Ore Geology Reviews 71 (2015) 1–13

Contents lists available at ScienceDirect

Ore Geology Reviews

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

Prospecting for new gold-bearing alteration zones at El-Hoteib area, South Eastern Desert, Egypt, using remote sensing data analysis

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ARTICLE INFO

Article history:
Received 10 February 2015
Received in revised form 23 April 2015
Accepted 26 April 2015
Available online 28 April 2015

Keywords:
Alteration zone
Gold exploration
Remote sensing
ASTER
SPOT
Arabian–Nubian Shield
Allaqi–Heiani suture
South Eastern Desert
Egypt

ABSTRACT

Gold has been mined in the Eastern Desert of Egypt since the time of the Pharaohs, yet the geological settings of such ore deposits and how certain deposits link to each other are still not fully understood. The application of remote sensing in identifying variations in surface mineralogy, structural elements, and lithologic contacts can help in identifying such relations. Signatures collected from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data is used to map the hydrothermal alteration zones of El-Hoteib area, which is located to the northwest of Iqat and Al-Fawi gold mines and prospective for gold. SPOT5 data is used to highlight the preliminary structural lineaments in the area. Band ratioing and principal component analysis techniques are used to refine the different lithologic units in the area. A simplified Crósta technique has been applied to the ASTER data to identify both the location and spatial extent of the different alteration zones around the Iqat-Al-Fawi area. A new gold-bearing alteration zone is detected to the north of Gabal El-Hoteib. It is structurally controlled by E–W to WNW–ESE structures with evidence of reactivation of such trends during the Quaternary. Ore microscopy examination, induced coupled plasma mass spectrometry and fire assay analysis revealed the presence of gold associated with excess zinc in most samples.

1. Introduction

The Allaqi–Heiani suture, identified in the Nubian Shield (Fig. 1a), is located at the northwesternmost end of the Hamisana Shear Zone and occupying the western part of the Yanbu-Onib-Sol Hamed-Gerf-Allaqi-Heiani fold-and-thrust belt (Abdelsalam and Stern, 1996; Abdelsalam et al., 2003) that extends roughly E–W in the southernmost part of the Egyptian Eastern Desert (Fig. 1b). It is composed of allochtonous ophiolitic thrust sheets, island arc metavolcanics–volcanoclastics, and metasedimentary assemblages intruded by syn- to post-orogenic granitoids (Abdelsalam et al., 2003). Several gold localities along this belt have been observed and exploited by ancient Egyptians more than 5000 years ago (e.g. Iqat, Al-Fawi, Um El-Tuyor and Betam), some of which are showing a significant economic value (Zoheir, 2011). Increasing demand for gold in the global market made it a necessity to prospect for new occurrences in the region through the development of new techniques.

Remote sensing plays an important role in the exploration of mineral deposits, and its capability in lithological mapping and detection of associated hydrothermal mineralization has been documented by numerous studies (e.g. Crósta and Moore, 1989; Loughlin, 1991; Abdelsalam and Stern, 2000; Ramadan et al., 2001; Ferrier et al., 2002; Crósta et al., 2003; Ramadan and Kontny, 2004; Liu et al., 2007; Zhang et al., 2007; Gabr et al., 2010). The technique is particularly useful in regions with extremely rugged topography, where it is impossible to do conventional geological mapping. The 20th century witnessed a huge development in remote sensing sensors as well as its associated image analysis techniques, which minimized the geologist's efforts before and during field expeditions. The newly developed sensors provide detailed information on the mineralogy of different rock types comprising the Earth's surface (Zhang et al., 2007). The development of satellite data analysis techniques increases the amount of confidence and accuracy of the investigated target(s), especially those related to both lithological and hydrothermal alteration mapping (e.g. Sabins, 1997, 1999; Abdelsalam and Stern, 2000; Ramadan et al., 2001; Crósta et al., 2003; Liu et al., 2007; Sadek et al., 2008; Gabr et al., 2010; Zoheir, 2011; Zoheir and Emam, 2012; Rajendran et al., 2013).

El-Hoteib area is located at the easternmost part of the Allaqi-Heiani suture, between latitudes 22°00′ and 22°25′ N and longitudes 34°42′ and 35°00′ E covering an area of about 1180 km^2. It is completely confined to the Wadi Allaqi district (Fig. 1b) and is characterized by a moderate relief with some conspicuous rugged peaks (e.g. Gabal Shanaiyla, Gabal El-Hoteib, Gabal Iqat and Gabal Al-Fawi). The area is relatively inaccessible due to its mountainous topography, proximity to the borderline, and the scarcity of the desert tracks crossing the area, which hinders any kind of exploration activities.

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http://dx.doi.org/10.1016/j.oregeorev.2015.04.021
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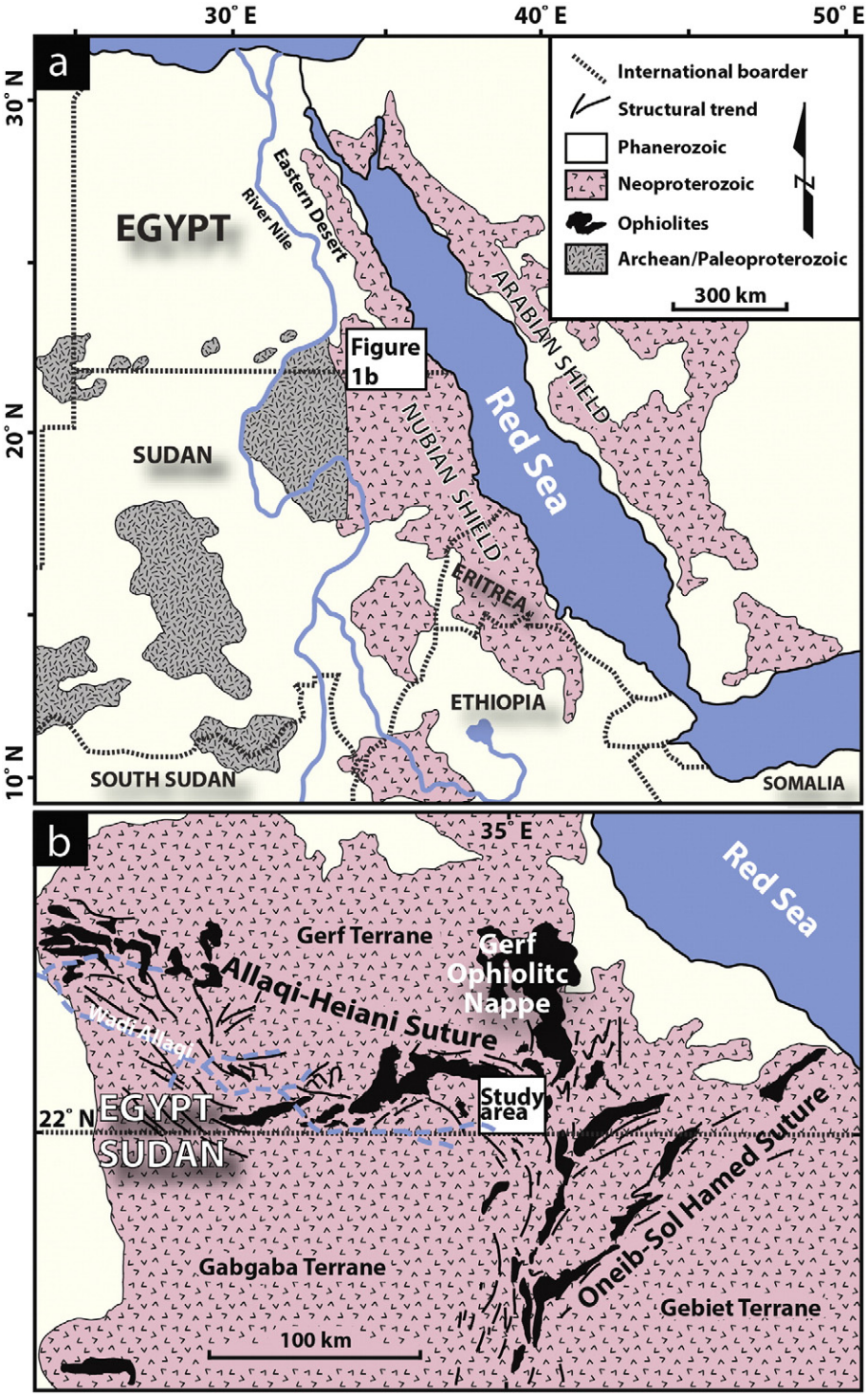

Fig. 1. a) Distribution of the Archean–Paleoproterozoic and Neoproterozoic rocks in the Arabian–Nubian Shield, b) tectonic sketch map of the Allaqi–Heiani, Oneib-Sol Hamed sutures and the Gerf Ophiolitic Nappe located at the northernmost part of the Hamisana Shear Zone.
Modified after Stern, 1994; Abdelsalam et al., 2003 and references therein.

Iqat and Al-Fawi are two ancient gold mines that are well known in the study area. Both mines have been exploited by ancient Egyptians and were likely to be active until the end of the early Islamic time (10th–11th century) (Zoheir and Emam, 2012). They are located in the southernmost part of the Eastern Desert of Egypt, 5–6 km directly to the north of the Egyptian–Sudanese border. Recently, these two mines have become of a great attraction to exploration companies due to their significant gold grades (several ppms of Au) found within and outside the old mining sites (Salem, 2007; Zoheir, 2008a; Zoheir and Emam, 2012). The recorded Au concentration is usually associated with shear zone hosted auriferous quartz veins (Zoheir and Emam, 2012).

The present contribution uses an integrated analysis of satellite imagery and lithological, mineralogical and structural data, to detect