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GEOCHEMISTRY OF UMM RUS GOLD-QUARTZ VEINS, CENTRAL EASTERN DESERT EGYPT. A NEW CONTRIBUTION

O.A. KAMEL[1], M.M. EL MAHALLAWI[1], AND H.M. HELMY[1]

ABSTRACT

Gold-bearing quartz veins of the Umm Rus area occur at the south-eastern contact of a Precambrian granodiorite cupola within younger gabbros of 573-615 Ma belonging to the Pan African orogenic belt. The rocks are intruded within low-grade metasediments. At such contact, a hybrid zone is developed characterized by the occurrence of quartz diorite which grades into diorite and meta-ferrogabro. A limited number of mineralized quartz veins cut the granodiorite-gabbro complex. Different alteration zones are developed in the vicinity of the quartz veins.

The quartz veins have two main trends; NS and N30 E, the latter one is usaually gold-bearing. The mineralized parts of the veins commonly consist of highly sheared and banded smoky quartz, and the gold content depends on the relation with the dykes. The element is strongly correlated with As and Ag, but moderately with Cu. Near to intermediate and basic dykes, the contents of Au, Ag and As are noticably increased.

KEY WORDS: Umm Rus gold-quartz veins. Geological Setting. Geochemistry, Discussion, Eastern Desert, Egypt.

1. INTRODUCTION

The Umm Rus area (Fig. 1) is delineated by latitudes 25° 25′ and 25° 30′ N and langitudes 34° 30′ and 34° 36′ E. The Umm Rus mine was worked during three successive periods, i.e. Ancient Egyptian, Roman and recent times. Fig. 2 is a plan of the Umm Rus gold mine after Hawary (1938), showing two main shafts (150 and 182 m long) and five mining levels (with a total length of 1533 m). The ore reserves were estimated as 16,000 tons with an average of 11.6 gm/ton Au (Hawary,1938). The geology, mineralogy and geochemistry of the Umm Rus mine area have been studied by Hilmy et al. (1968), Abu Zeid et al. (1987), Helmy (1991), Kamel et al.,(1992 and 1998), and Harraz and El Dahhar (1994).

2. GEOLOGICAL SETTING

The Umm Rus granodiorite forms a mineralized cupola within younger gabbros of 573-615 Ma(Kamel etal.,1983) and associated by the gold-bearing quartz veins. The contact zone shows distinct development of quartz diorite, diorite and meta-ferrogabro towards the gabbros, which intruded low-grade metasediments, The Umm Rus gold mine is located at the south-eastern contact of the granodiorite body. Twenty four different quartz veins extend over an area about nine Km and are fissure fillings traversing the granodiorite, hybrid contact zone, and gabbros. Also, the veins are structurally controlled. Three mineralized quartz veins (Q1, Q2 and Q3) are located at the vicinty of Umm Rus gold mine. In many cases, the mineralized quartz veins are highly sheared and laminated, and occur at the contacts between the granodiorite and the gabbros. The field observations indicate that veins of milky quartz were first formed, then intersected by different dykes, especially the alkali rhyodacite and dacite dykes. While , smoky quartz was formed as a later phase accompanied by basic mugearites and camptonite lamphropyres. The dykes commonly have trends parallel to the quartz veins, and the lateral distibution of gold and other sulphides is strongly affected by the occurrence of dykes.

The mineralized parts of the veins commonly consist of smoky quartz and have thickness not more then 35 cm. Different wellrock alterations (advanced phyllic, phyllic and propylitic) are usually developed along the contacts between the quartz veins and the host granodiorite (Kamel et al.,1992). The thickness of the alteration zones ranges from 20 to 70 cm, and may reach 1.5 m or even more.

The Umm Rus area is covered by granodiorite, gabbros, metagabbro and different dykes. Inhomogenous horblende-bearing rocks which are developed at the contacts between the granodiorite and the surrounding gabbros are most enteresting. They are represented by both meta-ferrogabbro (near the gabbros), diorite and

1. Geology Department, Faculty of Science, El Minia University, El Minia, Egypt

Fig.1: PHOTOGEOLOGICAL MAP OF UMM RUS AREA

"Central Eastern Desert, Egypt"

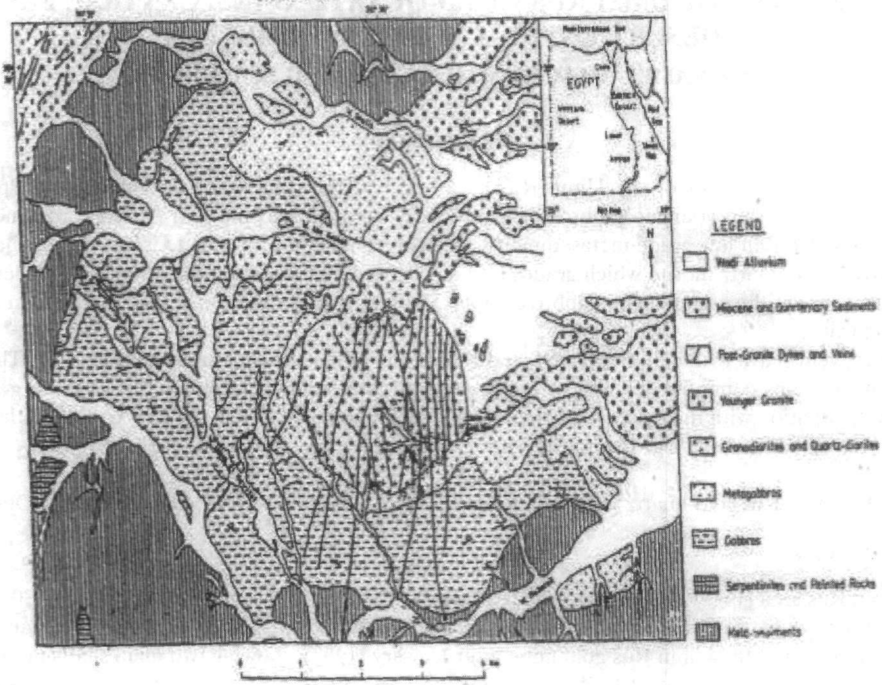
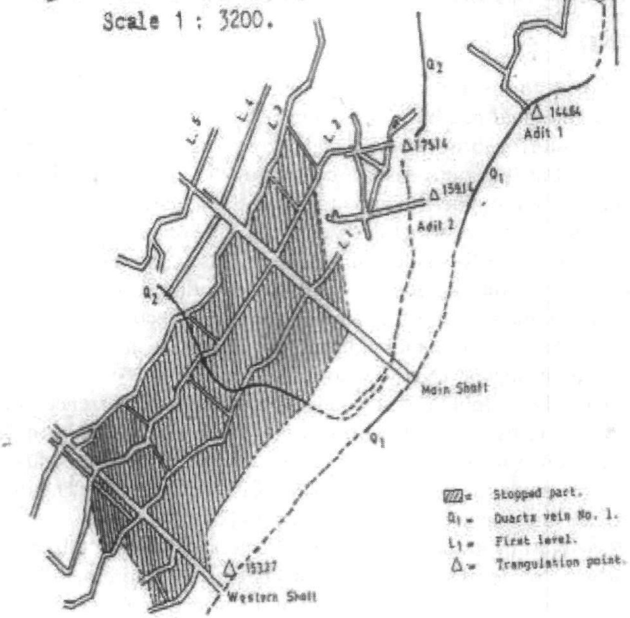


Fig.2: Plan of Umm Rus gold mine (Hawary, 1938).
Scale 1 : 3200.



quartz diorite (near the granodiorite).

The quartz veins are represented by two types: 1) milky quartz veins that consist of coarse-grained subhedral to anhedral quartz, and 2) smoky quartz veins filling fractures in the milky quartz.The latter display a ribbon structure and shows inclusions of carbonaceuos matter.

Sericite, quartz and muscovite represent the essentail minerals of the advanced phyllic alteration zone, with subordinate hornblende and sulphides. Major sericite and quartz with minor suphides and kaolinite constitute the phyllic alteration zone, while chlorite, epidote, calcite and pyrite are specific for the propylitic alteration zone. Concerning the sulphides, arsenopyrite and pyrite are most common, while chalcopyrite, tetrahedrite, marcasite and bornite are subordinate in abundance. Goethite and covellite are supergene minerals. The Au bearing minerals are represented by native gold and electrum (Au 0.79 and Ag 0.12) and sylvanite, while silver is represented by chlorargyrite(Kamel et al.,1992).

3. MATERIALS AND METHODS

The rocks and gold-bearing quartz veins of the Umm Rus gold mine were represented by different samples. The main quartz vein-Q1 was sampled along the main and western shafts and from different excavated levels and adit 1. While, the quartz vein- Q2 was sampled along adit 2.Some twenty six samples of the main quartz vein Q1 and the quartz vein Q2 were collected from adits 1 and 2 and quantitavely analyzed using the atomic absorption spectrophotometer (Tables 1 and 2). Also other forty two samples of the main quartz vein were spectrographically analyzed for As, Cu, Ag, Au, Zn and Pb. The analytical resuls represnt vertical and lateral distributions of As, Cu, Au, Ag, Zn and Pb along the main gold quartz vein Q1 as sampled from the third and fourth levels of the mine (Figs.3 and 4).

4. DISTRIBUTION OF GOLD AND ASSOCIATED ELEMENTS

Arsenic is the most common trace element in the gold-bearing quartz veins and the associated wallrock alterations. The element contents vary considerably in the quartz veins from below detection limit (at the surface) to 8000 ppm (at the fourth level). The element abudance ranges between 200 and 2000 ppm in the alteration zones.

The Au contents are rather erratic within and among the studied quartz veins. The Au contents vary from below detection limit up to 14.1 ppm in the quartz vein-Q1 , and up to 36 ppm in the quartz vein-Q2 , according to the type of mineral quartz and its relation to different dykes. The smoky quartz displays rather high Au concentratoins. The average Au contents were estimated as 5.3 and 21.7 ppm for the Q1 and Q2 respectively (Abu Zeid et al., 1987).

Table I : Atomic absorption data of samples from adit I (quartz vein-Q1) after Kamel et al.(1998). (Level 140 m)

Serial no	Sample no	Rock type	Element content in (ppm)							
			Cu	Pb	Zn	Ni	Co	As	Ag	Au
1	2	Quartz Vein	3	11	13	3	n.d.	600	0.3	6.3
2	11		1.6	7	6	n.d.	n.d.	1000	1.8	14.12
3	22		16	36	58	118	17	500	1.5	5.07
Mean			**6.87**	**18.0**	**25.7**	**40.3**	**5.67**	**700**	**1.2**	**8.49**
4	3	Alteration Zone	18	17	21	109	16	600	1.8	8.57
5	5		15	16	57	130	26	400	1.64	4.8
6	7		5	15	63	78	36	200	0.9	1.95
7	14		14	19	16	18	10	300	0.3	3.7
8	19		80	25	87	81	23	200	1.0	2.9
9	20		103	26	43	137	18	2000	2.9	29.8
Mean			**39.17**	**19.67**	**47.83**	**92.17**	**21.5**	**615**	**1.42**	**8.62**
10	4	Granodiorite Wall Rock	5	2.5	1	10	n.d.	100	-	n.d.
11	11		11	8	3	20	n.d.	400	-	2:26
12	18		10	12	2	22	1	300	-	1.2
13	22		6	n.d.	n.d.	34	3	n.d.	-	n.d.
Mean			**8.0**	**5.63**	**1.5**	**21.5**	**1.0**	**200**	**-**	**0.87**

(n.d.) = Below detection limit.
(-) = Not determined.

Table 2 : Atomic absorption data of samples from adit 2 (quartz vein-Q2),after Kamel et al.(1998). (Level 153 m)

Serial no	Sample no	Rock type	Element content in (ppm)							
			Cu	Pb	Zn	Ni	Co	As	Ag	Au
14	54	Quartz Vein	26	70	114	133	30	400	3.16	13.45
15	55		2	18	4	n.d.	n.d.	600	1.64	24.7
16	57		30	25	51	128	28	2000	4.5	36.0
Mean			**19.33**	**37.67**	**56.33**	**87.0**	**19.33**	**1000**	**3.1**	**24.71**
17	53 f	Alteration Zone	21	33	47	112	16	800	1.6	26.6
18	55 h		6	10	62	43	8	200	1.2	2.2
19	56 h		16	16	31	128	24	600	0.7	13.45
20	57 f		17	25	66	127	28	200	n.d.	1.03
21	59 h		4	14	18	12	6	200	n.d.	3.4
Mean			**12.8**	**19.6**	**44.8**	**84**	**16.4**	**400**	**0.7**	**9.336**
22	51	Granodiorite Wall Rock	8	10	n.d.	10	n.d.	300	-	3.88
23	52		10	30	3	11	4	100	-	trace
24	53		15	11	8	31	8	n.d.	-	trace
25	54		8	17	10	5	7	300	-	3.1
26	57		18	9	1	8	1	100	-	trace
Mean			**12.0**	**15.4**	**2.4**	**13.0**	**4.0**	**160**	**-**	**1.5**

(n.d.) = Below detection limit.
(-) = Not determined.

The concentrations of Au in altered granodiorite is up to 2.26 ppm and 3.88 in adits 1 and 2 respectively. The element enrichment reaches 8.62 and 9.33 ppm in the alteration zones

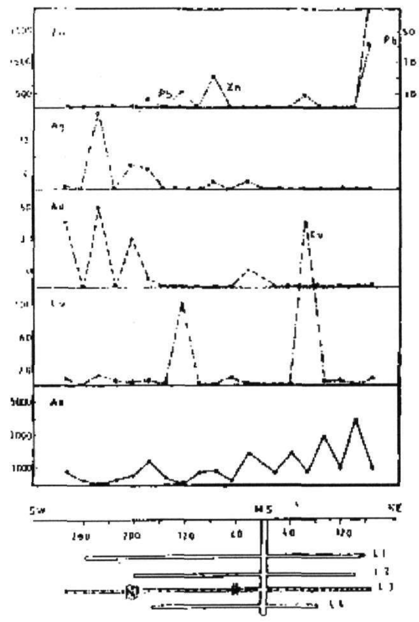
The Ag contents are rather low in the studied gold-bearing quartz veins and their wallrock alteration zones. The element concentration may reach a value of 1.8 and 4.5 ppm in Q1 and Q2 respectively. The wallrock alterations have similar contents (up to 2.9 and 1.6 ppm). The silver concentrations are rather pathetic with these of gold. The calculated correlation coefficients of silver with Au,Cu and As indicate that the element is sympathically correlated with Au(0.69), copper(0.128), but antipathatically correlated with As(-0.487)

Low values of Cu are determined for the studied quartz veins.The Cu concentrations reach 16 and 30 ppm for the veins-Q1 and-Q2 respectively. Samples that have noticeable Au concentrations have higher values of Cu. Meanwhile, the values of Cu in the country granodiorite and quartz diorite were given by El Mahallawi(1984) as 6 and 12 ppm respectively.

The average Zn content in the granodiorite wallrock of the main vein Q1 is 4.1 ppm, while the hydrothermal alteration zones have an average of 46.6 ppm. The estimated average of Pb in the altered granodiorite near the quartz veins is 15 ppm, and in the alteration zones is 19.6 ppm. The element concentration is 27.5 ppm in the quartz veins.

The average Co concentration of the studied granodiorite is 7 ppm, rather close to the recorded average for acidic igneous rocks. The quartz veins have a mean of 25 ppm, while the alteration zones concentration is 21 ppm. The average abundance of Ni in the country granodiorite is 9 ppm, and in quartz diorite is 11 ppm (El Mahallawi, 1984). The altered granodiorite of the mine area has values of 10-34 ppm in adit 1, and between 8 and 31 ppm in adit 2. The quartz veins have variable Ni contents that may reach 118 ppm for-Q1, and 133 for Q2. Also, the alteration zones show rather high contents of the element as 130 and 128 ppm for adits 1 and 2 respectively. Such high Ni concentration is rather due to the occurrence of niccolite inclusions in both pyrite and arsenopyrite. Concerning Cr, it has been mentioned that the smoky and milky quartz veins and different alteration zones have higher Cr contents (139, 93 and 15 to 98 ppm respectively) than the granodiorite host rock; 11.4 ppm(Helmy, 1991).

The lateral distribution of Au, As, Cu and Ag are particularly significant as illustrated in figures 3 and 4. From the lateral distributions of Au and associated elemnts, it can be mentioned that along the third level (Fig. 3), the maximum values of Au and Ag are present in the extreme SW part of the vein near the intersectoin of a basic camptonite dyke with the quartz vein. The conentration of As, Cu, Pb and Zn, however, are low. The values of these elements increase to the NW, while the Au values decrease in the same direction. However, a slight increase of Au is again observed near another intersection with an intermediate quartz mugearite dyke.



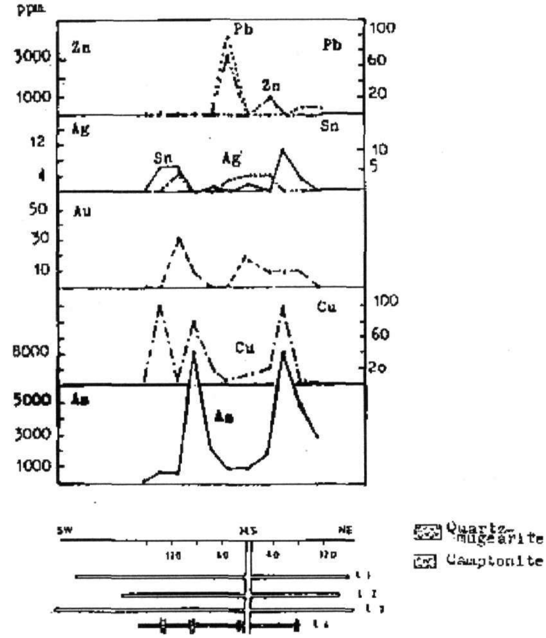


Fig 3. Distribution diagrams of As, Cu, Au, Zn and Pb along strike pf the main gold quartz vein-Q third level, Umm Rus gold mine.

Fig 4. Distribution diagrams of As, Cu, Au, Zn and Pb along strike pf the main gold quartz vein-Q forth level, Umm Rus gold mine.

The maximum concentration of As, Cu, Pb and Zn are met with in the NE part. In the fourth level (Fig.4), moderate concentrations of Cu, Au and Ag are observed in the SW part, near the intersections of the vein with quartz mugearite and camptonite dykes. The element concentraions increase again along the extension of the vein near the main shaft with maximum As, Pb, Zn, Au and Ag concentrations. Another part of the vein with moderate values of the analyzed elements is met with again in the NE part, near another intesection with the basic dyke.

The distribution diagrams along adits 1 and 2 of the three elements As,Cu and Ag are positively correlated with gold. The element is strongly correlated with sulver (0.764), and arsenic (0.913), but moderately correlted with copper(0.42).

Due to leaching by ground waters, the main vein has least values of As, Cu, Au, and Ag to a depth of 80m. This is followed downwards by a secondary enrichment zone with the elemental concentrations; As: 1000-2000 ppm, Au: 10-20 ppm and Ag:15 ppm. The extension of this zone is about 90m for the main vein.

5. DISCUSSION AND CONCLUSIONS

In the Umm Rus gold mine, the Au-bearing quartz veins are hosted by the Precambrian granodiorite rock, and located near the contacts of the rock with surrounding gabbros, where the meta-ferrogabbro occurs. The essential part of gold and the described elements occur associated with smoky quartz. Meanwhile, noticable amounts of such elements are also detected in the basic and intermediate dykes.

The conditions suitable to form a gold deposit were given by Hutchinsbn (1987), who noted that an efficient removed of gold depends on the nature of consistent minerals during the extraction processes. Also, Groves and Foster (1991), noted that most stable isotopic data of the Au-bearing quartz veins are consistent with either magmatic or metamorphic source of transporting fluids.

It should be mentioned that based on the geochemical data of Umm Rus granodiorite, and in veiw of absence of porphyry intrusoins both are not indicative for crustal melting but rather fractionation of an acidic magma. These facts most probably preclude the model of crustal contamination, and the porphyry magmatic models of Groves and Foster (1991). Still we have two possible sources of ore components, which are metamorphic and mantle-derived.Most probably, the contact meta-ferrogabbro could be a possible source of gold. Usually, gold is either incorporated in the pyroxenes and amphiboles or the immiscible sulphides (Lee and Tredoux,1986).The metaferrogabbro is commonly distributed near the gold mine, and commonly envolved few sulphide grains (as arsenopyrite, pyrite, chalcopyrite, tetrahedrite) and gold.

Therfore, a close relationship can be indicated for the gold bearing quartz veins and the meta-ferrogabbro rock. This is supported by the occurrence of relatively high Ni, Co, and Cr contents (95-113 ppm) in the mineralized quartz veins and other alteration zones. Also, this is in agreement with the conclusions of both Mikiucki and Ridley (1993), and Kolb, Meyer and Kisters (2000) concerning the role of hydrothermal fluids for gold deposits at different metamorphic grades. Kamel et al. (1983) also reported on similar K/Ar ages for hornblende separated from the Umm Rus granodiorute (570-610 Ma) and the metagabbro (580-606 Ma). Again, the same situation was also described by El-Bousiely et al., (1987) from El Sid gold mine.

So, the noticable gold contents in some quartz veins near the intersections with lamprophyre and mugearite dykes may suggest a genetic relationship. Therefore, it is widely accepted that such alkaline basic dykes are formed by mantle melting (Gottfreid and Greenland, 1972; Moiseenko and Fatyanov, 1972). So, it seems most probabale that the mineralizing solutions were partly introduced contemporaneous with lamprophyre dykes as concluded by Groves and Foster (1991). The latter authors also mentioned that such rocks may display primary enrichment of Au and other associated elements, i.e. high K, Rb, and Ba similar to their wallrock alterations.

Concerning the nature of the hydrothermal mineralizing fluids, the study of fluid inclusions from the gold-bearing quartz veins of Umm Rus mine indicate that they were caused by moderately hot fluids (270-300°C), with low salinity (0.8 to 3.5 equiv. wt. % NaCl) and pressure (700 to 1100 bars) as reported by Shazly et al. (1998).

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