

## Ancient Emerald Mines and Beryllium Mineralization Associated with Precambrian Stanniferous Granites in the Nugrus-Zabara Area, Southeastern Desert, Egypt

Mostafa M. Soliman

*Geology Department, Faculty of Science, Zagazig University,  
Zagazig, Egypt.*

---

**ABSTRACT.** Geochemical rock sampling and panning of alluvium suggest the occurrence of a geochemical province of beryllium, in which beryl is the main beryllium mineral, in the Nugrus-Zabara area. The province lies in a NW-SE belt parallel to a deep-seated tectonic zone of the Red Sea trend and extends for about 40 km from Um Kabu in the SE to Zabara in the NW. The province is restricted to certain horizons of mica schists and quartz veins in contact with greisenized and albitized stanniferous granites and is probably developed by pneumatolytic and hydrothermal fluids (developed during the evolution of stanniferous granite magma) which moved along deep-seated tectonic zones. The province is also characterized by biotitization, tourmalinization and silicification of the schists and increased concentrations of Be, Sn, Nb, Pb, Y and Cu in the granites, schists, quartz veins and pegmatite dykes. The ancient emerald mines are located within the boundaries of this province.

The Nugrus-Zabara area is located in the south eastern Desert of Egypt (Fig. 1) and was long known as a mining district for emerald and gold. At present, there are no active mines in the district. Records of old mining and ruins of habitations, dumps of workings for emerald, workshops, gold grinding stones (crushers), talcose and porcelain pots distributed over the district testify to the intensive and active mining operations carried out in the past. The ancient Egyptians (> 4000 B.C.) were the first to prospect for emerald and gold in the district. The last of mining operation for emerald was carried out by a French company during the 1920's (Hume 1934). The huge dumps near the old emerald mines usually contain rejected low grade crystals of beryl, and it is possible, especially after a rainfall, to collect broken green crystals of beryl up to 3 cm long. Judging the extensive mine excavations, the huge dumps, and the quantity of low grade beryl in the dumps it appears that the ancient mines yielded large quantities of emerald.



Bugrov (1972), Bugrov *et al.* (1973), United Nations (1974), and Soliman (1981, 1982, 1984a) believe that there is a clear spatial relationship between beryllium mineralization in Egypt and stanniferous granites. In the present work reconnaissance rock-sampling of the granites and panning of alluvium in the Nugrus-Zabara area have been carried out in order to study the beryllium mineralization and its relation to stanniferous granites in the district.

### General Geology and Tectonics

Rocks of the Nugrus-Zabara area (about 1680 km<sup>2</sup>) are late Precambrian in the age and include ophiolitic melange and associated sediments into which granodiorites and different granites have been intruded; all are traversed by dykes and quartz veins. The metasediments, which are the oldest rocks in the district (1200 - 850 Myrs., El Ramly 1972, in Saudi Arabia, the age reported for some ophiolites ranges between 800 and 600 Myr., Cleasson *et al.* 1984, Harris *et al.* 1984) and include essentially muddy and sandy sediments, psammitic gneisses, schists, mudstones and amphibolites as the more common rock types. The ophiolites (which represent pieces of Precambrian oceanic crust, Bakor *et al.* 1976, Church 1979, El Sharkawi and El-Bayoumi 1979, El-Bayoumi 1980, Shackleton *et al.* 1980, Takla *et al.* 1982) comprise both volcanic and plutonic rocks. The volcanic rocks comprise calc-alkaline and tholeiitic varieties. The calc-alkaline varieties are dominant. 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 and serpentinites. The metasediments-ophiolite melange covers an area of about 500 km<sup>2</sup> and forms an elongated NW-SE belt (Fig. 1). The general direction of foliation of the schists is nearly NW-SE. The metasediments and metavolcanics usually interdigitate and grade into each other.

The granodiorite complex (987 - 830 m.y., Hashad, 1979 in Shackleton *et al.* 1980) occupies about 1000 km<sup>2</sup> (Fig. 1) and consists of several diorite and tonalite masses. The rocks range about granodiorite in composition tending to be granite at the core and more basic at the margins. There is no obvious relationships between these granodiorites and beryllium mineralization in the district.

Several biotite and/or muscovite granite plutons pertaining to the younger granite suite of Egypt (640 - 480 m.y., El-Shazly 1964) intrude the granodiorite complex and the metasediment-ophiolite melange (Fig. 1). The biotite granites being the most abundant. They are usually intensively kaolinized and sericitized (Fig. 2) and sometimes associated with vein-type gold mineralization (*e.g.*, Hangalia gold mine). Some biotite granites show gneissose texture. The muscovite granites are white or light grey, forming small bodies intruding schists and biotite

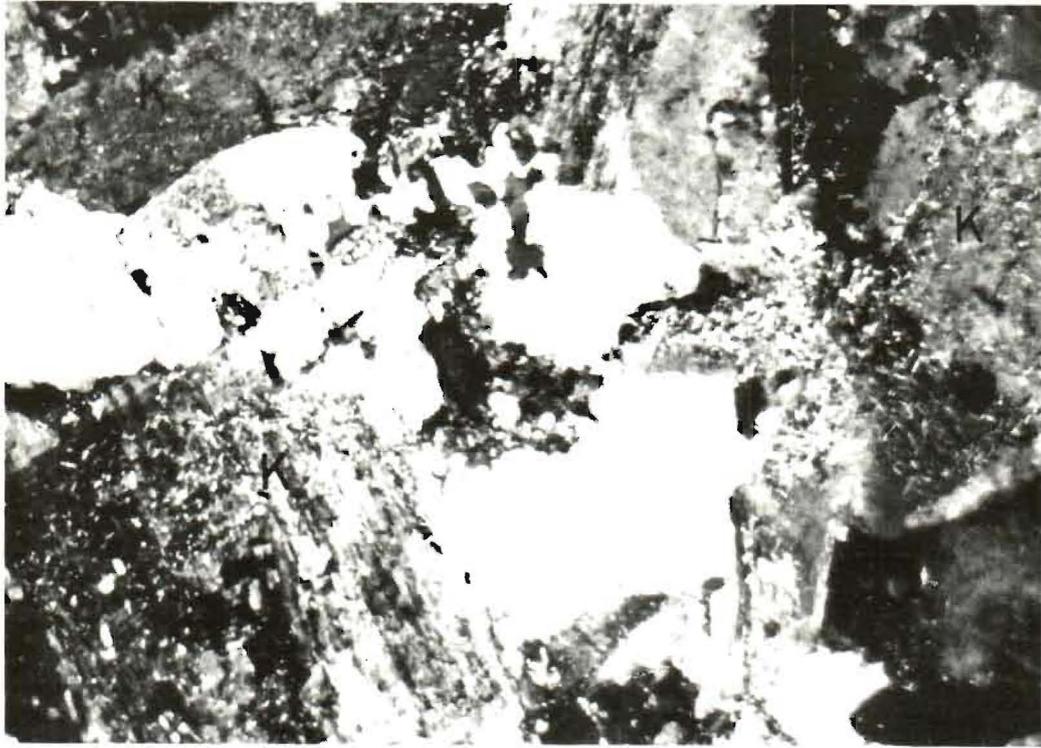


Fig. 2. Photomicrograph of biotite granite from Gabal Nugrus showing intensive alteration of feldspars (K). C.P. X 75.

granites. They consist of albite, quartz, K-feldspar and muscovite. The albite is usually fresh (Fig. 3) and sometimes replaces K-feldspar. The biotite granites and muscovite granites are greisenized in parts. At the contact of some gneissose biotite granites and schists there are abundant pockets of biotite-rich rock consisting of biotite, actinolite and talc-carbonate. These pockets are commonly cut by beryl-bearing quartz veins and pegmatite dykes. The majority of the ancient emerald mines are excavated in these pockets.

The petrographic, mineralogical and geochemical characteristics (the geochemical data from Zaghoul *et al.* 1976, and Hume *et al.* 1935) of the biotite and muscovite granites of Nugrus-Zabara area (Table 1) suggest that they were formed by solidification of magmas developed by partial melting of crustal (metasedimentary) material, *i.e.*, S-type granites (Chappell and White 1974).

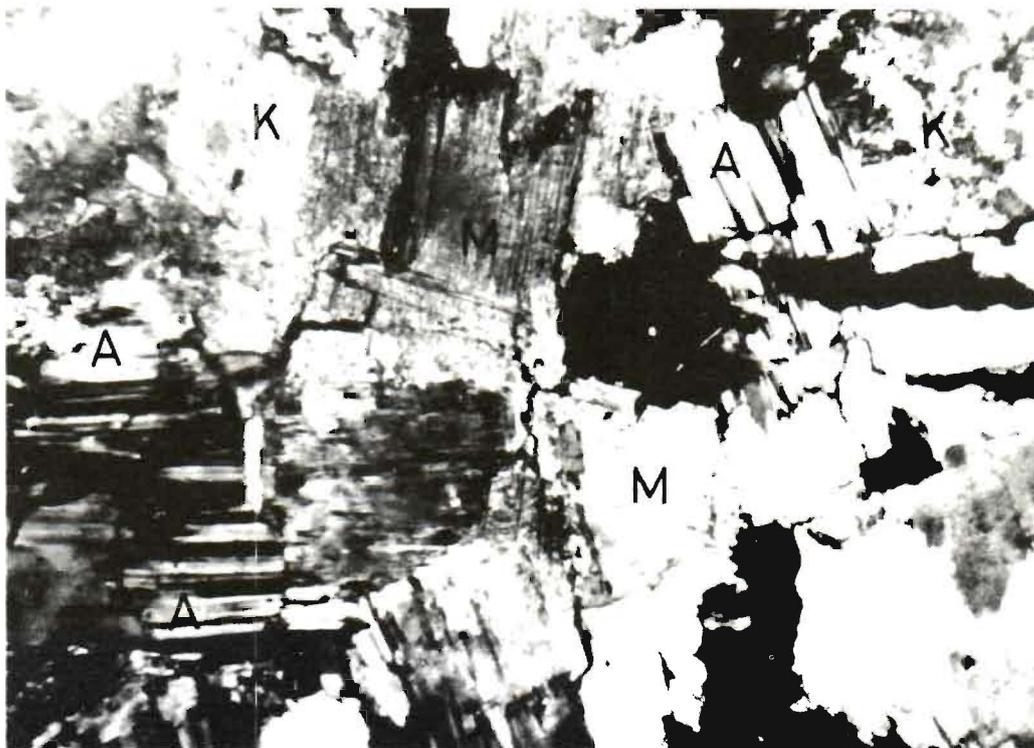


Fig. 3. Photomicrograph of albitized muscovite granite from Sikait area showing fresh albite crystals (A), muscovite (M) and altered K-feldspars (K). C.P. X 75.

Propylitization is common in the granodiorite complex. Weak greisenization and albitization are recorded in some younger granite masses; silicification, biotitization; actinolitization and tourmalinization are common in the schists. Some schists are crowded with big rod-like crystals of dark brown tourmaline up to 6 cm long. Carbonatization and the development of talc-carbonates are common in the ultramafic ophiolites (serpentinites).

The results of an aeromagnetic survey carried out by Lockwood Geophysical Corporation (1968) indicate that the Nugrus-Zabara area is traversed by three deep-seated tectonic zones have NW-SE (parallel to the length of the Red Sea) and WNW-ESE trends, while the block fault has a NE-SW trend (Fig. 1). The terms "deep-seated tectonic zones" and "block faults" refer to zones of deep faults in the earth's crust which are characterized by linear trends. They are possibly

**Table 1.** Chemical and mineralogical properties of typical S-type granites compared with those of the younger granites of Nugrus-Zabara area.

S-type characteristics (Chappell and White 1974)	Younger granites of Nugrus-Zabara area
(1) Usually small intrusions.	They form small plutons, sometimes less than one km <sup>2</sup> , e.g., the muscovite granite of wadi Sikait area.
(2) Restricted range of composition: gabbro-diorite 2%, granodiorite 18%, granite 80%.	They exhibit a very limited range of composition, always granites to adamellites.
(3) Relatively low sodium, Na <sub>2</sub> O normally < 3.2% in rocks with approx. 5% K <sub>2</sub> O, decreasing to 2.2% in rocks with approx. 2% K <sub>2</sub> O.	Na <sub>2</sub> O ranges from 3.01% to 4.72% in rocks ranging from 3.77% to 5.18% K <sub>2</sub> O.
(4) Mol. Al <sub>2</sub> O <sub>3</sub> /(Na <sub>2</sub> O + K <sub>2</sub> O + CaO) > 1.1	Mol. Al <sub>2</sub> O <sub>3</sub> /(Na <sub>2</sub> O+K <sub>2</sub> O+CaO) ranges from 1.4 to 1.8.
(5) SiO <sub>2</sub> > 65%	SiO <sub>2</sub> ranges from 74.19 to 76.24%
(6) Biotite dominant over hornblende, muscovite and two-mica granite common.	The granites are biotite-and/or muscovite-bearing.
(7) > 1% CIPW normative corundum	CIPW normative corundum generally ranges from 0.7 to 3.8%.
(8) Accessory minerals include monazite, garnet, cordierite, and andalusite.	Zircon, monazite, fluorite and xenotime are common.
(9) Hornblende-bearing xenoliths are rare and metasedimentary xenoliths are common.	No hornblende-bearing xenoliths found and metasedimentary xenoliths occur.

rejuvenated periodically over a long period of time; and are usually associated with metasomatic processes including greisenization, albitization, silicification and tourmalinization and Sn, Nb, Be, W, Mo, Bi, B and F mineralization (Garson and Krs 1976, Krs 1977, Soliman 1981).

### Mineralization

Known mineralization in the Nugrus-Zabara area occurs as disseminated and vein-types of beryl, gold, talc and asbestos. Beryl (sometimes the gem variety) occurs in quartz veins and pegmatite dykes cutting mica schists, sometimes as crystals disseminated in the schist itself (Hume 1934, Basta and Zaki 1961, Hassan and El-Shatoury 1976).

Beryl in quartz veins forms well-developed hexagonal crystals embedded in a fragmented quartz matrix (Fig. 4). In some cases beryl



Fig. 4. Photomicrograph of berylliferous quartz vein from Um Kabu showing well developed hexagonal crystal of beryl embedded in a fragmented quartz matrix. C.P. X 75.

crystals are fractured and replaced by quartz (Fig. 5). These features suggested that beryl crystallized first followed by quartz. Beryl usually contains minute gas and fluid inclusions with irregular outlines (Fig. 5).

A few small grains (up to 2 mm diameter) of datolite (reddish brown and almost like garnet in colour) are recorded in some pegmatite dykes associated with bluish green beryl and yellowish green lithium mica.

Small quartz veins (about 2 cm in length and 2 cm thick) carrying cassiterite are recorded traversing the gneissose biotite granites of the Zabara area. Short fibrous anthophyllite asbestos together with vermiculite occurs along the peripheries of some granite pegmatite dykes cutting mafic rocks at the Hafafeat area. These ore minerals are probably developed by the action of hydrothermal solutions on mafic rocks along fracture zones. Small scale talc and steatite bodies occur in shear

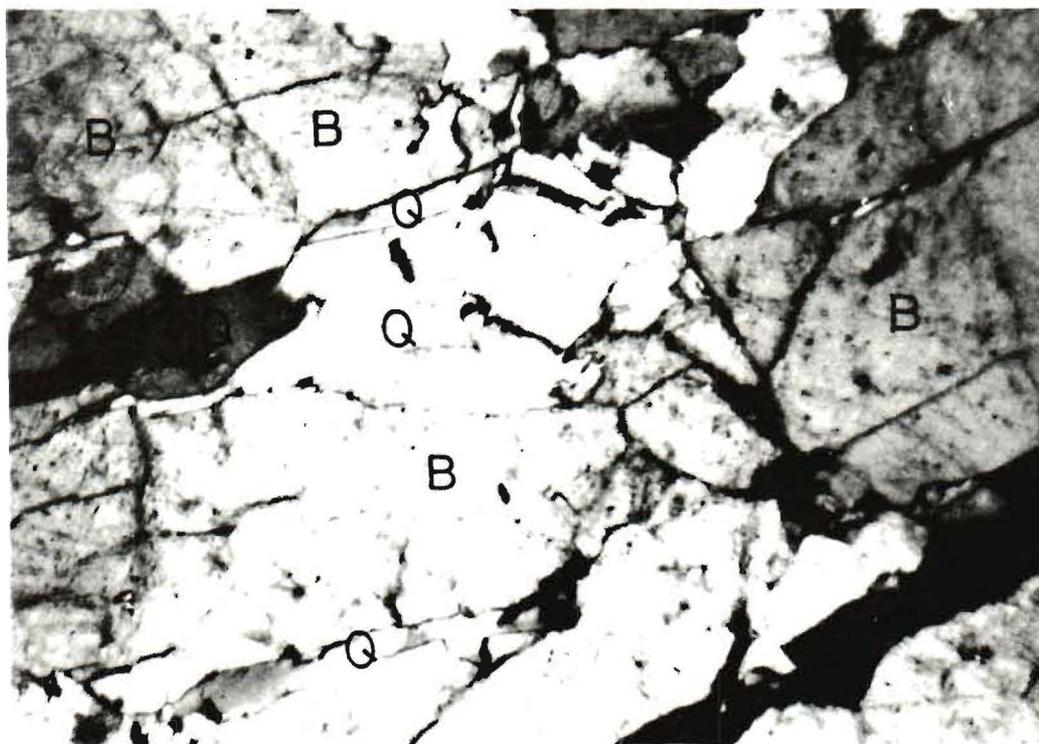


Fig. 5. Photomicrograph of beryl (B) in quartz vein from Um Kabu area. The beryl is cracked and replaced by quartz (Q). C.P. X 75.

zones in the serpentinites. A few small chromite lenses also occur in these serpentinites. Auriferous quartz veins cutting altered biotite granites in the northwestern parts of Gabal Nugrus were exploited by the ancient Egyptians (the area is known as the Hangalia gold mine). Some gneisses are radioactive and carry accessory columbite, zircon, thorite, monazite, fluorite and galena (Hassan 1973, El-Shazly and Hassan 1972). These gneisses (*e.g.*, at Wadi Abu Rusheid) which are probably psammitic in nature (Fig. 6) and are microclinized in part.

### Heavy Mineral Survey

Twenty-one alluvial samples (about 15 kg for each) were collected from the stream sediments fillings the dry streams (wadis) in the Nugrus-Zabara area. The sampling depth is about 30 cm below the surface. The heavy minerals of these

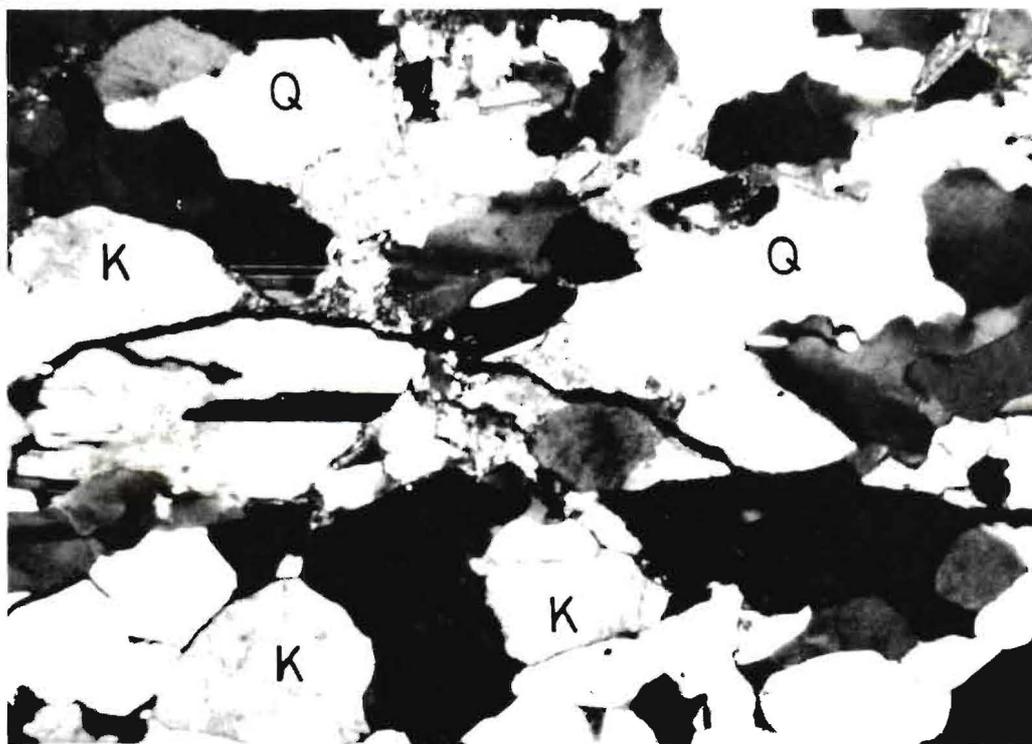


Fig. 6. Photomicrograph of psammitic gneiss from wadi Abu Rusheid showing abundant quartz (Q) and K-feldspar (K). C.P. X 75.

samples were obtained by panning in the field (see Soliman 1981, 1984b). The heavy minerals were identified microscopically and checked by X-ray diffraction analysis and by the tinning test (Soliman 1984b). The major part of the heavy concentrates from the studied samples consists of magnetite, ilmenite and amphiboles. Identified minerals whose presence may indicate metallization (*e.g.*, beryl, cassiterite and columbite) or be an indicator of hydrothermal processes (*e.g.*, fluorite and tourmaline) or regional metamorphism (*e.g.*, garnet (Overstreet 1963) are shown in Fig. 7. The data shows that beryl associated with tourmaline, fluorite and sometimes cassiterite or columbite occur in an elongated NW-SE belt extending for about 40 km from Um Kabu in the SE to Zabara in the NW and may demarcate a beryllium geochemical province. The ancient emerald mines are located within the boundaries of this province. Field verifications show that the granites in this belt are usually greisenized and albitized and the schists are sometimes intensively tourmalinized, actinolized and silicified and are cut by many quartz veins and pegmatite dykes carrying beryl, tourmaline and yellow-green mica. The altered schists are usually in contact with greisenized and albitized granites, suggesting that penumatory and hydrothermal processes were active in this district.

### **Geochemical Rock-Sampling Survey**

A geochemical rock-sampling survey was carried out in the Nugrus-Zabara area. Four groups of rocks were sampled: the post-magmatically altered granitic rocks, schists, mineralized quartz veins and pegmatite dykes. The altered granitic rocks were from Wadi Abu Rushead, Zabara, Hangalia gold mine and Hafafeat areas. The altered schists were from the Zabara emerald mine area. Quartz veins and pegmatites were from the old emerald mines of Um Kabu-Um Dfbaa, Nugrus, Sikait and Zabara area (Fig. 7). Barren and unaltered granitic rocks were also sampled to determine the regional background concentrations of the different ore elements in the district. The analysis of these samples was semi-quantitative for Sn, Be, Nb, Pb, W, Cu, Y and Ti using a Hilger and Watts large quartz-and-glass emission spectrograph in the laboratories of the Geological Survey of Egypt. The results of these analyses are discussed below.

### **Ore Element Distribution in Altered Granites**

Mean values and standard deviations of the analysed trace elements in the altered granitic rocks of Nugrus-Zabara area, compared with data of geochemically similar and tin-mineralized Nigerian younger granites of Olade (1980) are given in Table 2 and the inter element relationships, in the form of coefficients of correlation, of these elements are given in Table 3.

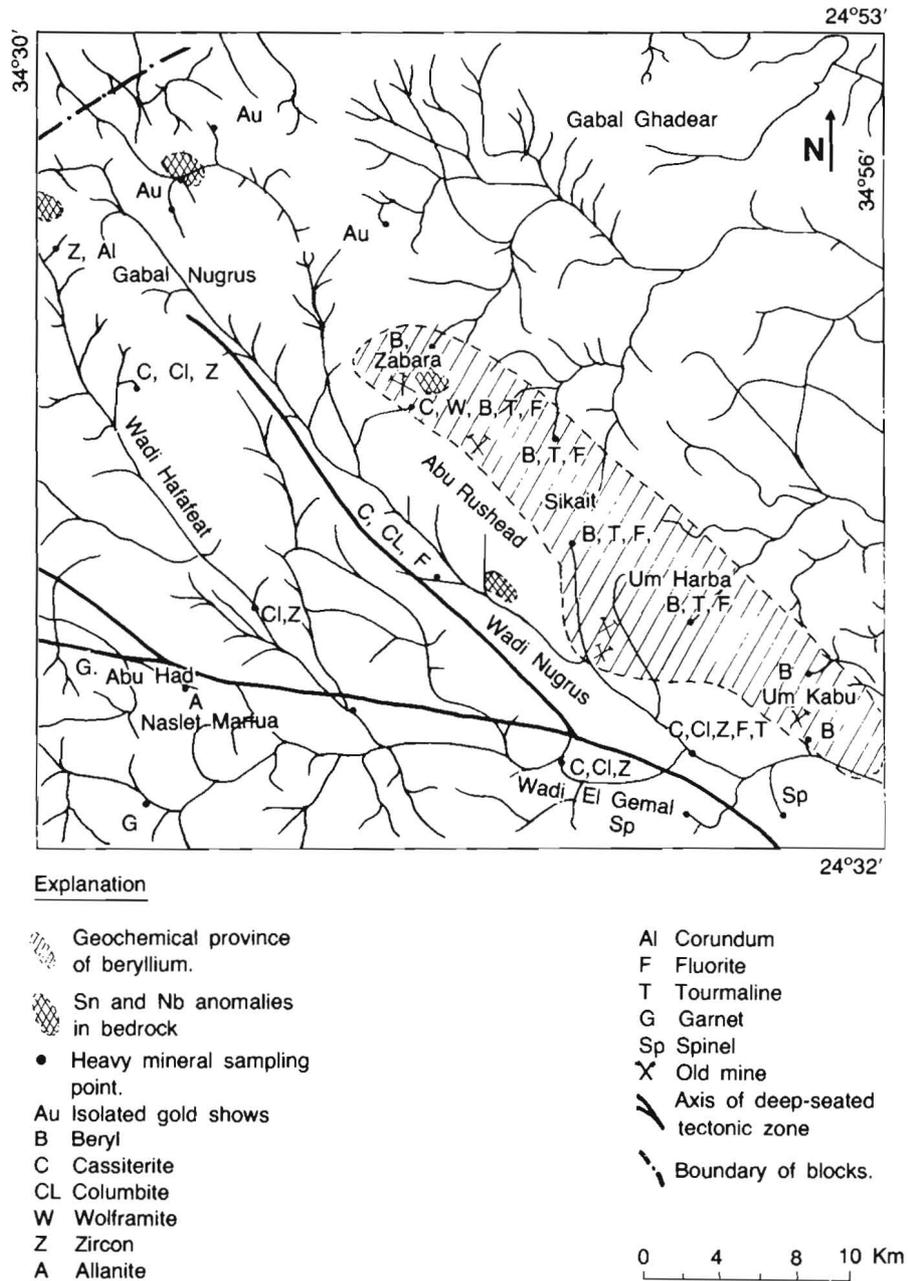


Fig. 7. Location of the geochemical province of beryllium in the Nugrus-Zabara area.

**Table 2.** Mean values ( $\bar{X}$ ) and standard deviations (S) of trace elements (ppm) in the granitic rocks of the Nugrus-Zabara area, compared with Nigerian granites. (n = number of samples, (-) = not determined).

Locality	Sn		Nb		Pb		Y		Zr		Cu		Ti	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S								
Abu Rushead (n = 120)	227	169	558	196	319	207	129	177	293	458	50	124	682	111
Hangalia gold mine (n = 25)	36	64	37	47	86	106	43	48	89	48	32	28	434	120
Hafafeat (n = 30)	34	28	39	32	50	40	87	46	4151	2953	14	8	1120	532
Zabara (n = 55)	88	164	33	16	34	30	159	43	200	150	28	18	859	767
Nigerian mineralized granites, Olade (1980)	22	-	156	-	56	-	211	-	262	-	16	-	-	-

**Table 3.** Inter-element correlations in samples from the granitic rocks of Nugrus-Zabara area (values in coefficient of correlation).

Locality	Abu Rushead	Hangalia gold mine	Hafafeat	Zabara
Sn-Pb	+0.27	-0.05	+0.02	-0.04
Sn-Nb	+0.23	-0.35	-0.24	-0.09
Sn-Cu	+0.16	-0.11	-0.18	-0.02
Sn-Zr	+0.28	-0.25	-0.08	-0.17
Sn-Y	-0.01	-0.14	-0.22	+0.11
Nb-Cu	+0.07	-0.11	-0.08	+0.15
Nb-Zr	+0.14	-0.02	-0.03	+0.04
Nb-Y	-0.04	-0.26	-0.08	+0.23
Cu-Zr	+0.41	+0.07	+0.09	-0.03
Cu-Y	+0.02	+0.34	-0.14	+0.01
Zr-Y	+0.06	+0.03	-0.17	+0.72
Pb-Nb	+0.35	-0.02	-0.27	+0.11
Pb-Cu	+0.14	+0.18	-0.16	+0.04
Pb-Zr	+0.22	+0.16	+0.08	-0.06
Pb-Y	-0.04	+0.25	+0.29	+0.14
Ti-Pb	-0.26	-0.14	-0.21	-0.27
Ti-Sn	-0.21	-0.27	+0.37	+0.16
Ti-Nb	-0.31	-0.17	+0.17	-0.05
Ti-Cu	-0.20	-0.05	+0.17	+0.02
Ti-Zr	-0.50	+0.20	+0.12	+0.27
Ti-Y	-0.11	-0.19	-0.16	+0.13

The data of Table 2 show that the altered gneisses of the Abu Rushead area contain distinct concentrations of Sn, Nb, Pb and Cu relative to the Hafafeat, Zabara and Hangalia granites as well as to the tin-mineralized anorogenic Nigerian younger granites. High concentrations of Sn and Nb (> 3000 ppm for both) were detected in some samples from the Abu Rushead gneisses, suggesting the occurrence of discrete minerals of Sn and Nb in these gneisses. Trace amounts of cassiterite, columbite, zircon, galena, fluorite, pyrite, monazite, xenotime and thorite were identified in the heavy concentrates separated by heavy liquids from these rocks.

The Hangalia, Hafafeat and Zabara granites contain high Sn and low Nb and Y values relative to the Nigerian younger granites. High values of Be (up to 100 ppm) were recorded in a few samples from the Zabara granite. The most striking feature is the remarkable Zr enrichment in the Hafafeat granites.

The enrichment of the Zabara, Hafafeat and Hangalia granites in Sn may be ascribed to their derivation from stanniferous granitoid magmas formed by partial melting of metasedimentary source material. A large body of recent work (Tauson 1968, Smirnov 1968, Tauson and Kozlov 1973, White *et al.* 1977, Smith *et al.* 1982) shows that granitoid magmas suitable for the generation of tin mineralization are commonly formed by partial melting of metasedimentary material.

Table 2 shows that the high tin values in the studied gneisses and granites are associated with the metasomatically altered gneisses of Abu Rushead and the metasomatically altered granites of Zabara areas, suggesting that the concentration of Sn is controlled in part by the evolution of a late stage aqueous fluid. Groves and McCarthy (1978) and Smith *et al.* (1982) attribute the tin mineralization to this aqueous fluid phase.

The absence of large tin deposits in the Nugrus-Zabara area, although the evolution of some granite magma in the district involves the development of aqueous fluid phases, suggests either that these original stanniferous magmas did not contain sufficient tin to generate large deposits, or that there was a lack of interaction between the rock, magmatic fluids and meteoric water, as claimed by Smith *et al.* (1982).

The frequency distributions of Sn, Nb, Pb, Y, Zr, Cu and Ti in the altered gneisses and granites of Nugrus-Zabara area are log normal and show positive skewness (Fig. 8).

Weak positive or negative correlation coefficient values are recorded as between pairs of elements in a particular environment as well as for an individual element as between gneisses and granitic rocks of Abu Rushead, Hangalia, Hafafeat and Zabara (Table 3), suggesting differences in the geochemical behaviour and mobility of these elements as well as differences for an individual element under different geological environments, probably due to the occurrence of these elements in different mineral phases.

#### **Ore Element Distribution in Schists, Quartz Veins and Pegmatite Dykes**

Mean values of the analysed trace elements in quartz veins, pegmatite dykes and schists of the Nugrus-Zabara area (Table 4), show that the altered schists, quartz veins and pegmatite dykes contain high concentrations of Sn, Be, Nb, W, Pb, Y, Mo, Zr and Cu. The pegmatite dykes are enriched in Nb, Pb, Y and Zr whereas the quartz veins are more enriched in Sn, W, Be, Mo and Cu. These results indicate that Nb, Pb, Y and Zr are concentrated in the residual granitic liquids of S-type magmas crystallized as pegmatite dykes, and Sn, W, Be, Mo and

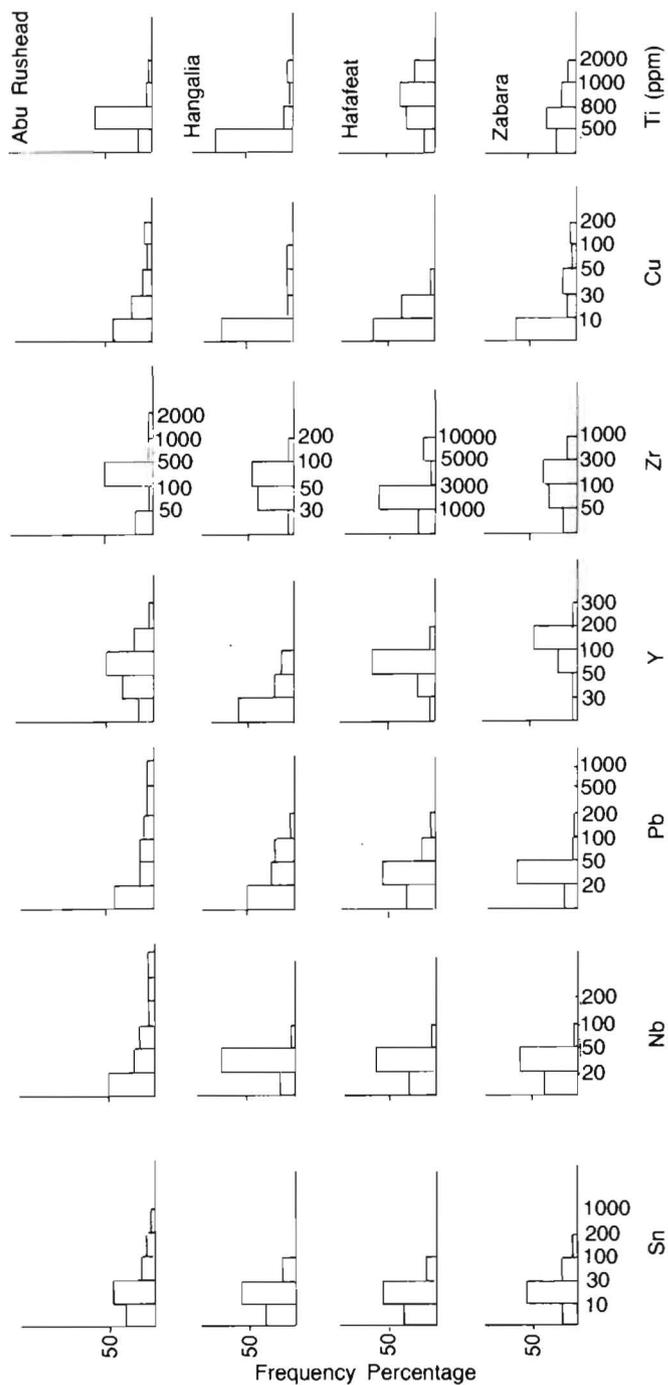


Fig. 8. Frequency distribution of Sn, Nb, Pb, Y, Zr, Cu and Ti in the granitic rocks and gneisses of Nugrus-Zabara area.

**Table 4.** Average trace elements (ppm) of quartz veins, pegmatite dikes and schists, Nugrus-Zabara area. (n = number of samples).

	Quartz veins (n = 10)	Pegmatite dykes (n = 8)	Schists (n = 20)
Sn	1300	80	50
W	180	—	—
Nb	100	500	30
Be	3000	100	350
Mo	500	20	10
Pb	50	200	20
Y	30	100	30
Zr	100	200	100
Cu	180	30	100
Ni	—	10	80
Cr	—	10	2000

Cu are associated with the quartz veins condensed from siliceous hydrothermal fluids derived from these magmas. This is probably related to differences in the mobility and stability of the complexes of these elements under different geological conditions.

The schists are enriched in Cr and Ni suggesting that they are of basic magmatic origin.

The metasomatism in gneisses; the greisenization and albitization processes in the granites; the occurrence of fluorite, cassiterite, columbite, pyrite and galena in the gneisses and granites; and the development of tourmaline and beryl disseminated in the schists; and quartz veins and pegmatite dykes cutting schists in contact with greisenized and albitized granites can be directly related to the formation of volatile-rich residual liquids during the evolution of S-type magmas in the district.

#### Trace element distribution in barren granites

The average values of trace elements in barren and unaltered granites and gneisses of the Nugrus-Zabara area (which may represent the regional background values of these elements in the district) compared with barren Nigerian younger granites of Olade (1980), are given in Table 5. The data show that the barren granites of the Nugrus-Zabara area comprise at least two phases: The stanniferous

granites (containing more than 10 ppm Sn, Smith *et al.* 1982) and the non-stanniferous granites (carrying < 10 ppm Sn). The stanniferous granites are enriched in Sn, and the non-stanniferous granites are depleted in Sn relative to the barren stanniferous Nigerian granites. Both stanniferous and non-stanniferous granites of Nugrus-Zabara area are depleted in Nb, Pb, Y, Zr and Cu relative to the barren Nigerian granites. The Hafafeat granites are markedly enriched in Zr relative to other granites studied as well as the Nigerian granites (Table 5).

**Table 5.** Average trace elements (ppm) of barren granites and gneisses of the Nugrus-Zabara area compared with barren stanniferous Nigerian granites of Olade (1980).

	Abu Rushead n=4	Gabal Nugrus n=10	Hangalia n= 5	Hafafeat n=7	Zabara n=5	Gneissose <sup>+</sup> granites n=3	Abu Had n=3	Naslet Marfua n=3	Nigerian stanniferous granites
Sn	20	10	20	30	50	—	5	5	10
Nb	40	30	30	20	50	10	20	30	96
Be	5	3	6	—	10	—	6	5	6
Y	30	30	30	30	50	30	30	30	152
Pb	20	10	30	20	20	10	10	20	29
Cu	10	8	10	10	10	15	5	8	16
Zr	100	100	80	4000	200	150	100	200	203

(+) In the south western part of the area.

## Conclusions

Available data suggest the existence of a geochemical province of beryllium in the Nugrus-Zabara area, lying in a NW-SE belt parallel to a deep-seated tectonic zone of the Red Sea trend. The province is probably formed by pneumatolytic-hydrothermal processes associated with the emplacement of stanniferous S-type granites. It is characterized by greisenization and albitization of the granites, biotitization, actinolitization, tourmalinization and silicification of the schists and an increase in concentration of Sn, Be, Nb, Pb and Y in granites, gneisses, schists, quartz veins and pegmatite dykes. The ancient emerald mines are located within the boundaries of this province.

## Acknowledgements

The writer thanks his colleagues at the Geological Survey of Egypt, particularly Mr Salah Abdel Hamead. Thanks are also due to Dr. M.Y. Atawia (Egyptian Nuclear Material Corporation) for carrying X-ray analyses.

### References

- Bakor, A.R., Gass, I.G. and Neary, C.R.** (1976) Jabal Al Wask northwestern Saudi Arabia: An Eocambrian back-arc ophiolite. *Earth Planet. Sci., Lett.* **30**: 1-9.
- Basta, E.Z. and Zaki, M.** (1961) Geology and mineralization of wadi Sikait area, Southeastern Desert of Egypt. *Egypt. J. Geol.* **5**: 1-38.
- Bugrov, V.A.** (1972) *Assessment of the mineral potential of the Aswan region: Technical report on geochemical operations carried out from July 1968 to June 1972.* Intern. Rep. Geol. Surv. Egypt. Cairo 196 p.
- Bugrov, V.A., Abu El-Gadayer, A. and Soliman, M.M.** (1973) Rare metallic albitites as a new type of ore mineralization in Egypt. *Annals Geol. Surv. Egypt.* **3**: 185-206.
- Chappell, B.W. and White, A.J.R.** (1974) Two contrasting granite types. *Pacific Geol.* **8**: 173-174.
- Church, W.R.** (1979): Granitic and metamorphic rocks of the Taif area, Western Saudi Arabia: Discussion and reply. *Geol. Soc. Am. Bull.* **1**, **90**: 893-895.
- Cleasson, S., Pauister, J.S. and Tatsumoto, M.** (1984) Samarium-Neodymium data on two late Proterozoic ophiolites of Saudi Arabia and implications for crustal and mantle evolution. *Contrib. Mineral. Petrol.* **85**: 244-255.
- El-Bayoumi, R.M.** (1980) *The ophiolites of Wadi Ghadir area, Eastern Desert of Egypt.* Ph. D. Thesis, Faculty of Science, Cairo University, Egypt.
- El-Ramly, M.F.** (1972) A new geological map for the basement rocks in the eastern Desert and south Western Desert of Egypt. *Annals Geol. Surv., Egypt.* **2**: 1-18.
- El-Sharkawi, M.A. and El-Bayoumi, R.M.** (1979) The ophiolites of Wadi Ghadir area, Eastern Desert, Egypt. (Abstract) *5th Confr. African Geol. Cairo.*
- El-Shazly, E.M.** (1964) On the classification of the Precambrian and other rocks of magmatic affiliation in Egypt. *Intern. Geol. Congress. India.* Sec. 10.
- El-Shazly, E.M. and Hassan M.A.** (1972) Geology and radioactive mineralization at wadi Sikait- wadi El-Gamal area, Southeastern Desert, Egypt. *Egypt. J. Geol.* **16**: 201-234.
- Garson, M.S. and Krs. M.** (1976) Geophysical and geological evidence of the relationship of Red Sea transverse tectonics to ancient fractures. *Geol. Soc. America Bull.* **87**: 169-181.
- Groves, D.I. and McCarthy, T.S.** (1978) Fractional crystallization and the origin of tin deposits in granitoids. *Mineralium Deposita* **13**: 11-26.
- Harris, N.B.W., Hawkesworth, C.J. and Ries, A.C.** (1984) Crustal evolution in northeast and east Africa from model Nd ages. *Nature* **309**: 773-776.
- Hassan, M.A.** (1973) Geology and geochemistry of radioactive columbite-bearing psammitic gneiss of wadi Abu Rushead, Southeastern Desert, Egypt. *Annals Geol. Surv. Egypt.* **3**: 207-225.
- Hassan, M.A. and El-Shatoury, H.M.** (1976) Beryl occurrences in Egypt. *Mining Geology.* **26**: 253-262.
- Hume, W.F.** (1934) *Geology of Egypt.* vol. 2 part 3. Geol. Surv. Egypt. Cairo.
- Hume, W.F., Harwood, H.F. and Theobald, L.S.** (1935) Notes on some analyses of Egyptian igneous and metamorphic rocks. *Geol. Mag.* **72**: 3-32.
- Hunting Geology and Geophysics** (1967) *Photogeological survey of the Aswan region, Egypt.* Contractor's report for the United Nations, London, 137 p.
- Krs, M.** (1977) Rift tectonics development in the light of geophysical data, Red Sea region. *Studia Geoph. et Geod.* **21**: 342-350.
- von Knorring, O. and Rooke, J.M.** (1973) *Trace element content of some alkali granites and gneisses from Egypt and Uganda.* 17th. Ann. Rep. Res. Inst. Afr. Geol. University Leeds, England. pp. 34-35.
- Lockwood Geophysical Corporation** (1968) *Airborne magnetometer, scientillation counter, dual frequency and electromagnetometry survey for a part of Aswan region, Egypt.* Contractor's report for the United Nations, Toronto, Canada 79 p.
- Olade, M.A.** (1980) Geochemical characteristics of tin-bearing and tin-barren granites, northern Nigerian. *Econ. Geol.* **75**: 71-82.

- Overstreet, W.C.** (1963) A regional heavy mineral reconnaissance as a guide to ore deposits in deeply weathered areas with semi-humid to humid temperate to tropic climate. In: *"Prospecting Methods and Techniques, Mineral Resources Development Series No. 12, United Nations, New York* pp. 149-162.
- Sabet, A.H., Tsogoev, V.B., Bessonenko, V.V., Baburian, L.M. and Pokryshkin, V.I.** (1976) Some geological and tectonic peculiarities of the Central Eastern Desert of Egypt. *Annals Geol. Surv., Egypt.* v: 33-52.
- 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* **285**: 427-474.
- Soliman, M.M.** (1981) Mineral exploration in Egypt. In: **Gabrielsen, H. (Ed.)**, *Proceedings of the 4th International Conference on Basement Tectonics*, Oslo, Norway. pp. 157-164.
- Soliman, M.M.** (1982) Tin and beryllium mineralization in relation to post-magmatic alteration, Homr Mikpid area, Southeastern Desert, Egypt. *J. Univ. Kuwait (Sci.)* **9**: 163-172.
- Soliman, M.M.** (1984a) Geochemical exploration for Sn, Nb, Be, Mo and Bi mineralization, Homr Akarim area, Southeastern Desert, Egypt. *J. Afr. Earth Sci.* **2**: 287-299.
- Soliman, M.M.** (1984b) Geochemical exploration for ores in the Gabal Mueilha area, Southeastern Desert, Egypt. *Arabian Journal for Science and Engineering* **9**: 267-279.
- Smith, T.E., Miller, P.M. and Huang, C.H.** (1982) Solidification and crystallization of a stanniferous granitoid pluton, Nova Scotia, Canada. In: **Evan, A.M. (Ed.)**, *Metallization Associated with Acid Magmatism*. John Wiley, New York pp. 301-320.
- Smirnov, V.I.** (1968) The sources of ore forming material. *Econ. Geol.* **63**: 380-389.
- Takla, M.A., Sharkawi, M.A. and Basta, F.F.** (1982) Petrology of the basement rocks of Gabal Mohagara-Ghadir area, Southeastern Desert, Egypt. *Annals Geol. Surv. Egypt.* **12**: 121-140.
- Tauson, L.V.** (1968) Distribution regularities of trace elements in granitoid intrusions of the batholith and hypabyssal types. In: **Ahrens, L.H. (Ed.)**, *Origin and Distribution of the Elements*. International Series of Monographs No. 30, Pergamon, Oxford. pp. 629-639.
- Tauson, L.V. and Kozlov, V.D.** (1973) Distribution function and ratios of trace element concentrations as estimators of the ore-bearing potential of granites. In: **Boyle, R.W. (Ed.)**, *Geochemical Exploration*. Canadian Institute of Mining and Metallurgy Spec. **11**: 37-44.
- United Nations** (1974) *Assessment of the mineral potential of the Aswan region: Technical report on geochemical operations 1968-1972 for the Government of ARE (Egypt)*. DP/SF/UN/114, New York. 79 p.
- White, A.J.F., Beams, S.D. and Cramer, J.J.** (1977) Granitoid types and mineralization with special reference to tin. In: **Yamada, N. (Ed.)**, *Plutonism in Reference to Volcanism Project Meeting, Japan*, pp. 89-100.
- Zaghloul, Z.M., Essawy, M.A. and Soliman, M.M.** (1976) Geochemistry of some younger granite masses, Southeastern Desert, Egypt. *J. Univ. Kuwait (Sci.)* **3**: 231-242.

(Received 05/12/1984;  
in revised form 12/03/1985)

## مناجم الزمرد القديمة ومعدنة البريليوم المرتبطة بالجرانيت القصديري في منطقة نجرس - زابارا بجنوب الصحراء الشرقية بمصر

مصطفى محمود سليمان

قسم الجيولوجيا - كلية العلوم - جامعة الزقازيق - مصر

توحي نتائج المسح الجيوكيميائي الصخري والمسح المعدني في  
رواسب الوديان في منطقة نجرس - زابارا والتي تضم مناجم  
الزمرد القديمة المشهورة في جنوب الصحراء الشرقية بمصر  
بوجود إقليم جيوكيميائي للبريليوم مرتبطاً وموازياً لمنطقة بنائية  
عميقة موازية لطول البحر الأحمر. ينحصر هذا الإقليم في  
صخور غنيّة بالميكاً ومقطوعة بعروض المرو والبجماتيت والتي  
توجد بالقرب من صخور جرانيت تعرض لعمليات ألبتة  
وجرزنة ويحتمل تكون هذا الإقليم بواسطة عمليات غازية  
وحرماية صاحبت تداخل كتل جرانيت قصديري تكوّن من  
صهير ناتج عن انصهار جزئي لصخور رسوبية في القشرة  
الأرضية.

من أهم صفات إقليم البريليوم هذا، تعرض الصخور  
الجوانيتية لعمليات جرزنة وألبتة وتعرض صخور الشيست  
لعمليات نمو وتكوين معادن البيوتيت والتورمالين  
والاكتينوليت والكلوارتر وكذلك ارتفاع تركيزات عناصر  
القصدير والبريليوم والنيوبيوم والرصاص واليتريوم والنحاس  
في الصخور الجرانيتية والشيست وعروق المرو والبجماتيت.  
كما تقع جميع مناجم الزمرد القديمة داخل إقليم البريليوم  
هذا.