1. Introduction, literature and research review

Intrusional-related gold occurrences in Egypt are located in the Precambrian basement rocks of the Arabian-Nubian Shield (ANS) that are mainly confined to quartz-mineralized shear zones and very important as productive shear zones and quartz veins (Klemm et al., 2001). It is considered as the orogenic-mesothermal Au deposits hosted in gabbroic rocks.

The quartz veins are commonly formed within, or above the brittle-ductile shear zones around 2-3 kbar and 200-350°C in low-grade rocks (Bons, 2001), that is referred to these hydrothermal veins considered as syntectonic to post-tectonic. The quartz textures have been classified by Göze and Möckel (2012) into three major groups; primary, recrystallization, and replacement. Stipp et al., (2002), determined three main different dynamic recrystallization mechanisms; (1) Bulging recrystallization (BLC) which was dominant between ~280 and ~400°C; (2) subgrain rotation recrystallization (SGR) which occurred at ~300°C; and (3) the grain boundary migration recrystallization (GBM) that occurred at ~50°C.

In this work, we study the deformational textures of quartz from mesothermal quartz veins and hydrothermal alteration minerals to define the nature and origin of the hydrothermal fluids as well as mechanism and environment of formation of quartz veins.

2. Methodology

Detailed geological mapping and field observations of the hydrothermal alteration and mineralization were carried out, and more than 150 samples were collected during field working campaigns. A detailed deformational quartz textures and important as hydrothermal alteration and mineralization studies were carried out using polarizing and ore microscopes, and X-ray diffractometer (XRD) in Geochemistry Research Laboratories of Istanbul Technical University (ITU/JAL), Istanbul, Turkey.

3. Geological and petrographical studies

Detailed field study of Atud gold mine area (Fig. 1b) revealed that the Atud gold mine area covers 18 km², and composed mainly of metabasalt-diorite complex (Fig. 2a-2b) emplaced into sedimentary (Fig. 2a-2c) and tect-carbonate rocks (Fig. 2a-2c) and metasendiments (Lapilli metabuffs (Fig. 2e) and Ash metabuffs (Fig. 2d)). This complex is later intruded by olivine gabbro norte (Fig. 2g). The Atud gold deposit area is traversed by many quartz veins (Fig. 2b) and dykes of different compositions (basic and intermediate).

4. Atud Gold mineralization, quartz veins, and hydrothermal alteration:

4.1 Gold mineralization

It is located in the eastern and southeastern slope of Gabal Atud. It relates to a system of hydrothermal veins (quartz veins) along a NNW- to NW-trending shear zone, that occupy the pre-existing fractures (open-space filling) cutting through the metagabro-diorite complex (Fig. 1b). In addition, it is associated with the metasomatic hydrothermal alteration zones, and is observed at the contact with the quartz veins and these zones (Harruz, 1999).

4.2 Quartz veins

Field and microscopic observations suggest that there are two generations of these quartz veins: (1) the old one is characterized by grayish to white, mineralized trending N30°-40° W dipping around 45° toward W. (2) the younger vein generation is crystallized later, unmineralized, milky white, trending NE-SW dipping 15° toward NW (Fig. 3a-b).

(a) at the first level (Level 42m), the main quartz vein is comprised mainly of bluish or grayish quartz frequently associated with variable amounts of milky quartz (Fig. 3c). Greyish quartz veins that have ~ 50 cm thick directed N 20 W dipping 45 W, cut by small veinlets of milky quartz (Fig. 3d), and affected by shearing and deformation directed nearly N-S (Fig. 3e) causing brecciation. Pinching, swelling and bifurcation into small veins and veinlets are observed (Fig. 3f).

(b) At the second level (Level 72m), the main quartz veins extend discontinuously up to 270 m along with nearly 70 cm thick, and are mainly milky quartz trending N 30°-40° W dipping 35 W with variable amounts of bluish greyish quartz (Fig. 3g).

(c) At the third level (Level 165m), high amount of milky quartz with smaller amounts of bluish or greyish quartz characterize the main quartz veins that directed N 40° W (Fig. 3h).

4.3 Hydrothermal alteration

Three main hydrothermal alteration zones of mineral assemblages with gradual boundaries occurred around quartz veins and associated with the main shear/fault zone trending NNW-SSE. These zones are distinguished based on geological and petrographical data as well as XRD analyses (Fig. 5 & 6).

(a) Zone 1: sericite / kaolinite + muscovite + quartz + pyrite ± ankerite ± dolomite ± albite
(b) Zone 2: muscovite ± dolomite ± albit + sericite / kaolinite + anthophyllite + chlorite ± quartz + albite / sericite
(c) Zone 3: carbonate (ankerite + calcite) + chlorite (clinochlorite + chlorite) + albite ± pyrite ± arsenopyrite ± muscovite ± quartz.

5. Conclusions

Gold mineralization in the Atud gold deposit is mainly associated with quartz and hydrothermal veins that occupy pre-existing fractures (open-space filling).

% There are two generations of auriferous quartz in the Atud gold mine; the oldest one is NNW-SSE, while the younger is NE-SW
% The mineralized veins largely exhibit bulging recrystallization (BRC) deformation with bulged and recrystallized grains at the quartz grain boundaries that occurred at temperatures of around 250 to 400°C.
% X-ray Diffraction (XRD) data revealed that the hydrothermal alteration minerals associated with gold mineralization are mostly quartz, pyrite, sericite, kaolinite, and dolomite with selective ankerite, chlorite, and albite.