestone dominate the district-scale geology of thick Carboniferous to Early Permian sedimentary sequences. The Chatree deposit occurs in coherent andesitic to rhyolitic lavas, which is overlain by fine-grained volcaniclastics, epiclastic siltstone and mudstone (Fig. 2) (Corbett, 2006; Cumming et al., 2008). Alteration in the regional scale is associated with volcanic centers and major NE-SW fault systems (Corbett, 2006: Crossing, 2006). Alteration of southern part of the Chatree deposit is propylitic alteration (chlorite±epidote-calcite-pyrite), while alteration of northern part of the deposit is argillic and phyllic alteration (sericite-illite-quartz-pyrite) (Cumming, 2006).

The radiometric age of gold mineralization of the Chatree deposit is estimated to be 250.9 ± 0.8 Ma. The age is close to the emplacement of the andesitic volcanics (Early Triassic) (Zaw et al., 2007; Salam et al., 2007 and 2008). Granodiorite intruded in the southern part of the Chatree deposit. An age of granodiorite is estimated to be 244 Ma suggesting the age of post mineralization in the area (Zaw et al, 2007; Salam et al, 2007 and 2008). Dikes are cutting all of rock units.

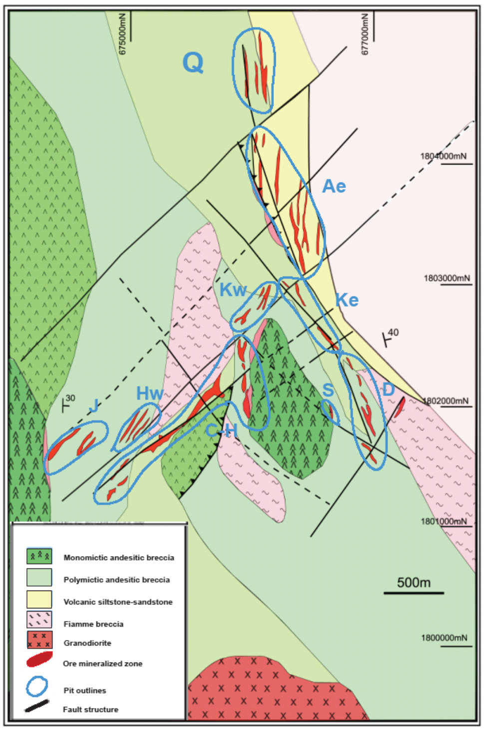

Fig. 2 Geologic map of the Chatree deposit (partly modified from Salam et al., 2004).

3 Vein characteristic and Petrography

The area studied in Q prospect is one of the major prospects of the Chatree deposit (Fig. 2). There are many veins at Q prospect. The veins are orientated along NW-SE, NE-SW and N-S direction with moderate to steeply dipping. Veins mineralized also occur between strata consisting of volcanic-sedimentary and andesitic volcanic-clastic rocks. Gold occurs in veins and stockworks with minor amount breccia of the andesite volcanic-clastics and volcanic-sedimentary rocks. Gold-bearing veins are composed of mainly quartz, adularia, chlorite, carbonate and sulfide minerals.

Mineralization stages at Q prospect were examined on the basis of cross-cutting relationships of veins (Fig. 3). The stages are divided into four stages:

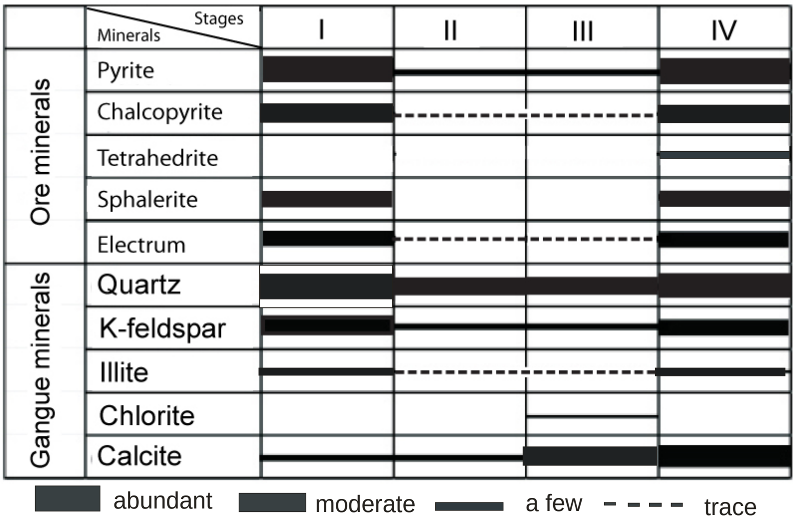

Fig. 3 Paragenetic sequence ore and gangue minerals of Q prospect at the Chatree deposit.

Stage I: light-dark grey quartz veins, veinlets and breccias containing precious and base metal mineralization. The constituent minerals are a large amount of microcrystalline quartz with small amounts of pyrite (dendritic pyrite), chalcopyrite, K-feldspar and calcite.

Stage II: a large amount of barren coarse-grained comb quartz with a small amount of coarse-grained pyrite.

Stage III: a large amount of barren medium–grained mosaic quartz with small amounts of pyrite and chlorite.

Stage IV: Ores of stage IV shows network structure composed of mainly quartz and calcite. The stage IV is characterized by a precious and base metal mineralization. The constituent minerals are fine to coarse-grained quartz with small amounts of K-feldspar and calcite. Clasts of stages I (dark grey quartz), II and III are included in network as breccias.

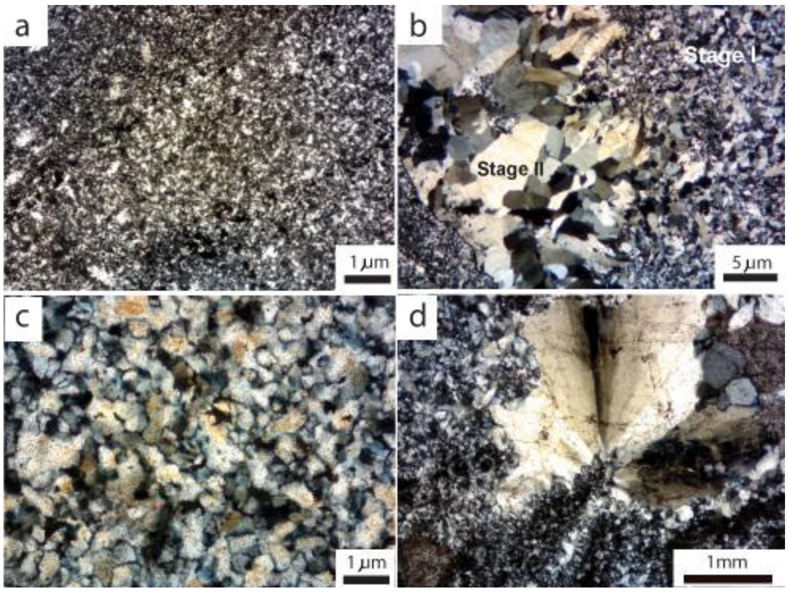

Fig. 4 Photomicrographs (crossed nicols) showing quartz texture from stages I to IV. a: Microcrystalline quartz in stage I. **b:** Comb quartz (stage II) cutting fine- grained quartz (stage I). **c:** Mosaic texture of medium-grained quartz. **d:** Flamboyant texture of quartz in stage IV.

Gain size of quartz from stages I to III changes from fine-grained to coarse-grained according to progress of mineralization stages (Fig. 4). Stage I is also composed of a large amount of fine-grained pyrite. Quartz in stages II and III is medium to coarse-grained quartz crystals. Stage IV consists of quartz fine-grained to coarse-grained with large amount of pyrite, chalcopyrite and sphalerite. Electrum is abundant in aggregates of fine-grained quartz and inclusion in pyrite in stages I and IV.

4 Geochemistry

Twenty-six samples were analyzed by PIXE at NMCC and ICP-MS at Akita University to clarify geochemical characteristics of gold mineralization of Q prospect. The chemical contents of K_2O, CaO, Au, Cu and Zn components are shown in Table 1. The variations of Au, K_2O and CaO contents accord with the variations of abundance of electrum (Au, Ag), adularia ($KAl_3Si_3O_8$) and calcite ($CaCO_3$) (Fig 5). The fact that the positive correlated among Au, K_2O and CaO contents suggests that electrum precipitated with adularia and calcite. Fine-grained quartz in stages I and IV also has high Au content. Some samples in Stage I contain electrum and dendritic pyrite. The mineral assemblage and texture suggest precipitation of ore minerals from supersaturated hydrothermal solution. Based on the presence of brecciated structure and flamboyant texture in quartz network veins of stage IV and the possibility that the flamboyant texture was formed by boiling of hydrothermal solution (Dong et al., 1995), precipitation of gold in quartz veins of Q prospect thought to be caused by boiling. These characteristics are similar to those of typical epithermal gold-bearing quartz veins such as the Hishikari deposit. The gold mineralization of Q prospect is thought to be one of style of epithermal gold mineralization.

Table 1 Chemical compositions of gold-bearing quartz from stages I to IV by PIXE and ICP-MS analyses.

ppm	Vg-1eu	Vg-1ed	Vg-1Lg	Vg-1IIw	Qgs-3II	Q-III	Hbx-2IV	Hbx-3IV
Au*	1.0	1.9	2.4	1.9	0.6	0.5	0.6	1.5
Cu*	35.6	26.3	29.6	11.9	11.0	20.4	6.9	23.7
Zn*	11.1	23.8	190.9	68.9	29.1	15.4	11.2	30.0
K_2O**	8930	4360	19100	6020	474	74.0	183	18300
CaO**	2710	168	11500	18000	2302	204	916	48300

*: ICP-MS **: PIXE

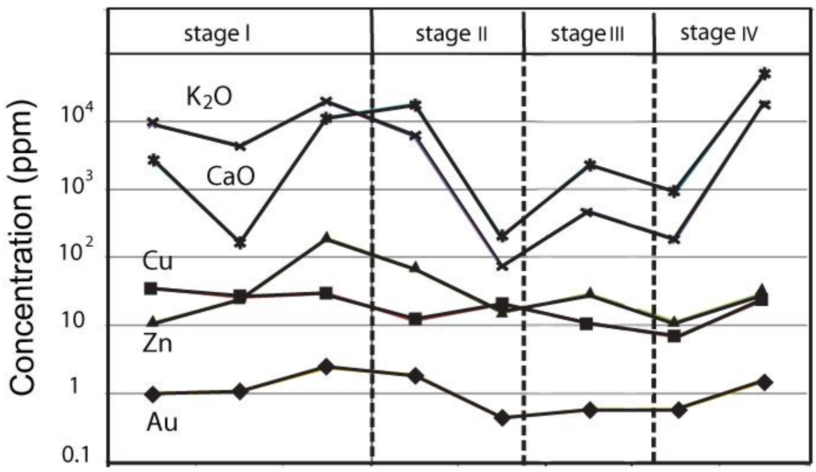

Fig. 5 Diagram showing variations of K_2O, CaO, Cu, Zn and Au contents from stages I to IV.

5 Conclusions

Gold-bearing quartz veins in Q prospect of the Chatree deposit are divided in to four stages. The gold-bearing quartz veins are composed mainly of quartz, adularia, chlorite, calcite and sulfide minerals. The grain size of quartz changes from fine to coarse-grained crystals according to progress of mineralization stages. Stages I and IV are composed of mainly fine-grained quartz with a large amount of fine-grained pyrite. In the Q prospect, quartz-adularia-calcite may be precipitated with gold in the stage I and IV. K_2O and CaO contents of gold-bearing veins also show a weak positive correlation with Au, Cu, Zn in stages I and IV. Gold mineralization of Q prospect at the Chatree deposit is one of epithermal-type mineralization and the gold mineralization could be caused by boiling.

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