Geochemistry, Ore Characteristics and Origin of Gold and Base Metal Mineralization in Skarn Zone at Shwe Min Bon, Southern Shan State, Myanmar

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(ミャンマー. シャン地方南部シューミンボン地域におけるスカルン鉱床の金および銅鉱化作用)

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論　文　内　容　の　要　旨

Skarn deposits are primarily associated with intrusive rocks emplaced into or near carbonate rocks formed in magmatic arcs related to subduction. Skarn-type Cu-Au deposit at Shwe Min Bon is one of the primary gold deposits among around 300 gold occurrences in Myanmar. It is necessary to understand the formation environments and type of skarn deposit at Shwe Min Bon in order to establish a genetic model that can be applied to further exploration of skarn deposit in the similar geologic setting of other areas in Myanmar. At Shwe Min Bon, the Cu-Au mineralization occurred along the contact between the Nwabangyi Dolomite and Shweminbon Formation and the Cretaceous dioritic rocks. This study focused on the genetic characterization of skarn and ores at Shwe Min Bon. In addition to the skarn and ore mineral assemblages, fluid inclusion microthermometry was carried out to understand the evolution of hydrothermal system in both space and time. The whole-rock geochemistry of intrusive rocks which were related to the skarn deposits were analyzed in order to understand the formation environment of skarn deposit. This dissertation consists of seven chapters and the main contents in each chapter are as follows:

Chapter I introduced the research background, description of the study area, problem statement and objectives of this study. The methodology and procedure of analyses are described. The backgrounds on skarn deposit are also described.

Chapter II described the geologic setting, stratigraphy and lithologies of the Shwe Min Bon area. This literature review focused on the stratigraphy and geological structure of the research area.

Chapter III demonstrated on the geology, petrography and geochemistry of the host rocks in Shwe Min Bon. The host rock consists of diorite, granodiorite and siltstone, sandstone and marble of Shweminbon Formation. The dioritic rocks belong to the calc-alkaline series and indicate meta-aluminous characters.

Chapter IV described the occurrence of skarn at the contact between intrusive rocks and marble suggesting that both exoskarn and endoskarn were developed in the Shwe Min Bon area. In the Shwe Min Bon deposit, seven orebodies are mined. Among them, Bwet Taung, Tiger Mouth, Shwe Taung Gyar and Lunhtoe orebodies are the main mineralized zones. Based on field observation, the Bwet Taung, Zin Yaw, Tiger Mouth and Shwe Gu Lay orebodies are classified as proximal skarns. The Shwe Taung Gyar and Lun Htoe orebodies are identified as distal skarns. Moreover, a hydrothermally altered zone occurs in the Bwet Taung and Tiger Mouth orebodies where igneous rocks intruded into the clastic rock of the Shweminbon Formation. From north to south, skarn is zoned from intrusive rocks in the sequence: garnet, pyroxenoid to marble. Three skarn stages were

recognized: prograde skarn (pre-ore stage), retrograde skarn and Cu-Fe-As-Bi sulfides mineralization (retrograde I) and Bi-Te mineralization associated with calcite (retrograde II) in brecciated marble. In addition, supergene stage marked by secondary Cu mineralization (malachite and azurite) is closely associated with oxidized zone. The prograde and retrograde alteration extensively occurred in exoskarn zone. Silicification also occurred on the Shweminbon Formation in the shear zone.

Chapter V characterized the condition of ore mineralization and skarn formation in the Shwe Min Bon deposit. The ore minerals include native gold, chalcopyrite, bornite, chalcocite, tennantite, sphalerite, galena, magnetite, hematite with minor enargite and cosalite. In the present study, Bi-bearing minerals such as tellurobismuthite, bismuthinite, emplectite, wittichenite, hedleyite and cosalite were identified. Gold mineralization was mainly associated with chalcopyrite and tennantite in the retrograde stage I and with tellurobismuthinite in the retrograde stage II. The temperature and salinity of fluid associated with the prograde skarn formation were high temperature (314-492°C) and hypersaline (up to 46.4 wt. % NaCl equiv.). The Cu-Au mineralization mainly occurred in the retrograde stage I, characterized by moderate temperatures (260-320°C) with a moderate salinity 5.0-6.0 % NaCl equiv. Retrograde stage II was formed at low temperature (180-200°C) and a low salinity 2.0-3.0% NaCl equiv. The gold mineralization at Shwe Min Bon appears to have occurred at lower temperatures later than the prograde skarn minerals and mostly confined to the retrograde stage.

Chapter VI discussed the classification of the type of the Shwe Min Bon skarn deposit and the geologic setting where the Shwe Min Bon deposit was formed. The skarn deposit at Shwe Min Bon was classified as oxidized Cu skarn based on the occurrence of hematite and magnetite, in addition to the andradite-rich compositions of the garnet. Meta-aluminous composition of dioritic rocks of I-type affinity suggests that those dioritic magmas were formed by partial melting of igneous protoliths. The dioritic rocks of calc-alkaline character were generated in a volcanic arc setting.

Chapter VII summarized the results of the research and concluded that the skarn deposit at Shwe Min Bon is characterized by the oxidized skarn-type Bi-bearing Cu-Au deposit formed at a magmatic arc in subduction setting.