TECTONIC SETTING AND MINERALIZATION AT GABAL ABU HOUDEID AREA, SOUTH EASTERN DESERT, EGYPT.

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Abstract

Egypt is a part of the highly complicated orogenic belt of East Africa, which comprises the Arabian-Nubian Shield (ANS) in the north and the Mozambique belt in the south. This complex tectonic situation led to the formation of several mineral deposits related to the Pan-African orogenic cycle. The Gabal Abu Houdeid (GAH) area is located at the southern part of the Eastern Desert of Egypt, at the boundaries between Egypt and Sudan. It is considered as the extreme north part of Hamisana shear zone. The Hamisana shear zone is one of the major high strain zones of the Pan-African (Neoproterozoic) ANS. This research reports the inter-relationship between mineralization (base-metal sulfide and invisible gold) and tectonic setting in GAH area, SE Egypt. In order to document this relationship a comprehensive study includes, integrated remote sensing and GIS, field relations, petrographical, geochemical, structural and tectonic studies were conducted at the GAH area.

This thesis consists of seven chapters that discuss the different aspects of the research. Chapter 1 introduces the research background and significance of this study, presents the study area within the ANS tectonic context, and describes the methodology used during this study.

Chapter 2 discusses the multispectral remote sensing (Landsat ETM+ and ASTER) image enhancement and interpretation were implemented to determine, extract, and delineate of different litho-tectonic rock units, and their related structures in the study area. The integrated image transformation methods include Principal Component Analysis (PCA), Band Ratioing (BR), and False Color Composites (FCC) on selective bands of the ETM+ and ASTER data, have been found to be scene-dependent, and complementing each other for identification of lithology and structural features in different scales through the GAH area.

Chapter 3 describes the geological characteristics of each rock unit cropping out in GAH area on bases of the remotely sensed data, the field relations and the petrographic studies. These reveal that the Neoproterozoic basement rocks expose in the GAH area comprise three main litho-tectonic rock units; mafic–ultramafic dismembered ophiolitic rocks, island arc-related metasediment-metavolcanic rocks, and syn- and post-tectonic intrusive rocks. The syn-post tectonic intrusives including granodiorite, gabbro, muscovite granite and alkali feldspar granites.

Chapter 4 discusses the structural setting of GAH area through ductile and brittle deformational analysis. This reveals four deformational events, are distinguished in the Neoproterozic rocks. Event D1 a pure compression stress regime with σ 1stress axis trending NNW-SSE to N–S represents an early shortening event associated with the Pan-African thrusting, during which intra-oceanic arcs and plateaus were accreted. Event D2 characterized by structures developed under ENE-WSW compressional regime (shortening event), and considered as the early stage of the second episode of collision within the Pan-African orogeny. Event D3 transpressional deformation associated with E-W contraction and N-S extension. It is the main event that controlled the deformation along the Hamisana Shear Zone during the late stages of the collision between the East and West Gondwana in terms of escape tectonics. The D4 event is interpreted as a post-orogenic extensional event manifested by E-W dextral strike-slip and dip-slip normal faults striking NNW-SSE to N-S and E-W, which began to occur after the emplacement of post-tectonic granites.

Chapter 5 examines geochemical characteristics of each rock unit cropping out in GAH area in order to reconstruct or deduce the tectonic environment in which these rock unites were formed. The

GAH ophiolites are reflect cumulate and non-cumulus, enriched mantle with depleted-K and enriched-Ti mantle source, and related to a back-arc setting oceanic tholeiite geochemistry. The island-arc related biotite schist and quartzites are show geochemical characteristics of back arc sediments originate from a blended felsic-mafic source. The metavolcanics geochemically show basaltic composition are derived from alkaline to sub-alkaline magma in arc and/or back arc settings. The magmatic activities in the GAH area basement complex is represented by an early syn-tectonic I-type granitoids mainly granodiorites, and post-tectonic gabbros and muscovite-alkali feldspar granites. The post-tectonic intrusive rocks wither gabbros or younger granites both shown within-plate tectonic signatures.

Chapter 6 discusses the geological and mineralogical characteristics of the mineralized areas of GAH based on the investigation of the geology, ore minerals, and structural analysis in order to clarify the condition of mineralization and the inter-relationship between tectonic setting and the mineralization in the study area from the deformational phases point of view. The GAH base-metal sulfide and invisible gold mineralization are restricted to quartzites, which is considered as member of island arc-related metasediments. These quartzite bands are closely situated in a map-scale, NNW-SSE to N-S striking brittle-ductile shear zone, in the uppermost part of the Hamisana Shear Zone. The base-metal sulfide mineralization are represented by two phases; an early mineralization phase includes pyrite, pyrrhotite, argentite and invisible gold, whilst the late phase, dominated by pyrite, galena, sphalerite, chalcopyrite, ± invisible gold and covelite. The gold associated with base-metal sulfide minerals in GAH area mostly occurs as invisible gold or submicrometer-size inclusions in pyrite. The early pyrite phase revealed the presence of trace amounts of Au (up to 8.3 ppm), which is higher than the late stage pyrite (up to 1.5 ppm). Structural controls on the GAH mineralization has been documented at different scales. The exceptional geographic location of the GAH area within a major high strain belt zone, reflects the decisive role in the deformation history as well as the mineralization. The structural interpretation of the quartzite bands and surroundings indicate the base-metal sulfide and associated gold mineralization are mostly syn-kinematic and controlled by D3 transperssional deformation event, which in turn controlled the emplacement of syn-tectonic granitoid intrusion and related hydrothermal solution system under ductile-brittle conditions.

Chapter 7 discussion on the light of the previous six chapters and outlines the conclusions of this study based on different data types analyses, interpretation and integration. Tectonic evolutionary scenario for GAH area was proposed on the basis of inter-relationship between lithology, structure and geochemistry with aided of multispectral remotely sensed data. These data integration, suggest that the exposed rocks in GAH area are most likely developed in a combined escape tectonic and back-arc tectonic setting. The back arc deformation manifested by the obducted ophiolitic slices onto the island arc assemblage. Thrust, folding and crustal shortening fabrics, are observed and recorded through ophiolitic and island arc rock assemblages. The escape tectonic manifested by the transpressional deformation (post-dating the obduction) regime superimposed onto these rocks and may be more or less contemporaneous to calc-alkaline magmatism expressed in the emplacement of syn-tectonic granites. The base-metal sulfide and associated gold mineralization are mostly syn-kinematic and controlled by D3 transperssional deformation event.