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Ore-forming mechanism and its relationship with deformational and metamorphic episodes at Haimur gold mine, Nubian Shield, Egypt

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Abstract

The Haimur area represents the central part of the Wadi Allaqi region in the southern block of the Egyptian Eastern Desert near Nasser Lake and the Nile valley. It is made up of ophiolitic assemblage comprising serpentinite and talc carbonate, listwenite, metagabbro/amphibolite and metabasalt and island arc assemblages. The orogenic gold deposits in the Haimur area occur in the form of smoky/white sulphide-bearing quartz / quartz-carbonate veins or lenses cutting through the listwenite zone-related rocks. The NE-trending auriferous veins were formed due to an extensional to transtensional shearing related to NW Najd shear tectonics. Gold was observed in association with late-pyrite and chalcopyrite paragenetically formed in the gold phase (second phase), while the first phase is the sulphide phase including early-pyrite and arsenopyrite. Arsenopyrite was formed during early metamorphic recrystallization at a high-temperature range between 405 and 512 °C. However, gold was formed at lower temperature through retrograde metamorphism. Three types of fluid inclusions have been recognized: aqueous (type-I), mixed aqueous–carbonic (type-II) and hydrocarbonic (type-III). The *P*–*T* conditions of trapping were obtained from the isochore lines of intersection between $T = 300$–320 °C and pressure range of 60–180 MPa. The Haimur gold deposit was supposed to be derived from metamorphic fluids created by dehydration and decarbonation of ophiolitic mélange assemblages and volcano-sedimentary rocks, in which the gold was transported as $Au(HS)^{2-}$ complexes and precipitated in reduced environment. The strong linkage between the deformation and metamorphism triggered gold deposition in structurally favourable sites related to the Najd fault system.

1. Introduction

In the Nubian Shield (NS) that extends from the eastern side of the River Nile toward the Arabian Peninsula and southward to the Mozambique Belt (Vail, 1988), most of the essential gold deposits are of orogenic type which commonly exist in the Egyptian basement rocks in the form of auriferous quartz-carbonate veins and/or lenses as well as related alteration zones. The orogenic gold deposits are the most economic world-class deposits that contain high anomalies of gold concentrations. They are always linked with stages of deformational–metamorphic events during orogeny (e.g. Kerrich & Cassidy, 1994; Oberthur, 1994; Goldfarb *et al.* 2001; Groves *et al.* 2003).

During the fractional crystallization processes of melt, gold and base metals are commonly incorporated either within pyroxenes and amphiboles or in association with other sulphide minerals (Mustard *et al.* 2006). They have been proposed to be leached from mafic and/or ultramafic rocks during metamorphic processes (Fyfe & Henley, 1973; Almond *et al.* 1984; Lee & Tredoux, 1986). In Egypt, the gold is deposited and concentrated by regional metamorphism under greenschist–amphibolite facies (Dardir & Greiling, 1987; Greiling *et al.* 1994; Greiling & Rashwan, 1994; Botros, 1995, 2002, 2004; Loizenbauer & Neumayr, 1996; Helmy *et al.* 2004; Abdelnasser & Kumral, 2016, 2017; Abu-Alam *et al.* 2019). Moreover, the gold-bearing quartz veins mostly occur within or close to granitic intrusions that are surrounded by metavolcanic–sedimentary assemblage, ophiolite and associated rocks (serpentinite, talc carbonate and listwenite). Therefore, there is probably a genetic link between gold mineralization and intrusion of syn- to late-orogenic granitic bodies (Amin, 1955; El-Gaby *et al.* 1988; Hussein & El Sharkawi, 1990; H Harraz, unpub. PhD thesis, Tanta Univ, 1991; AbdelTawab, 1992; Surour *et al.* 1999, 2001; Botros, 2004). However, Klemm *et al.* (2001) suggested that the post-orogenic intrusions just provided the heat sources that resulted in driving of hydrothermal convection cells, where interstitial waters dissolved the available mineral species. The possible mixing between metamorphic–magmatic fluids during gold remobilization, transportation, and circulation of hydrothermal water has been discussed by many authors

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