GOLD METALLOGENY OF THE MOZAMBIQUE BELT IN NORTHEASTERN MOZAMBIQUE

マニュエル, アウグスト, マニュエル, ノペイア

（様式２）

氏　　名　：マニュエル アウグスト マニュエル ノペイア
Manuel Augusto Manuel Nopeia

論文題名　：　GOLD METALLOGENY OF THE MOZAMBIQUE BELT IN NORTHEASTERN MOZAMBIQUE
（モザンビーク国北東部、モザンビーク帯の金鉱床メタロジェニー）

区　　分　：　甲

論　文　内　容　の　要　旨

The northeastern Mozambique terrane comprises medium- to high-grade metamorphic complexes of Mozambique Belt, which have been linked with several occurrences of gold, base metals, gemstones, and graphite. The geological characteristics and metallogenesis of most of these occurrences are little known due to lack of studies. At a time when greenfield discoveries are becoming scarcer, detailed study of less investigated terranes such as the northeastern Mozambique is fundamental to discover new gold deposits and to understand their formation mechanisms. This study aims to provide an exhaustive description of the mode of occurrence, geological and geochemical characteristics, and age of gold mineralization, and to establish a well-grounded metallogenic model for gold mineralization in the region.

Chapter 1 introduces the research background, the rationale and objectives of the study, and revisits the history and development of geological exploration in the northeastern Mozambique.

Chapter 2 presents the geological and tectonic settings of northeastern Mozambique. The northeastern Mozambique terrane lies within the Mozambique Belt. The Mozambique Belt is a nearly N-S tectonic domain which extends from the Arabian-Nubian Shield into Ethiopia, up to Mozambique to the south, formed during the East African Orogen (EAO). The EAO resulted from amalgamation of the Arabian-Nubian Shield region and oblique continent-continental collision between eastern Africa (Kenya-Tanzania) and a collage of continental blocks including Madagascar, Sri Lanka, Seychelles, India and East Antarctica, between *ca.* 750 and *ca.* 620 Ma. The Mozambique Belt was formed in the last stage of the EAO, known as the Pan-African Orogeny. The northeastern Mozambique terrane is underlain by medium- to high-grade metamorphic complexes, ranging from Paleoproterozoic to Neoproterozoic in age. Gold mineralization in the study area is hosted by the Neoproterozoic Xixano Complex composed of amphibolite and paragneiss, which is a part of the Cabo Delgado Nappe Complex (CDNC) thrusted over the Mesoproterozoic basement.

Chapter 3 re-evaluates the geochemistry and metamorphism of amphibolite and paragneiss of the Xixano Metamorphic Complex, which host the gold mineralization in the region. The whole-rock major and trace elements geochemistry showed that the protolith of amphibolite was magmatic in origin, mainly of tholeiitic basalt in composition, while the quartz-feldspar gneiss (and schist) resulted from regional metamorphism of greywacke and litharenite. The amphibolite in the study area, although hosting mineralized quartz veins, did not experience significant hydrothermal alteration. Based on mineral paragenesis and amphibole-plagioclase geothermobarometry, the amphibolite and metasedimentary rocks of the Xixano Complex experienced amphibolite facies metamorphism. Temperature and

pressure (T-P) conditions of peak metamorphism of the amphibolite varied from 696 to 777 °C, and 595 to 714 MPa, respectively.

Chapter 4 investigates the geological and geochemical characteristics of gold mineralization in the Nanlia and Makorongo prospects located in the southeastern part of the Xixano Complex. The gold mineralization in the Nanlia and Makorongo prospects occurs as nearly E-W-trending quartz veins hosted parallel to subparallel to the foliation of amphibolite. The ore mineralogy consists of pyrite, pyrrhotite, chalcopyrite, magnetite, galena, and sphalerite, with minor tellurides, xilingolite, and gold-silver alloy. The T-P conditions of ore-formation were estimated from intersecting isochores of coeval carbonic and aqueous fluid inclusions and sphalerite geobarometry at 420 – 620 °C and 160 – 280 MPa, and 330 – 440 °C and 150 – 200 MPa in the Nanlia and Makorongo prospects, respectively. Gold mineralization in these prospects postdated the peak metamorphism of the host rocks. The mineralization resulted from fluid unmixing at estimated depths of 6.0 – 10.6 km and 4.7 – 7.6 km in the Nanlia and Makorongo prospects, respectively.

Chapter 5 presents the geological and geochemical characteristics of gold mineralization in the Namicupo prospect located in the southwestern part of the Xixano Complex. Gold mineralization in the Namicupo prospect is present as quartz veins emplaced parallel to the foliation of quartz-feldspar paragneiss. The mineralization occurred in two stages. The first stage primary mineralization consists of Au-rich gold-silver alloy associated with pyrite and chalcopyrite. The second stage supergene mineralization consists of Ag-rich gold-silver alloy intergrown with goethite, barite, and minium. Primary quartz from the mineralized veins at Namicupo hosts three types of fluid inclusions that coexist in the same crystal: Type A aqueous-carbonic inclusions, Type B carbonic inclusions and Type C aqueous inclusions. The oxygen isotopic ratios ($\delta^{18}O_{SMOW}$) of water calculated from those of primary quartz, and sulfur isotopic ratios ($\delta^{34}S_{CDT}$) of primary sulfides vary from -1.0 to +2.5 ‰ and -3.5 to +0.9 ‰, respectively. Based on isochore intersection of coeval carbonic and aqueous inclusions, primary gold mineralization in the Namicupo prospect was formed at an approximate average T-P conditions of 375 °C and 175 MPa. The supergene mineralization was caused by oxidation of primary gold-bearing sulfides and gold-silver alloy under moderately acidic and oxidizing conditions, which resulted in liberation of gold and silver and associated chemical mobilization by thiosulfate.

Chapter 6 discusses the Re-Os dating of sulfides associated with gold mineralization in the Nanlia and Makorongo prospects. Two pyrite separates, one from Nanlia and another from Makorongo, and one pyrrhotite separate from Makorongo were analyzed. The Re-Os ages for pyrite were estimated by assuming an initial $^{187}Os/^{188}Os$ of 0.12 (mantle value) and calculating ages at 560 Ma (Nanlia) and 580 Ma (Makorongo). A highly radiogenic pyrrhotite separate yielded an age of 562 Ma. These ages are younger than the previously reported peak metamorphism age of the amphibolite host rocks but coeval with that of the peak metamorphism of the underlying Marrupa Complex.

Chapter 7 summarizes the main findings and achievements of the study. The gold mineralization in the Xixano Complex of Mozambique Belt is classified as orogenic-type gold, which resulted from devolatilization of the underlying basement rocks during prograde metamorphism triggered by intracontinental thrusting of the CDNC between 580 and 560 Ma, during the late stages of the Gondwana assembly. The auriferous metamorphic fluids ascended through the Pan-African thrust faults to the overlying Xixano Complex, which was already undergoing retrograde metamorphism and gold was deposited therein. Uplift of northeastern Mozambique terrane exposed the primary mineralization in the Namicupo prospect to a supergene alteration that contributed to the enrichment of gold in the region.