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Geochemical exploration for gold in the Nile Valley Block (A) area, Wadi Allaqi, South Egypt

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ABSTRACT

The present work aims to estimate Au-anomalous distribution patterns, the optimum grain size fraction and pathfinder elements for gold placer. The obtained data of analyzed elements (Au, Ag, As, Ba, Cd, Co, Cr, Cu, Fe, Ga, Hg, Li, Mn. Mo, Ni, Pb, Rb, Sb, Se, Sr, Te, Ti, V, Y and Zn) in both the fine (−0.25 mm) and coarse (−1 mm+0.25 mm) grain size fractions of 32 dry stream sediment samples, which have been derived from metamorphosed Island Arc volcanic rocks of Late Proterozoic age, revealed that most of the analyzed elements in both grain size fractions are asymmetrically distributed and did not pass the tests of normality. The coarse grain size fraction appears to be the better size fraction for Au detection and can be considered as the optimum grain size fraction for future application in regional stream sediment surveys. The presence of Au anomalies in the upper part of the stream and beside the mine is either sourced by the main Au-mineralization or new potential extension of the mineralization in the study area. Silver, Cd, Se, Zn and Te can be considered as useful pathfinder elements for Au in the coarse grain size fraction, and they may be used for future geochemical exploration for Au in the area. Recommendation of the authors is pointing to perform lithogeochemical survey in the eastern and western parts of the mine.

1. Introduction

Stream sediments surveys remain the general geochemical methodology used in regional reconnaissance exploration for Au in areas where relief permits development of distinct drainage systems (Hale and Plant, 1994; Fletcher, 1997). The Nile Valley Block (A) is located at about 220 Km to the south of Aswan, in the Wadi Allaqi Region (Fig. 1). The Nile Valley Block (A) area varies in topographic relief from moderate mountainous Island Arc meta-lava (meta-andesites and meta-andesites-metadacites) to low-lying metapyroclastic rocks of andesitic composition. It occupies about of 54 Km^2 and drains into Wadi Allaqi. The area is famous for the old Au mine, which is located at the intersection of Lat. 22° 34′ 45″ N and Long. 33° 21′ 50″ E. After 1956, the Au mine of the study area was officially closed due to the low Au content, although the remaining Au-bearing veins were again investigated and reported on by Kochin and Bassyouni (1968) and El Shimi (1996). The study area is currently explored by Gippsland Limited, an Australian Junior and Egyptian Mineral Resource Authority. The recent drilling reports by the private companies were reviewed to re-evaluate the Au mine. This indicates that the study area warrants further exploration. Mining activities were confined to a low relief hill, formed by numerous open pits, trenches, four mining shafts and slimes heaps in the area. The stream sediments of the investigated area include a mixture of different grain size fractions ranging from boulder, gravel, sand, silt and clay sizes, which were derived from weathering processes of the surrounding Island Arc metavolcanic rocks and their metapyroclastic rocks of Late Proterozoic age.

The main purpose of this paper is to study statistical features and geochemical characteristics of Au and other analyzed elements in both fine (−0.25 mm, which could potentially be diluted by a windblown dust) and coarse (−1 mm+0.25 mm) grain size fraction of stream sediment samples. In addition to outlining the anomalies of Au, Ag and associated elements, we also estimate the optimum grain size fraction, and determine the pathfinder elements for Au during future detailed geochemical exploration using stream sediment samples in the study area.

2. Geological setting and mineralization

The study area is covered mainly by the Precambrian basement complex rocks of Late Proterozoic age, which is composed of metagabbroic, Island Arc metavolcanic and their metapyroclastic rocks of andesitic composition (Fig. 1). The Island Arc

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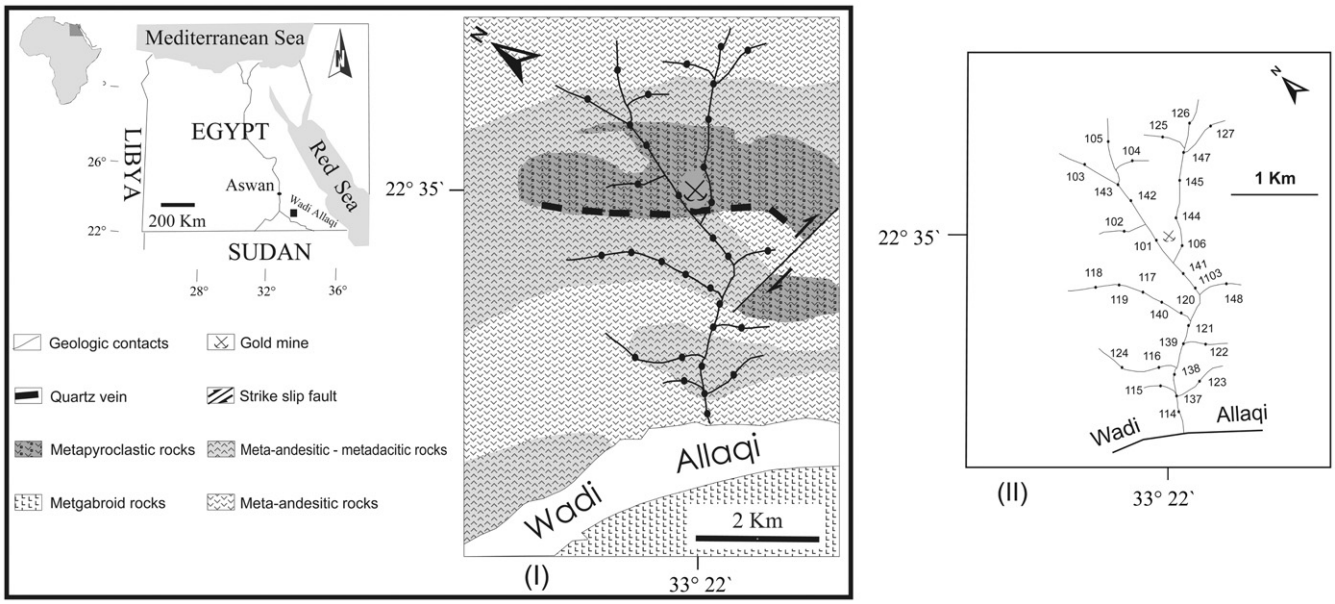

Fig. 1. (I) Geologic map and (II) stream sediment sampling stations in the study area.

metavolcanics are composed mainly of meta-andesitic and meta-andesitic-metadacitic intercalated rocks. They have been transected by the E–W strike slip fault. The ore deposit of the Nile Valley Block (A) area consists of Au-bearing veins and their alteration zones that exist at the top of a low relief hill. The most important auriferous quartz veins (striking N30W and dipping 63 NE) occur mostly in the sheared contact between Island Arc metavolcanics and their metapyroclastics and they are associated with hematitic and limonitic alteration zones (Darwish, 1996). The Au content in both the quartz veins and alteration zones is less than 0.3 ppm (El Shimi, 1996).

3. Sampling and analytical methods

The stream sediment sampling technique used in this study covered the whole Nile Valley Block (A) area (ca. 54 km^2) and included a total of 32 samples (sample density of 3 samples/5 Km^2). They were collected from dry streams of different orders (Fig. 1) at depths of about 25–30 cm to avoid sand windblown, gravel fractions and truck pathways. These samples were taken by using mattock and shovel; each sample was nearly of 10 kg weight and was placed in pre-numbered sample packets. All samples were dried and screened in the field using a 1 mm sieve; accordingly, the -1 mm fraction was subdivided into fine and coarse grain size fractions, which were used for this study. Each sample was quartered and fifty grams of each subsample were ground using an electric agate mortar to -75 μm for chemical analyses. About 0.1 gram of each powdered subsample was completely digested with acid mixtures (HNO_3, HF, HCl, H_2O_2) using a microwave and the element concentrations in the obtained clear solutions were measured by ICP-MS for Au, Ag, As, Ba, Cd, Co, Cr, Cu, Ga, Hg, Li, Mn. Mo, Ni, Pb, Rb, Sb, Se, Sr, Te, V, Y and Zn. However, Fe and Ti were determined using ICP-AES. The procedures of dissolution and chemical analyses were done at Laboratory of Geochemistry in Martin-Luther University, Germany.

The detection limits for analyzed elements are shown in Tables 1 and 2. The accuracy and analytical precision of the analytical method were assessed by analyzing certified reference materials (Buffalo-River-Sediment), blanks with known amounts of elements and duplicate samples in each analytical set. The results were within the 95% confidence limits of the recommended values for these certified materials. Generally, analytical precision was $\pm 3\%$ for the analyzed elements.

4. Results and discussions

The nature of the sediments is usually coarse in the upper stream sites and become fine in the downstreams. The distributions of the Au and analyzed elements are also varied depending on the lithologic units, elemental mobility, gradient of the Wadi and its tributaries, physico-chemical factors, variation of the grain size fractions and dilutions of the sediments by windblown sand.

In this study, some statistical parameters were calculated to exhibit the overall features of the element concentrations in both fine and coarse size fractions. The geochemical data were also statistically examined by using Kolmogorov–Smirnov and Shapiro–Wilk tests for testing normality of the distribution applying the null hypothesis. Paired-sample *t*-test has been performed to show any differences between means of the analyzed elements in the fine and coarse grain size fractions.

In all cases, the confidence interval was 95% (p-value=0.05), the geochemical data were subjected to box and whisker plots to present the variation of elements' concentrations in the fine and coarse grain size fractions of the stream sediment. According to the obtained results of the statistical treatments, the geochemical data were logarithmically transformed to improve the normality of distribution and to calculate R-mode cluster analysis. Moreover, geochemical signatures and geochemical maps have been estimated and drawn, respectively. Some software were used in this study such as Coral Draw X4 software (for geologic and sampling stations' maps), Microsoft Excel 2003 software (for preparation of tables), Statistica, version 7 and Origin 8 softwares (for figures), Statistical Package for Social Sciences (SPSS), version 13.0, software (for all statistical analyses) and Surfer version 8, Golden software (for geochemical maps).