CHARACTERIZATION OF ARCHEAN GOLD MINERALIZATION AT THE TATI GREENSTONE BELT, NORTHEASTERN BOTSWANA

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論 文 名　：CHARACTERIZATION OF ARCHEAN GOLD MINERALIZATION AT THE TATI GREENSTONE BELT, NORTHEASTERN, BOTSWANA
（ボツワナ北東部、タティ・グリーンストーン帯における始生代の金鉱化作用の特徴に関する研究）

区　　分　：甲

論　文　内　容　の　要　旨

Greenstone belts have contributed a significant amount of gold worldwide, mainly from Canada, Australia, Southern Africa, Brazil, and India. While the origin of these deposits has been debated since the 1970s, the genesis is not fully understood yet because of post-depositional deformation, metamorphism and lack of modern referents for comparative studies. The Tati Greenstone Belt located in the northeastern part of Botswana in the southern margin of the well-known Zimbabwe Craton is a host to a number of Archean gold deposits such as Mupane deposits, Signal Hill, Golden Eagle, Map Nora, Monarch, and many other small gold deposits and there is still potential for the discovery of similar ores around the belt. The reason to choose the Tati Greenstone Belt for this study was there is limited information on the genesis and evolution of gold deposits within the belt which can be helpful for exploration companies. This study will characterize selected gold deposits occurring within the Tati Greenstone Belt to develop a genesis model which can be used for the discovery of similar ores. The results will also be compared with other Archean gold deposits around the world occurring in greenstone belts to identify the unique points of gold deposits occurring within the Tati Greenstone Belt. Previous research on the Tati Greenstone Belt documented the general geology of the area based on fieldwork, petrological studies, and structural information. Therefore, the genesis and evolution of gold mineralization in the area are poorly understood and insufficiently documented in peer-reviewed work. The proposed study will integrate petrology, geochemistry including laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and sulfur isotope, and fluid inclusion studies of the mineralized and host rocks to understand the nature, evolution, and mode of occurrence of gold deposits within the Tati Greenstone Belt.

Chapter 1 introduces the history of the Tati Greenstone Belt and a literature review on the contributions of previous studies on gold deposits within the Tati Greenstone Belt, justifies the research, and mentions the aims and objectives of the study.

Chapter 2 gives an overview of the geological and tectonic setting of the Tati Greenstone Belt. The Tati Greenstone Belt forms part of the Francistown Granite-Greenstone Complex located in the southern extremity of the Zimbabwe Craton in northeastern Botswana and separated from the Kaapvaal Craton by the Limpopo Mobile Belt. The Tati Greenstone Belt is approximately 65 km long and 20 km wide and consists of a group of Archean metasedimentary, metavolcanic, and intrusive rocks. The belt deposited at ~2.7 Ga, underwent low to medium-grade

metamorphism from 2630±70 Ma to 2570±70 Ma, and was intruded by granitoids of tonalitic composition and late Karoo dolerite dykes.

Chapter 3 describes the mineralogical and isotopic characteristics of gold mineralization at the Tau deposit of the Mupane mine, one of the gold deposits in the Tati Greenstone Belt. The study explains the genesis of the Tau deposit based on ore petrography, mineral chemistry of sulfides, and sulfur isotope data. Mineralogical characteristics of the host rocks indicate that banded iron formation at the Tau deposit includes iron oxides (magnetite), carbonates (siderite and ankerite), silicates (chlorite and amphibole), and sulfides (arsenopyrite and pyrrhotite). The deposit features arsenopyrite-rich zones associated with biotite-chlorite veins, which are indicative of the precipitation of arsenopyrite associated with potassic alteration. The replacement of magnetite by pyrrhotite in some samples suggests that sulfidation was likely to be the dominant gold precipitation mechanism because it is considered to have destabilized gold-thiocomplexes in the ore-forming fluids. Based on textural relationships and chemical composition, arsenopyrite is interpreted to reflect two generations. Arsenopyrite 1 is possibly early in origin, sieve textured with abundant inclusions of pyrrhotite. Arsenopyrite 1 was then overgrown by late arsenopyrite 2 with no porous textures and rare inclusions of pyrrhotite. The mineralogical assemblages, textures and mineral chemistry data at the Tau gold deposit revealed two-stage gold mineralization commencing with the deposition of invisible gold in arsenopyrite 1 followed by the later formation of native gold during hydrothermal alteration and post-depositional recrystallization of arsenopyrite 1. LA-ICP-MS analysis of arsenopyrite from the Tau deposit revealed that the hydrothermal event responsible for the formation of late native gold also affected the distribution of other trace elements within the grains as evidenced by varying trace elements contents in arsenopyrite 1 and arsenopyrite 2. The range of $\delta^{34}S$ of gold-bearing assemblages from the Tau deposit is restricted from +1.6 ‰ to + 3.9 ‰, which is typical of Archean orogenic gold deposits and indicates that overall reduced hydrothermal conditions prevailed during the gold mineralization process at the Tau deposit.

Chapter 4 investigates the nature and formation conditions of gold mineralization at the Tau deposit, Mupane mine, Tati Greenstone Belt. Evidence from fluid inclusions and arsenopyrite geothermometer was employed to understand the formation conditions associated with gold mineralization at the Tau deposit. The results indicated that the first stage and second stages of gold mineralization and the associated alteration at the Tau deposit occurred at pressure and temperature conditions of 75 - 145 MPa and 290 - 370 °C and 85 - 160 MPa and 330 - 370 °C, respectively. These observations suggest an increase in temperature from the first stage to the second stage of mineralization, resulting in the recrystallization of invisible gold-bearing arsenopyrite in the first stage to form native gold-bearing arsenopyrite in the second stage.

Chapter 5 describes the genesis of gold mineralization at the Martial Lode deposit, Golden Eagle mine located within the Tati Greenstone Belt. The chapter reports the hydrothermal alteration patterns associated with gold mineralization based on mineralogical and geochemical signatures. The results from this chapter indicate that the circulation of hydrothermal fluids caused distinct fluid-rock interactions characterized by sulfidation reactions associated with arsenopyrite and gold mineralization at higher temperatures suggested by arsenopyrite geothermometer and later overprinting of biotite by chlorite during cooling at the Martial Lode deposit.

Chapter 6 gives the conclusions from the discussion and interpretations of the previous chapters. The results from the studied deposits enabled us to propose a genetic model of gold deposits within the Tati Greenstone Belt which involves infiltration of gold-bearing hydrothermal fluids post-deformation which reacted with Fe-rich host rocks leading to the precipitation of sulfides associated with gold mineralization.