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The Evaluation of Secondary Cu, Co, Ni, Cr and Mo Dispersion Patterns in the Southeastern Egyptian Desert

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ABSTRACT. Geochemical stream sediment surveys were carried out in the Samiuki-Hamata area of the Southeastern Egyptian Desert. Results indicate that in prospecting for Cu the fine fractions of the stream sediments (< 0.075 mm) are suitable for cold extraction technique, and the coarser fractions (< 1 and > 0.25 mm) are more suitable for spectrographical analyses. The soluble Cu ranges from 0.6 to 7% of the total Cu suggesting that mechanical dispersion of Cu is dominant and chemical dispersion plays a limited role in the development of the secondary dispersion trains and halos in this arid conditions. Spectrographical analyses of the −0.5 + 0.25, −0.25 + 0.15 and −0.15 + 0.075 mm fractions of the stream sediments gave the best contrasts for Ni, Cr and Mo, respectively, indicating differences in their geochemical patterns. The reconnaissance stream sediment survey revealed a pattern of Cu distribution that is relatable to known mineral occurrences. Cr, Co and Ni are coprecipitated and are probably related to a common source material such as the mafic-ultramafic ophiolites. The Cu mineralization probably had a volcanic origin. The mineralized zones were then remobilized by late-stage Ca and Mg-bearing hydrothermal solutions associated with the rejuvenation of deep fault zones, resulting in the present association of Cu and talc mineralization within shear zones.

The Samiuki-Hamata metavolcanic complex covers an area of 4800 km^2 in the Southeastern Desert of Egypt (Fig. 1). A small massive Cu sulphide body occurring at Samiuki was worked by the ancient Egyptians (> 4000 B.C.) whose working extend up to 15 m underground. Pre-Pharaonic slag, pottery and crusher stones are common in the district, and the slag contains blebs of metallic Cu up to 6 mm in diameter. The principal ore minerals are chalcopyrite, sphalerite, galena and pyrite, whereas malachite, azurite, and chrysocolla, mixed with hematite and limonite, occur in the supergene zone, and were the secondary minerals usually excavated by the ancients. Malachite staining, with apparent economic significance, occurs along a NW-SE fracture zone cutting the metavolcanic complex at Abu

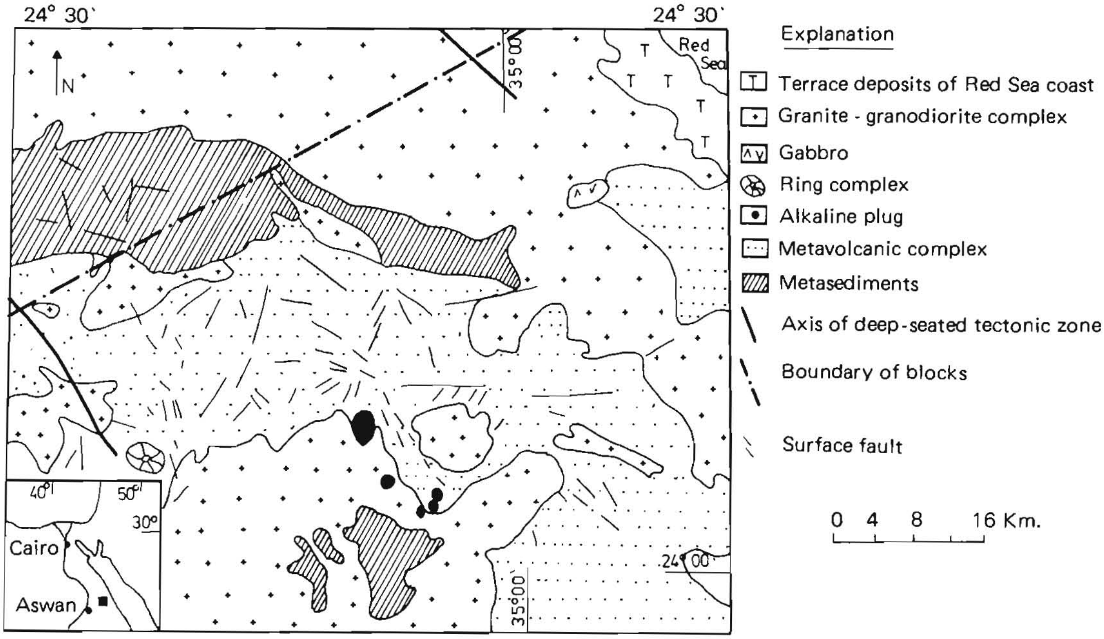

Fig. 1. Geological map of Samiuki-Hamata area, (after Hunting 1967, Lockwood 1968).

Gurdi, Darheab, Maakel and Helgait. Some of these occurrences are associated with talc-steatite-pyrite mineralization. Previous studies on the Samiuki mineralization have been made by Nassim *et al.* (1954), El-Shazly and Afia (1958), Kamel and Karamani (1962), Polytecijna (1959), Lockwood Geophysical Corporation (1968), Hunting Geology and Geophysics (1967).

In recent years, the Regional Planning Authority of Aswan and the Geological Survey of Egypt with the assistance of the UNDP initiated a comprehensive program for the assessment of the mineral potential of the Southeastern Desert of Egypt (80,000 km^2). In this program, geochemical stream sediment surveys were carried out in the Samiuki-Hamata area. The aims of these surveys were (i) to explore for new ore bodies and (ii) to identify any extensions of the known ore bodies. The effectiveness of stream sediment sampling techniques was tested near a known area of Cu mineralization at Darheab. The objectives were (i) to delineate geochemical anomalies that relate to mineralization; (ii) to assist in understanding the main factors affecting the metal dispersion and development of secondary dispersion trains and halos in the Egyptian arid climate; and (iii) to determine the size fractions of the stream sediments that are most suitable for geochemical prospecting and exploration purposes in arid terrains.

Topography and Physical Features

The Samiuki-Hamata area is a rugged mountainous desert of high relief (some peaks rising up to 1747 m above sea level, *e.g.*, Jabal Abu Hamamead). The area is strongly dissected by a radiating wady system centred to Samiuku area. Most wadis have steep sides and flat bottoms; the area is generally difficult to access; extremely arid and hot, and the rocks are well exposed. Rainfall is low and water and vegetation are sparse. Vegetation is represented by sparsely distributed acacia trees and low-lying shrubs that occur mainly in the big wadis. True soils are absent; poorly sorted rock fragments, including sands, gravels, pebbles and boulders up to 2 m in diameter, are the main constituents of the wadi sediments. Stream sediments in wadis draining granitic terrains are mechanically more sorted than those in wadis draining the metamorphic rocks. In a few cases, where catchments are of mafic and ultramafic rocks, the slopes are covered by a thin eluvial and colluvial veneer resembling skeletal immature soil (*e.g.*, in the Samiuki area). Mean temperature ranges from 15°C in January to 35°C in July with diurnal extremes ranging from about zero to over 50°C. Optimum conditions for field work occur between September and April.

General Geology and Tectonics

The Samiuki-Hamata area consists of a late Precambrian metasediments-metavolcanics association into which granites, granodiorites, syenites and trachytes have been intruded; all are traversed by dykes and quartz veins. The metasediments, the oldest rocks in the district, were originally muddy and sandy sediments; mudstone, schists and amphibolites are the more common rock types. The metasediments form an elongate NW-SE belt in the northern part of the area (Fig. 1). They are associated and interdigitate with a thick calc alkaline volcanic sequence. Rock types present range in composition from basalts through andesites to dacites and rhyolites. Eruptive rocks occur as pillow lavas, tuffs, agglomerates and breccias. Metamorphism up to the amphibolite facies has taken place. Associated intrusive rock types include gabbros, dolerites, microgranites and lamprophyres. The metavolcanics have been previously interpreted as an early phase of geosynclinal filling (Akaad and El-Ramly 1960) and more recently as formed in ensimatic island arc or continental margin volcanic arc setting (Garson and Shalaby 1976, Gass 1977, Hashad and Hassan 1979, Engel *et al.* 1980). The mafic-ultramafic rocks are, in this contract, interpreted as ophiolites (Nasseef *et al.* 1980). Stern (1979) and Shackleton *et al.* (1980) have subdivided the metavolcanics into the calc-alkaline types erupted in an immature arc setting and those of ophiolitic, low K-tholeiitic affinity that represent tectonically displaced oceanic crust originally formed above a subduction zone. El-Ramly *et al.* (1982) indicated that the basic metavolcanics have mixed tholeiitic/calc-alkaline character, whereas the acidic metavolcanics are dominantly calc-alkaline.

The granite-granodiorite association occupies about 2750 km^2 (Fig. 1) and consists of several diorite and tonalite masses. The rocks present range about granodiorite, tending to be granite at the core and more basic at the margins where xenoliths and less defined clots of basic composition are common; gneissose varieties are recorded. These granitic rocks are weathered to form extensive sandy plains with scattered accumulations of boulders in tor-like outcrops. The wadis in these plains are ill-defined, and during rainfalls much of the run-off is in sheet flow. Some volcanic plugs and a ring complex of syenites and other alkaline rocks are exposed in the southeastern part of the district (Fig. 1).

Propylitization is common in the granitic rocks. Silicification, pyritization, chloritization and the formation of talc are frequent in the basic and intermediate varieties of the metavolcanics.

The Samiuki-Hamata area is strongly folded primarily along NW-SE and secondarily along NE-SW axes (Hunting 1967), and is cut by faults and dykes whose strike directions are predominant by NW-SE and NE-SW. Many wadis show rectilinear courses following the two fault trends, indicating preferential erosion along major fault zones. Several NW-SE shear zones up to 2 km long and 2-20 m in width are recorded in the metavolcanics. Malachite staining, talc-carbonate rocks, fine silica and chlorite are frequent in these shear zones.

The aeromagnetic survey carried out by Lockwood Geophysical Corporation (1968) in the Southeastern Desert of Egypt showed that the Samiuki-Hamata area is traversed by two deep-seated tectonic zones and a block fault. The deep-seated tectonic zones have a NW-SE direction parallel to the lineation of the Red Sea, whereas the block fault has a NE-SW direction and divides the Samiuki-Hamata district into two blocks (Fig. 1). The term deep-seated tectonic zones refers to zones of deep rifts running deep through the crust which behave as channel ways for the ascending magmatic products. On the surface, they are characterized by linear trends of several hundred kilometres extent, and whose width is measured in hundreds of meters. These zones are prominent structural features in the crust and are characterized by various geological processes, among which are mineralization and hydrothermal alterations. Two distinctive types of such zones occur in the Southeastern Desert of Egypt (Krs *et al.* 1973, Krs 1977, Garson and Krs 1976, Soliman 1981 a and b, 1982). The most characteristic features of the first type are huge tholeiitic dykes giving rise to anomalous magnetic and electrical properties along the whole zone. The second type is characterized by anomalous radioactivity, intense metamorphism, and frequent acidic and alkaline ring complexes, intrusions, and metasomatic alterations.

Geochemical studies

Sixty stream sediment samples were collected along a 4 km wadi traverse draining known mineralized and background areas in the Darheab area. Stream sediments were sampled at about 20 cm depth below the surface and at interval of between 50 to 100 m. Each sample was consisted of 300 g of < 1 mm fraction of the sediments. Each sample was then sieved through 0.75, 0.5, 0.25, 0.15 and 0.075 mm stainless steel sieves. All these fractions were analysed twice, first for cold extractable copper (C_x Cu) by the use of biquinoline reagent (McPhar Kit) and for Cu, Cr, Ni and Mo by means of the emission spectrograph to ascertain which size fraction of the stream sediments and which analytical technique would give the better geochemical contrast.

Rose & Keith (1976) indicated that the geochemical contrast between stream sediment samples from mineralized and non-mineralized (background) areas depends on the difference between the anomaly and background as well as their standard deviations. Ukpong and Olade (1979) have shown that the geochemical contrast (t) can be derived from the following equation by the use of Student's t-test (Freund and Williams 1977):

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 - n_2 - 2}} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where $\bar{X}_1$ and $\bar{X}_2$ are the mean values of anomalous and background samples, n_1 and n_2 are the number of anomalous and background samples and S_1 and S_2 are the standard deviations of anomalous and background samples.

The calculated geochemical contrasts for Cu, Cr, Ni and Mo for cold extraction and spectrographical techniques for the six size fractions of the stream sediments are shown in Tables 1 and 2.

The cold extraction technique for Cu gave the best contrast when applied for the fine fractions of the stream sediments (< 0.075 mm) and lower geochemical contrast for the coarser fractions (< 1 > 0.75 mm) (Table 1). On the other hand, spectrographical analyses for Cu gave the best contrast when applied for these coarser fractions and relatively lower values of geochemical contrast for Cu were obtained by this technique for the fine fractions (Table 1). The soluble Cu (determined by cold extraction) ranges from 0.6 to 7% of the total Cu content of the stream sediments; determined by spectrographical analyses. These observations indicate that Cu is bonded mainly to the coarser fractions of the stream sediments and a small portion of Cu is bonded to the fine clay and silt fractions. This portion of Cu is probably leached from the coarser fractions of the stream sediments as

Table 1. Comparison of contrast (t values) for different size fractions of the stream sediments on cold extraction (C_x Cu) and spectrographic analyses of copper (Cu).

Size fraction (in mm)		Arithmetic mean (ppm)		Standard deviation (ppm)		Variation coefficient %		Contrast (t values)
		Anomalous	Background	Anomalous	Background	Anomalous	Background	
1.00-0.75	C_x Cu	4	1	4	0.7	110	53	2.85
	Cu	95	17	44	7.0	47	40	7.57
0.75-0.50	C_x Cu	5	2	5	1.0	98	76	3.21
	Cu	74	10	57	6.0	77	59	5.19
0.50-0.25	C_x Cu	4	1	3	1.0	84	66	2.86
	Cu	78	11	44	3.0	56	31	6.30
0.25-0.15	C_x Cu	4	2	2	1.5	51	70	2.89
	Cu	32	21	19	8.0	57	38	2.20
0.15-0.075	C_x Cu	6	3	3	1.5	56	56	4.16
	Cu	23	13	12	6.0	54	46	2.66
< 0.075	C_x Cu	9	4	4	1.7	47	49	5.61
	Cu	19	9	11	6.0	57	69	3.53

Table 2. Comparison of contrast (t values) for different size fractions of the stream sediments on spectrographical analyses.

Size fraction (in mm)		Arithmetic mean (ppm)		Standard deviation (ppm)		Variation coefficient %		Contrast (t values)
		Anomalous	Background	Anomalous	Background	Anomalous	Background	
1.00-0.75	Ni	28	13	16	7	57	51	3.25
	Cr	45	26	35	11	78	45	1.42
	Mo	32	11	29	8	90	82	2.08
0.75-0.50	Ni	23	9	10	6	44	66	4.39
	Cr	40	22	34	9	85	42	1.41
	Mo	16	7	12	3	71	38	3.02
0.5-0.25	Ni	24	9	9	2	39	23	6.62
	Cr	26	20	5	14	18	70	0.66
	Mo	22	6	15	3	67	43	2.98
0.25-0.15	Ni	16	8	8	4	50	55	3.18
	Cr	25	5	7	2	30	40	8.65
	Mo	32	8	16	2	71	29	2.95
0.15-0.075	Ni	15	7	7	2	48	39	3.96
	Cr	25	10	10	2	40	20	3.00
	Mo	21	6	9	3	41	42	4.05
< 0.075	Ni	17	10	8	3	46	38	2.63
	Cr	36	25	31	7	85	28	0.85
	Mo	23	7	18	5	77	77	1.89

the result of oxidation, chemical disintegration and transition of Cu into a water-soluble state during the brief and infrequent rains (Bugrov 1974).

These observations indicate that mechanical dispersion of Cu is dominant and chemical dispersion plays a limited role in its secondary dispersion pattern in the arid Egyptian climate. Similar results were recorded by United Nations (1974), Bugrov (1974) and Soliman (1981a).

The geochemical contrasts for Ni, Cr and Mo for the six fractions of the stream sediments based on spectrographical analyses are given in Table 2. The 0.5-0.25; 0.25-0.15 and 0.15-0.075 mm fractions gave the best contrasts for Ni, Cr and Mo, respectively. The uneven concentration of these elements in different size fractions of stream sediments is probably due to differences in their mobility and stability which Overstreet and Marsh (1981) ascribe to differences in types of ore minerals containing these elements.

Reconnaissance Stream Sediment Survey

About 2000 stream sediment samples were collected from an area of about 3000 km^2. Sampling at a depth of 20 cm and for particle size < 1 mm was carried out on a 2000 $\times$ 1000 m grid, giving an average sampling density of one sample per 1.5 km^2. Semiquantitative analyses for Cu, Co, Ni, Cr, Mo and Pb in these samples were obtained by means of the emission spectrograph in the laboratories of the 'Aswan Mineral Survey-UNDP Project'. Mean values and standard deviations for the concentrations of these elements are given in Table 3.

The background value of Cu (its mean value in about 150 samples from a non-mineralized area) is 20 ppm. The highly anomalous concentrations of Cu ($>$ mean + 2 standard deviations, *i.e.*, $>$ 50 ppm) are presented in Fig. 2, which shows that Cu anomalies are concentrated mainly near known Cu occurrences at

Table 3. Means, standard deviations and range of stream sediment data (ppm).

	Arithmetic mean	Geometric mean	Standard deviation	Variation coefficient (%)	Range
Cu	35	11	54	154	10-4000
Co	12	6	7	58	5-50
Ni	21	5	47	223	5-300
Mo	7	4	9	128	0-50
Cr	74	50	95	128	30-1000
Pb	13	10	15	115	0-200

Darheab, Samiuki, Maakel, Helgait and Abu Gurdi. Isolated samples with more than 3000 ppm Cu were encountered in many wadis, usually near malachite staining.

The known Cu occurrences and related geochemical anomalies lie in a NW-SE linear zone that extend for about 60 km from Abu Gurdi in the SE to Samiuki in the NW (Fig. 2). It is also parallel to a deep-seated tectonic zone with the NW-SE trend and is characterized by intensive metamorphism, metasomatism and mineralization caused by alkaline and silicic intrusions.

The well documented (*e.g.*, Horikoshi 1969, Tatsumi and Clark 1972, Descarreaux 1973, Goodfellow 1974, Cameron 1974, Garrett 1974, Shiikawa *et al.* 1974) world-wide association of the calc-alkaline volcanic complexes with sulphide ore bodies indicates that the mineralization here described is probably of the Kuroko type, and is similar in many respects to the Canadian Precambrian massive sulphide. Some of the deep-seated mineralized zones appear to have been subjected to remobilization by late-stage Ca- and Mg-bearing hydrothermal solutions along deep-seated tectonic zones.

Figure 2 shows that the dispersion halos and trains of Cu are limited; probably due to the weak nature of Cu mineralization in the district. The concentration of

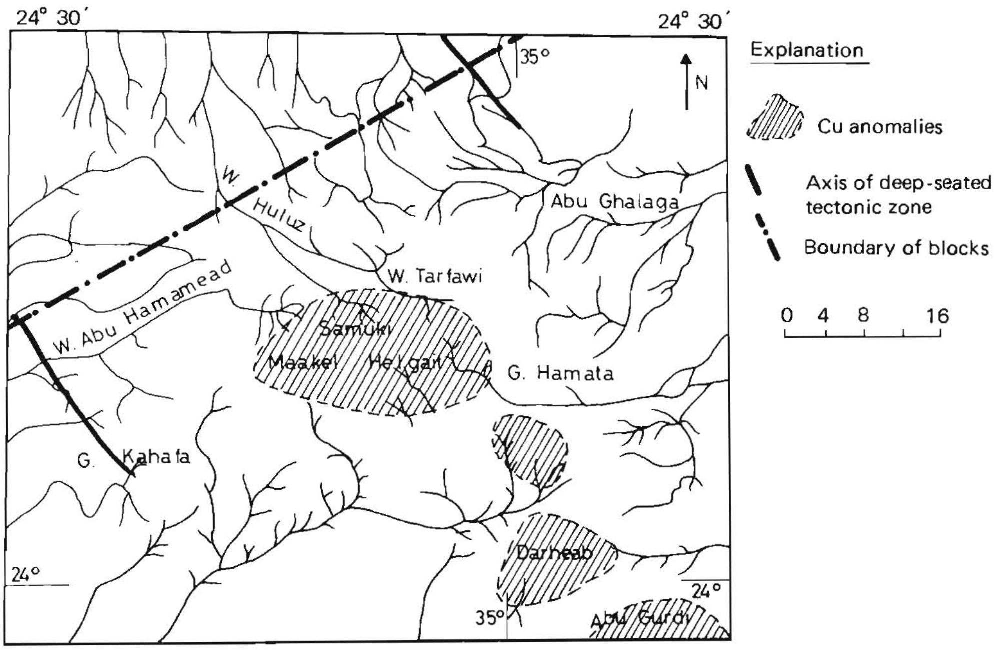

Fig. 2. Geochemical anomalies of Cu in stream sediments, Samiuki-Hamata area.

Table 4. Correlation coefficients (r).

	Cu	Co	Ni	Mo	Cr
Co	0.33	–	–	–	–
Ni	0.20	0.87	–	–	–
Mo	0.16	0.12	0.16	–	–
Cr	0.33	0.65	0.76	0.22	–
Pb	−0.07	−0.08	−0.03	0.40	−0.03

Cu in these geochemical anomalies is greatest near the known Cu occurrence and decreases with distance from the source due to dilution with barren stream sediments. Long dispersion trains of Cu (up to 3.5 km) are recorded in wadis draining areas of known Cu mineralization. The length of these dispersion trains is probably affected by the amount and transporting capacity of the water flowing through these wadis, dragging, rolling and carrying the stream sediment particles with their associated Cu minerals. The considerable length of the dispersion trains facilitates the detection of small zones of Cu mineralization by regional reconnaissance survey.

Anomalous Ni, Co and Cr values (> 500, 100 and 1000 ppm, respectively) were detected in a few erratic samples all over the district. Strong positive correlation was found between Co and Ni (+ 0.87), Co and Cr (+ 0.65) and between Cr and Ni (+ 0.76), Table 4,suggesting that these elements are coprecipitated and most probably related to a common source rock such as the mafic-ultramafic ophiolites. The detected correlation between Pb and each of Cu, Co, Ni and Cr (Table 4) suggest that there is no reliable sympathetic relationship between them, and, therefore, they have not been coprecipitated. On the other hand, intermediate correlation is found between Pb and Mo and weak correlation is found between Cu and each of Co, Ni, Mo and Cr (Table 4).

Conclusion

The results presented in this paper show that the fine fractions of the stream sediments (< 0.075 mm) are a suitable sampling medium in prospecting for Cu by the cold extraction technique, while coarser fractions (< 1 and > 0.25 mm) are more suitable for spectrographical analyses. The soluble extractable Cu in stream sediments ranges from 0.6 to 7% of the total Cu content, suggesting that Cu minerals are chiefly mechanically dispersed. Chemical dispersion of Cu (represented by the soluble extractable Cu absorbed on the fine fractions of the stream sediments) plays a limited role in the development of the secondary dispersion pattern of Cu in the district.

Different concentrations of Ni, Cr and Mo were recorded in different fractions of the stream sediments suggesting differences in their mobility probably due to their association with different rock types. The reconnaissance stream sediment survey revealed the presence of some Cu anomalies related to known Cu occurrence and hydrothermally altered rocks at Samiuki, Helgait, Maakel, Darheab and Abu Gurdi. The Cu mineralization in the district is probably of sumbarine volcanic origin deposited at deep levels by hot springs related to some siliceous phases of the metavolcanic complex. Some of the deep-seated mineralized parts were probably remobilized through late-stage Ca and Mg-bearing hydrothermal solutions associated with rejuvenated deep-seated tectonic zones, resulting in the development of the present Cu and talc ore bodies as well as the malachite staining and hydrothermal alterations throughout the metavolcanic complex.

Anomalous concentrations of Ni, Co and Cr are recorded in some alluvial samples and are probably related to mineralized ultramafic rocks. In the arid environment of the study area, reconnaissance surveying along secondary dispersion trains proved to be a successful method of delineating small zones of Cu, Co, Ni and Cr mineralization.

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References

Akaad, M.K. and **El-Ramly, M.F.** (1960) Geological history and classification of the basement rocks of the central Eastern Desert of Egypt, *Egypt. geol. Surv., Cairo*, Paper no. **9**.

Bugrov, V. (1974) Geochemical sampling techniques in the Eastern Desert of Egypt, *J. geochem. Explor.* **3**: 67-75.

Cameron, E.M. (1974) Geochemical methods of exploration for massive sulphide mineralization in the Canadion Shield. *In*: **Elliot, I.L,** and **Fletcher, W.K. (eds)** *Geochemical Exploration 1974*, Elsevier Publ. Co., Amsterdam, 1975: pp. 21-49.

Descarreaux, J. (1973) A petrochemical study of the Abitibi volcanic belt and its bearing on the occurrences of massive sulphide ores, *Bull. Can. Inst. Min. Metall.* **66**: 61-69.

El-Ramly, M.F., Hashad, A.H., Attawyia, M.Y. and **Mansour, M.M.** (1982) Geochemistry of Kolet Um Kharit bimodal metavolcanics, Southeastern Desert, Egypt, *Annals geol. Surv. Egypt,* **11**: 103-120.

El-Shazly, E.M. and **Afia, M.S.** (1958) Geology of Smiuki deposit, Eastern Desert, Egypt. *Egypt. J. Geol.* **2**: 25-42.

Engel, A.E.J., Dixon, T.H. and **Stern, R.J.** (1980) Late Precambiran evolution of Afro-Arabian crust from ocean arc to craton, *Bull. geol. Soc. Am.* **91**: 699-706.

Freund, J.E. and **Williams, F.J.** (1977) *Modern Business Statistics*, *2ed.* Pitman Publ. Ltd., London, 541 P.

Garrett, R.G. (1974) Copper and zinc in proterozoic acid volcanics as a guide to exploration in the Bear Province, Canada. *In*: **Elliot, I.L.** and **Fletcher, W.K. (eds)** *Geochemical Exploration 1974*, Elsevier Publ. Co., Amsterdam, pp. 371-388.

Garson, M.S. and **Shalaby, I.M.** (1976) Precambrian Lower Paleozoic plate tectonics and metallogenesis in the Red Sea region, *Spec. Pap. geol. Ass. Can.* **14**: 573-596.

Garson, M.S. and **Krs, M.** (1976) Geophysical and geological evidence of the relationship of Red Sea transverse tectonics to ancient fractures, *Bull. geol. Soc. Am.* **87**: 169-181.

Gass, I.G. (1977) The evolution of the Pan-African crystalline basement in NE Africa and Arabia, *J. geol. soc. Lon.* **134**: 129-138.

Goodfellow, W.D. (1974) Major and minor element halos in volcanic rocks at Brunswick No 12 Sulphide Deposit, N.B. Canada. *In:* **Elliot, I.L.** and **Fletcher, W.K. (eds)** *Geochemical Exploration 1974*, Elsevier Publ. Co., Amsterdam, pp. 279-295.

Hashad, A.H. and **Hassan, M.A.** (1979) On the validity of an ensimatic island arc cratonization model to the evolatuon of the Egyptian Shield, *Annals geol. Surv. Egypt.* **9**: 70-80.

Horikoshi, E.L. (1969) Volcanic activity related to the formation of the Kuroko-type deposits in the Kosaka district, Japan, *Mineral. Deposita* **4**: 321-345.

Hunting Geology and Geophysics (1967) *Photogeological Survey for the Aswan Region, Egypt*, Contractor's report for the United Nations. London, 137 P.

Kamel, E. and **Karamani, E.M.** (1962) *Report on the geophysical work carried out in the area of Abu Gurdi and Darhib in the Eastern Desert for the prospoection of copper ore deposit*, Geol. Surv. Egypt, Cairo.

Krs, M. (1977) Rift tectonics development in the light of geophysical data, Red Sea region, *Studia geophys. geod.* **21:** 342-350.

Krs, M., Soliman, M.M. and **Amin, H.A.** (1973) Geophysical phenomena over deep-seated tectonic zones in the southeastern part of Eastern Desert of Egypt, *Annals geol. Surv. Egypt.* **3**: 125-138.

Lockwood Geophysical Corporation (1968) *Airborne magnetometer, scintillation counter and electromagnetometer survey of part of Aswan region, Egypt*, Contractor's report for the United Nations. Toronto, Canada, 79 p.

Nasseef, A.O., Bakor, A.R. and **Hashad, A.H.** (1980) Petrography of possible ophiolitic rocks along the Qift-Quseir road, Eastern Desert, Egypt: *Inst. appl. Geol. (Jeddah) Bull.* **4** (3): 157-168.

Nassim, S., Fahim, M., Afia, M.S. and **Foda, A.A.** (1954) *The prospecting work carried out in the wadi Hamata area,* Mines and Quarries Dept. Geol. Surv. Egypt. Cairo.

Overstreet, W.C. and **Marsh, S.P.** (1981) Some concepts and techniques in geochemical exploration. *Econ. Geol., 75th Anniversary vol.*: 775-805.

Polytecijna (1959) *Report on the results of geophysical measurements in the larger area of Um Samiuki*, Polytecijna, Czechoslovak Foreign Trade Corporation, Prague.

Rose, A.W. and **Keith, M.L.** (1976) Reconnaissance geochemical techniques for detecting uranium deposits in sandstones of northeastern Pennsylvania, *J. geochem. Explor.* **6**: 119-137.

Shackleton, R.M., Ries, A.C., Graham, R.H. and **Fitches, W.R.** (1980) Late Precambrian ophiolitic melange in the Eastern Desert of Egypt, *Nature* **85**: 472-474.

Shiikawa, M., Wakasa, K. and **Tono, N.** (1974) Geochemical exploration for kuroko deposits in northeast Honshu, Japan. *In:* **Elliot, I.L.** and **Fletcher, W.K. (eds)** *Geochemical Exploration 1974*, Elsevier Publ. Co., Amsterdam, pp. 65-76.

Soliman, M.M. (1981a) Mineral exploration practice in Egypt, (Abst.), *5th Conf. Basement Tectonics, Oslo, Norway.*

Soliman, M.M. (1981b) Geochemical surveys for Sn, Nb, Cu and Au mineralization, Mueilha-Dungash area, Southeastern Desert, Egypt, *Geol. Mag.* **118**: 545-549.

Soliman, M.M. (1982) Geochemical prospecting for Cu in Hamash area, Southeastern Desert, Egypt, *Geol. Mag.* **119**: 319-323.

Stern, R.J. (1979) Late Precambrian crustal environments as reconstructed from relict igneous minerals, central Eastern Desert of Egypt, *Annals geol. Surv. Egypt* **9**: 9-31.

Tatsumi, T. and **Clark, L.A.** (1972) Chemical composition of acid volcanic rocks genetically related to formation of the Kuroko deposits, *J. geol. Soc. Japan* **78**: 191-201.

Ukpong, E.E. and **Olade, M.M.** (1979) Geochemical surveys for lead-zinc mineralization, southern Benue Trough, Nigeria. *Trans. Instn Min. Metall.*, B 81-B 92.

United Nations (1974) *Assessment of the mineral potential of the Aswan region-Technical report, geochemical operations 1968-1972, for the Government of Egypt*, DP/SF/UN/114, New York, 79 p.

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دراسة وتقويم التشتت الثانوى لعناصر النحاس والكوبلت والنيكل والكروم والموليبدينوم بجنوب الصحراء الشرقية بمصر

مصطفى محمود سليمان

قسم الجيولوجيا - كلية العلوم - جامعة الزقازيق - مصر

تم إجراء مسح جيوكيميائى باستخدام رواسب الوديان فى منطقة أم سميوكى - حماطة فى جنوب الصحراء الشرقية بمصر وذلك لغرض دراسة وتقويم التشتت الثانوى للنحاس والكوبلت والنيكل والكروم والموليبدينوم فى البيئة الصحراوية الجافة وكذلك دراسة معدنة النحاس المعروفة فى المنطقة والكشف عن مناطق أخرى ممعدنة.

بينت الدراسة أنه فى حالة التنقيب عن النحاس، فإن رواسب الوديان الناعمة (حجم الحبيبات أقل من ٠,٠٧٥ مم) تعطى نتائج أفضل باستخدام طرق التحليل الكيميائى على البارد. أما رواسب الوديان الخشنة (والتى يتراوح حجم حبيباتها من ١ مم إلى ٠,٢٥ مم) فإنها تعطى نتائج أفضل باستخدام طرق التحليل الطيفي.

أثبتت الدراسة أن كمية النحاس القابلة للذوبان فى رواسب الوديان (والتى يمكن تقديرها بطريقة التحليل الكيميائى على البارد) تتراوح بين ٠,٦ الى ٧٪ من كمية النحاس الكلية (والتى يمكن تقديرها بالتحليل الطيفى) مما يدل على أن التشتت الميكانيكى للنحاس هو الغالب فى البيئة

الصحراوية الجافة وأن التشتت الكيميائى يلعب دورا ضئيلا فى تكوين هالات التشتت الثانوية فى هذه البيئة.

أثبتت الدراسة اختلاف تركيز عناصر النيكل والكروم والموليبدينوم فى رواسب الوديان باختلاف حجم حبيباتها وذلك لوجود تباين فى التشتت الجيوكيميائى وسيولة هذه العناصر.

أظهر المسح الجيوكيميائى الاستطلاعى بالمنطقة أن مناطق شذوذات النحاس مرتبطة أساسا بمواقع وجود خامات النحاس المعروفة سابقا.

أثبتت الدراسة الإحصائية تلازم وارتباط عناصر الكروم والكوبلت والنيكل فى رواسب الوديان. وقد يرجع ذلك إلى ارتباط هذه العناصر بمصدر صخرى عام واشتقاقها منه أثناء تجوية وتحلل هذا المصدر وهو غالبا أحد صخور الأوفيوليت القاعدية.

يمكن إرجاع معدنة النحاس فى المنطقة إلى أصل بركانى (مثل النوع الكندى أو اليابانى المعروف باسم كوروكو). ويبدو أن معدنة النحاس فى المنطقة قد تعرضت مؤخراً لعمليات إسالة بواسطة محاليل حرمائية غنية بالمغنسيوم والكالسيوم مصاحبة لتجديد نشاط بعض الفوالق العميقة فى المنطقة، وكان نتيجة ذلك ترسيب معادن التلك والنحاس سويا فى مناطق القص فى المستويات العليا لصخور الأوفيوليت وانتشار قشور الملاكايت والصخور الكربوناتية فى مواقع عديدة فى صخور المنطقة.