Journal of African Earth Sciences 90 (2014) 77–86

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Large-scale metal zoning in a late-Precambrian skarn-type mineralization, Wadi Kid, SE Sinai, Egypt

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ARTICLE INFO

Article history:
Received 4 January 2013
Received in revised form 19 November 2013
Accepted 21 November 2013
Available online 1 December 2013

Keywords:
Wadi Kid
Sinai
Metamorphic evolution
Monazite dating
Precambrian
Skarn mineralization

ABSTRACT

A Precambrian skarn-type mineralization is recently discovered in the Wadi Kid area in southeast Sinai, Egypt. Two sulfide ore types define large scale metal zoning; Cu–Zn–Co in calc-silicate rocks and Zn–Pb–As–Ag in metapelites. The sulfides and host rocks underwent amphibolite facies metamorphism (2.1–4.2 kbar and 500–620 °C). Dating by the chemical Th–U-total Pb isochrone method yields an Th–Pb isochrone age of 660 ± 25 Ma for metamorphic monazite from metapelites. Overall structural and textural relationships of silicate and sulfide minerals favor syn-tectonic formation during granitoids emplacement in a continental margin setting. Large-scale metal zoning reflects variable distances from the causative pluton(s). The Wadi Kid area is highly prospective for Cu, Zn, Pb and Ag mineralization.

1. Introduction

The Wadi Kid area (600 km^2) is located to the west of Gulf of Aqaba in southeast Sinai, Egypt. This area exposes continental margin volcano-sedimentary succession (Shimron, 1984; Bentor, 1985; Reymer, 1984; Reymer et al., 1984; El Gaby et al., 1991; Fowler et al., 2010). The volcano-sedimentary succession is deformed and syn-tectonically intruded by granite–diorite complexes (Bentor, 1983; Moghazi et al., 1998; Fowler et al., 2010). Strong geological evidences suggest that granitoids underplate the whole volcano-sedimentary succession; the rising magmatic diapirs are the principal heat source of metamorphism in the area (Reymer et al., 1984).

Many sulfide ore occurrences were recently discovered in the wider Kid area (Fig. 1); i.e., Um Zeriq 1, 2, and 3, Samra 1, 2, 3 and 4 and Shalal. Sulfides occur either as disseminations or massive lenses and veinlets in a variety of host rocks. Recent drilling in one of these localities (Um Zeriq 2) led to the discovery of massive sulfide zones hosted in metapelites.

In this contribution we study in detail the geology and mineralogy of three sulfide occurrences in the Um Zeriq area (Um Zeriq 1, 2 and 3). Special emphasis is placed on the metamorphic mineral assemblage in each area. Extensive electron microprobe analyses of metamorphic minerals and sulfides are presented. We also determine the age of metamorphism using monazite-dating technique. The present investigation helps to understand the genesis of the mineralization which is important before starting any new exploration and drilling programs.

2. General geology of the Wadi Kid area

The Wadi Kid metamorphic complex forms a very thick (4500 m) succession of volcano-sedimentary rocks deposited in active continental margin back-arc, remnant arc and intra-arc settings (Fowler et al., 2010 and references there in). Four "Formations" are noted in the Wadi Kid complex, from bottom to top; Um Zeriq, Malhaq, Tarr and Heib (Shimron, 1980; Fowler et al., 2010).

- Um Zeriq Formation (>1500 m) consists of schists and phyllites derived from quartz-rich graphitic aluminous pelites and psammites, and feldspathic lithic greywackes. Carbonate and impure dolomites form minor components of pelites at a lower stratigraphic level. These lithologies are interbedded with lavas, pyroclastics and volcanogenic sediments. Abu El-Enen et al. (2003) chemically showed that Um Zeriq pelites are similar to those of active continental margin shales.
- The Malhaq Formation lithologies are dominated by silicic and intermediate calc-alkaline volcanic products consisting of fine

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http://dx.doi.org/10.1016/j.jafrearsci.2013.11.015

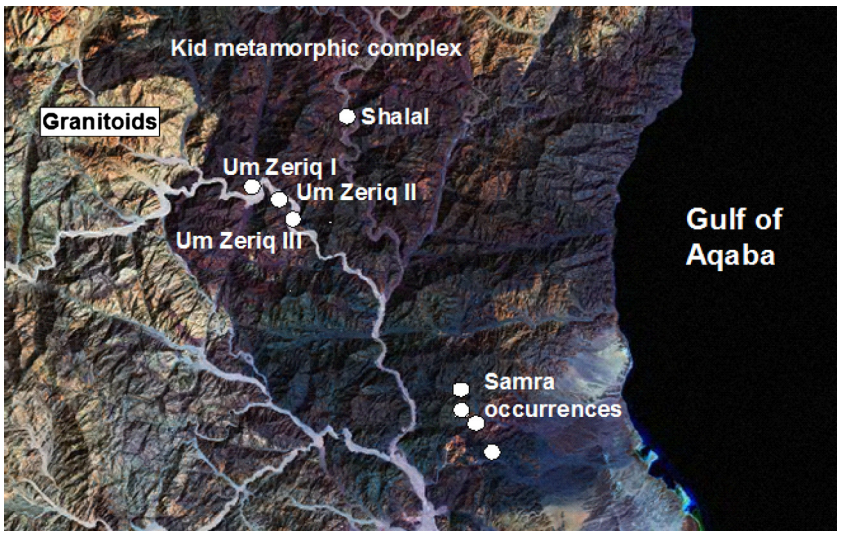

Fig. 1. Location of sulfide mineralizations in Southeast Sinai, Egypt.

to coarse-grained pyroclastics and lesser lavas. Stable metamorphic assemblage comprises biotite, hornblende, garnet and cordierite. This unit is commonly viewed as a back-arc sequence (Ghoneim et al., 1985; Abu El-Enen, 2008).

- Tarr Formation (about 800 m) consists of greywackes, dolomitic marls, marble, pelites, tuffs and flows. The Tarr Complex sediments were thought to have been deposited in a forearc–accretionary prism environment (Shimron, 1983).
- Heib Formation is a thick (>1000 m) sequence consists of rhyolitic and andesitic flows (upper stratigraphic level). The Heib volcanics are high K calc-alkaline formed in an active continental margin setting (El-Gaby et al., 1991).

The Kid area suffered extensive syn-tectonic plutonic activity commenced by the intrusion of syn-tectonic dioritic to granodioritic rocks and ended by the intrusion of late- to post-tectonic granitic batholiths (Bentor, 1983; Fowler et al., 2010).

The structural evolution of the Kid area was studied by many authors (e.g. Shimron, 1984; Reymer, 1984; Blasband et al., 2000; Fowler et al., 2010). Four deformational events (D1–D4) were recorded; D1 and D2 are more prominent in the northern Kid area. D1 comprises folding that fade northwards, minor thrusting and steep shears. D2 event involved formation of semi-recumbent open to tight folding and thrusts. D3 is mainly represented by WNW–ESE trending upright open to close macroscopic folds. D4 is represented by folds mainly in the northern Kid. Fowler et al. (2010) argue that D1 and D2 are deformation events associated with arc collision, with D1 involving initial rapid convergence in the inner parts of the arc followed by transfer of the main deformation to the thinner hotter crust of the back-arc.

3. Geology of the Um Zeriq area

The Um Zeriq area occupies the western part of the Wadi Kid complex. Both Um Zeriq and Malhaq Formations are exposed in this area (Fig. 3). The Um Zeriq Formation is thrusted to the north along major NNE-SSE thrust fault marking Wadi Um Zeriq. A silicified carbonate – impure dolomite body forms minor component of Um Zeriq pelites at the entrance of Wadi Um Zeriq (Fig. 3). The silicified carbonate rocks occur as highly jointed and cracked blocks and host one of the sulfide mineralizations (Um Zeriq 1). Along Wadi Kid, garnet–biotite schist dominates the lithology of Um Zeriq Formation where two other sulfide occurrences (Um Zeriq 2 and 3) are found.

Many structural elements (faults, shear zones, micro folds) are noted at Um Zeriq area. Faults have been traced along three main trends, NNE-SSW, ENE-WSW and NE-SW; some of these faults extend for more than 90 km. Wadi Um Zeriq is a main fault in the area and exhibits left-lateral, strike-slip motion (Figs. 2 and 3). Several shear zones along Wadi Um Zeriq attain widths of as much as 30 m and are traced for as long as 600 m. Structural elements in the area correspond to D2 deformation event of Fowler et al. (2010).

The three sulfide mineralizations (Um Zeriq 1, 2 and 3) occupy an area of approximately 7 km^2. The mineralizations are marked on surface by gossans, one of them (Um Zeriq 2) was traced in one drillhole (100 m depth) done by the Geological Survey of Egypt.

Um Zeriq 1 is located at the intersection of Wadi Um Zeriq and Wadi Kid, on the major strike-slip fault trending NNE-SSW. The main rock units are calc-silicates, metapelites and minor volcanics. All rock units dip to the east with angles ranging between 15° and 30°. The mineralized area is dissected by various dykes ranging in composition from rhyodacite to dolerite. The mineralised zone forms elongated body extending more than 350 m in a NNE direction. The zone is up to 12 m thick dipping 30° to the east following the regional structural regime. The sulfide mineralization is represented by gossans forming elongated pockets as much as 3 m long. Fresh sulfide ore forms small lenses, few centimetres long, elongated parallel to the rock schistosity.

The sulfide mineralization at Um Zeriq 2 and 3 is located along the fault zone marking Wadi Kid. On surface, the sulfide ore forms few meters long gossans in highly sheared rocks (up to 20 m wide and 500 m long). Massive sulfide lenses (mainly made of galena) are still preserved in the gossan pockets. Several quartz veins are observed in the sheared rocks, where they follow the regional structure of the area.

The drillhole penetrating Um Zeriq 2 (Fig. 4) revealed the presence of three mineralized zones:

(1) Gossans with massive galena, hematite and goethite forming the upper 1–2 m.
(2) Disseminated ore extending from a depth of 26.5 to 37 m; sulfide minerals constitute about 8 modal % of the core.