Relation Between Uranium Mineralization and Structural Features, Gebel Gattar, North Eastern Desert, Egypt.

A.B. Salman, M.H. Shalaby*, A. Ragab** and late M.M. AbuZaid**

* **Nuclear Material Authority, P.O. Box 530, El Maadi, Cairo, Egypt**

** **Ain Shams University, Cairo, Egypt.**

خلاصة

تقع منطقة جبل قطار بشمال الصحراء الشرقية بمصر جنوب غرب مدينة الغردقة حيث تعتبر هذه المنطقة من أهم المناطق لتواجدات اليورانيوم. وتغطي المنطقة صخور الحمامات الروسوبية وجرانيت جبل قطار التي تتبع عصر البريكامبري الأعلى. ويتكون جرانيت جبل قطار من النوع البرثيتيك الفاتح والكالس قلي وجميعها من النوع الذي تكون داخل اللوح .

وتظهر التراكيب الجيولوجية على صورة أنواع أولية وثانوية، وتمثل الطيات والصدوع والفواصل أهم التراكيب الثانوية، وتسود الصدوع الضاربة في اتجاهات شمال شمال شرق ـ جنوب جنوب غرب وهي تلعب دوراً هاماً في نقل المحاليل الحارة الغنية باليورانيوم. وقد تبين من دراسة العلاقة بين التراكيب الجيولوجية وتمعدنات اليورانيوم على السطح أو تحت السطح أن هذه المعدنات توجد في نطاقات قص أو تمزق داخل حوض تركيبي ناتج من قوى الشد والذي يصل طوله 2 كم وعرضه 0.5 كم. وقد تم الوصول إلى هذه النتيجة بناءً على ربط النظام التركيبي برطيقة توزيع تمعدنات اليورانيوم في موقع قطار -1 وقطار -6 .

وقد تم دراسة توزيع النشاط الشعاعي في موقع جبل قطار وكذلك الظواهر التركيبية والجيولوجية والشعاعية المرتبطة بها سواءً على السطح أو تحت السطح ويتراوح محتوى اليورانيوم بين 150 إلى 5570 جزء في المليون .

وقد أمكن تقسيم اليورانيوم بجل قطار إلى النوع العرقي لرواسب اليورانيوم. كذلك فإن وجود تمعدنات اليورانيوم على مستويات مختلفة يؤكد ترسب تلك التمعدنات من محاليل حارة صاعدة من خلال الفوالق الموجودة في الجرانيت. وتمثل تلك الظواهر إلى جانب حجم المواقع الحاوية لتمعدنات اليورانيوم احتمالات جيدة لوجود خامات إقتصادية لليورانيوم بمنطقة جبل قطار .

Abstract

Gebel Gattar area is situated in the northern Eastern Desert of Egypt, SW Hurghada city and is consideredas an area of high potentialities for uranium deposites. The area is covered by Hammamat sediments and Gattarian granites. The Hammamat sediments are dissected by different types of dykes, while Gebel Gattar granites are cut only by basic dykes. These granites are mentioned as the younger pink granites, perthitic leucogranites, calc-alkaline and within plate granites.

The structural deformations of the study area are represented by primary structures and secondary ones. The most prevailing structures are folding, faulting and jointing. The faults, especially those trending in the NNE-SSW and N-S directions played as passways to the ascending uranium-bearing hydrothermal solutions carrying uranium mineralizations. Most of them are located within a large pull apart basin. It is found from the relation between structures and uranium mineralization within the highly promissing shear zones that uranium mineralizations are located within a large pull-apart basin, having about 2 km length and 0.5 Km width. This idea is based up on the distribution of uranium mineralized lenses as shown in a block diagram. This conclusion is based on the structural framework of the area, the shape of mineralization and its distribution and their mutual relationships of GI, GII and GVI shear zones.

The gamma-activity measurments of the study area lead to the discovery of several occurrences which have been geologically, structurally and radiometrically studied in detail in surface and subsurface. The uranium content of the mineralized grab samples range from 155 ppm 5570 ppm.

From this study we can classify Gebel Gattar uranium as a hydrothermal vein-type uranium deposit. Also the presence of uranium mineralization at different levels of depth confirm the role of ascending hypogene solutions in the mineralizing the granites. These criteria as well as the dimensions of the uranium occurrences indicate potentialities of economic uranium deposite in the area of Gebel Gattar.

Introducton

Gabal Gattar area lies in the northern part of the Eastern Desert of Egypt at the intersection of coordinate 27^{o} 06' N and 33^{o} 16' E, at a distance of 35 Km from Hurgada City, at the Red Sea Coast. The younger Gattarian granites cover about 2/3 of its surface area in an NE-SW direction (Fig. 1). This paper deals with the relation between uranium mineralization in the area and the various structural features.

Geology

The area of G. Gattar mainly çomprises basement rocks of Precambrian age mainly represented by thé old Hammamat sediments of molasses type and the younger pink granites.

The Hammamat sediments are slightly metamorphosed. They consist of polymictic conglomerates derived from the pre-existing diorites, granodiorites, mafic and felsic volcanic clastics. The fine Hammamat sediments include greywackes, sandstones, slates and siltstones. Generally, the Hammamat sediments are deposited in discontinuous intermounataineous basins as a result of an alluvial fan braided stream complex [1]. On the other hand, Stern et al., [2] suggested that the deposition of Hammamat sediments, in the northern Eastern Desert, was in down faulted grabens nearly trending NE-SW.

It was reported that the age of the Hammamat sediments in the N.E.D. is bracketed between the Dokhan volcanics (59a ± 13Ma) and the Gattarian granites (57S Ma) [3].

Gabal Gattar granites represent the northern part of a large batholith of younger granites. El Rakaiby and Shalaby [4] classified the rocks of this complex batholith according to their mode of occurrenees and petrography into three phases named; G1, G2 and G3. Gabal Gattar pluton belongs to G3 phasewhivh is the youngest. The contacts between the granites and the Hammamat sediments are usually sharp with slight metamorphism in these sediments.

Gabal Gattar granites are predominantly formed of medium grained rocks varying in colour from pink to reddish pink in fresh samples and tend to turn pale pink to reddish brown due to alteration along shear zones. The commonest alterations in these granites are hematitization, silicification, episyenitization, fluoritization kaolinization and epidotization besides the frequent presence of manganese dendrites and carbonates.

Under the microscope, Gabal Gattar granites are perthitic leucogranites essentially composed of a nearly equal amount of quartz and potash feldspars in addition to plagioclase, minor amount of biotitc and few muccovite. The occessory minerals are zircon, fluorite, apatite and opaques such as sphalerite, chalcopyrites, pyrite, hematite and magnetite.

The geochemistry of Gabal Gattar granites have been studied by Stern and Gottfried [5]. They mentioned that these granites are characterized by their high silica, enrichment in total alkali contents, low to moderate alumina, low contents of CaO, MgO, total iron and titanium. Gabal Gattar granites have many common features with Group II Egyptian younger granite of Greenberg (1981) and the Group III younger granitoids of Saudi Arabia [6].

The emplacement of the younger granites of the Arabo - Nubian Shield was associated with diffuse extension and / or strike slip shear movements that follow the collisional events by about 25 to 75 Ma and are compositionally similar to the "within plate granites" (Sylvester, [7]. Attawiya [8] added that the magma of Gabal Gattar granites is of calc-alkaline type with some alkaline affinity and the trace element data showed that its magma had evolved in a within plate anorogenic environment.

Surface and subsurface works were caried out at G1 occurrence: They are composed of a main adit (425 m) and three cross cuts or drifts. D1 (53.23 m.), D2 (41.8 m.) and D3 (36.2 m.). The aim of these works was to follow up the surface structures controlling the uranium mineralization in depth and to study the behaviour, mode of distribution and the related alteration features at deeper levels.

Structures

The primary structures, in the study area, are mainly expressed by bedding, graded bedding, cross bedding and ripple marks. Secondary structural elements are folds, joints and pull-apart basins.

- Folds

Generally, the bedding of the Hammamat sediments is nearly horizontal to slightly dipping to the SE direction along the northern bank of Wadi Um EBalad and moderately dipping to SE in the area between W. Um El Balad and Wadi Balie (Fig. 1). It is relatively steeply dipping between Gabal Gattar granites and the Hammamat sediments along the southern bank Wadi Balie. Some minor asymmetrical anticlinal and synclinal folds are recorded with axes plunging 15^{o} to 30^{o} to the WSW direction.

- Joints

The most predominant surface and subsurface trends of joints in Gabal Gattar granites are the NNE-SSW and N-S both forming about 36% of the total measured joints. The next predominant trends are the NE-SW, WNW-ESE and NW-SE. The less abundant trends are the NNW-SSE, ENE-WSW and E-W respectively.

The uranium surface and subsurface mineralized joints at GI uranium occurrence predominate the N-S, NNE-SSW, NW-SE and NE-SW dirtection. Although the NNW-SSE and ENE-WSW joint trends are less abundant both in surface and subsurface, they are of the most important trends controlling the uranium mineralization when intersecting with the predominant trends.

- Faults

A large number of fault trends were measured in the studied area (Fig.1). Their distribution and abundance are as follows:

1- The predominant trends: NNE-SSW (19.54%) and NNW-SSE (17.73%).

2- The abundant trends: N-S (15%) and NW-SE (14.55%.

3- The common trends: NE-SW (12.73%) and WNW-ESE (11.81%).

4- The less common trends: E-W (4.55%) and ENE-WSW (4.09%).

The NNE -SSW faults are mainly sinistral while the NW-SE ones are mostly dextral. They both represent two complementary sets of shear fractures dominating in the Gulf of Aqaba and the Gulf of Suez particularly.

- Pull Apart Basins

Keary et al. [9] mentioned that where the curvature of strike - slip fault is pronounced or where one fault terminates side step to an adjacent parallel fault, the curved zone or area separating the faults is thrown into tension gives arise to an extensional trough known as a pull apart basin. Pull apart basins are now recognized as being important sites of mineral resources [10].

In the study area of Gattar, pull apart basins are recorded in both Hammamat sediments and the Gattarian granites. Their sizes are varying from few cms to hundreds of meters. The major and important pull apart basin is that including GI, GII and GVI uranium occurrences which represent two subparallel shear zones where the granites are highly altered and hematitized. The uranium mineralizations along these shear zones are in the orm of numerous disconnected lenses ranging in size from 0.5 x 0.5 m. to 100 x 5m., mostly accompanied with strong hematitizations, silicifications and abundant deep violet fluorite. The formed pull-apart basin by these two shear zones is an "S" shape one and have length-width ratio ≅ 3, (Fig. 2).

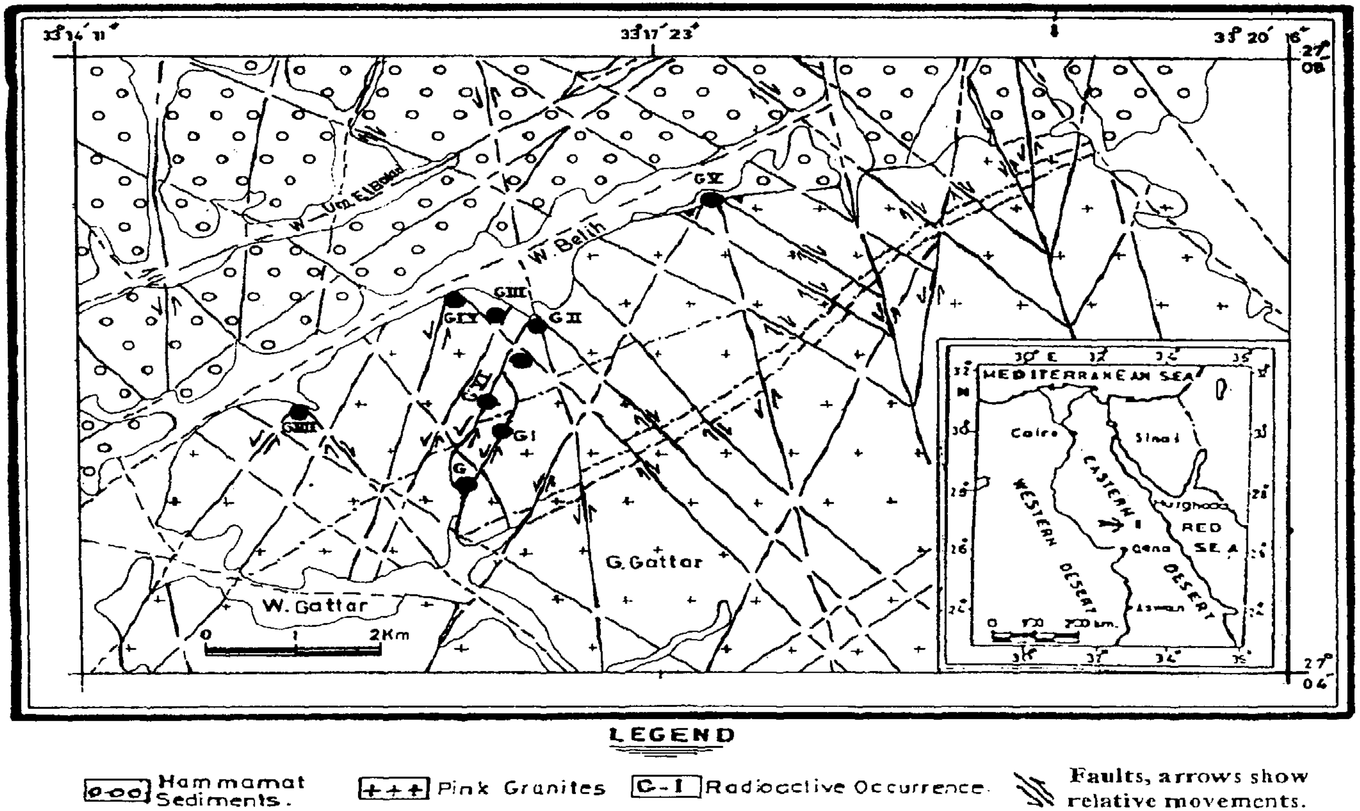


Figure (1) : Geological - structural map of G. Gattar area.

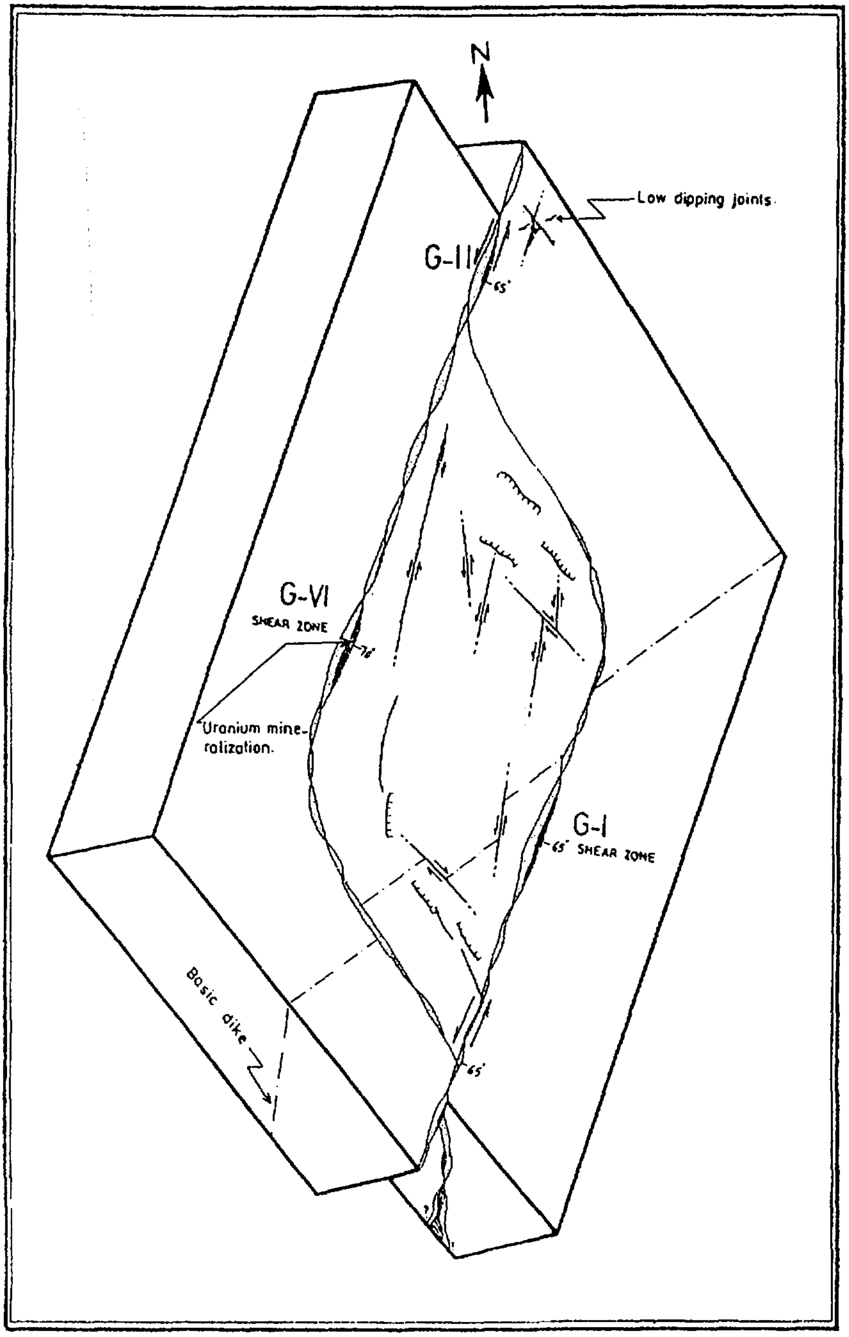


Figure (2) : Sketch map of the large pull-apart basin controlling the distribution of uranium mineralization in G-I, G-II and G-VI, G. Gattar prospect.

- **Model of Compressive Stress Fields**

Three elliptical models can be proposed to explain the direction of compressive stress fields from the time older than the Oligo - Miocene age (Fig. 3). This age corresponds to the age of the rifting and forming of the Red Sea and the Gulf of Suez [11].

In the oldest stress field (Fig. 3A), the maximum compressive stress(s1) was directed N 45°E - S 45°W and ($\sigma3$) N45°W - S45°E and ($\sigma2$) was vertical. Some NE-SW normal faults, basic dykes and quartz veins related to this stress field [12].

In the second stress field (Fig. 3B), the maximum compressive stress and mininum one of the first model have alternated their positions. This stress field originated some minor folds in the Hammamat sediments with NE-SW axes. It also contributed in the formation of the two complementary shears of strike slip fault striking NNW-SSE (sinistral) and WNW-ESE (dextral) with an interior angle of about 55°. Some normal faults were also recorded subparallel to the principal stress field striking NW-SE.

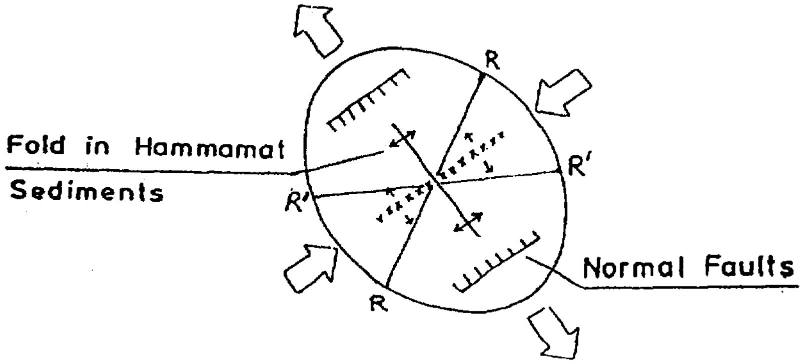
In the youngest field (Fig. 3C) the maximum stress ($\sigma1$) was directed around N10°W-S10°E, while (s3) strikes N80° E-S80° W and caused the main tectonic deformations parallel to the Gull of Suez and Gulf of Aqaba. This younger stress field is also represented by a local minor reverse fault, directed ENE-WSW, controlling GV uranium mineralization (Fig. 1). This last phase of stress field is more or less conformable with the NNW-SSE stress field mentioned by Youssef [13] and Shalaby [14].

The structural framework of Gabal Gattar could be considered as an effective ground perparation for the uranium mineralizations beside the network of joints which offered a sort of good passway, in the granites. The faults played as channels for the ascending hydrothermal solutions enriched with uranium through shear zones as well as their intersecting fractures and joints [15].

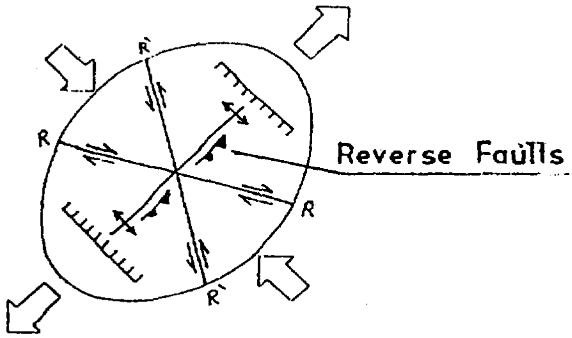
Uranium Mineralization

- **GI Uranium Occurrence**

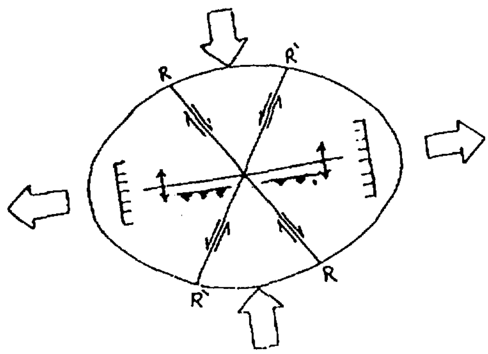
This occurrence is situated at the northern parts of Gabal Gattar along a NNE-SSW trending shear zone steeply dipping between 60° and 70° to the ESE direction (Fig. 1). It is extending about 2 Km in length and varies in width from 1m to more than 10 m.



(A) σ1 is N45°E - S45°E, σ2 vertical and σ3 is N45°W-S45°E.



(B) σ1 is N45°W - S45°E, σ2 is vertical and σ3 is N45°E-S45°E.



(C)σ1 directed to N10°W - S10°E, σ2 vertical and σ3 is N80E-S80W.

Figure (3) : Model of the main compressive stress fields prevailing in the area of G. Gattar in N.E.D. of Egypt.

The surface predominant mineralized joints are the N-S, NNE-SSW, NE-SW, ENE-WSW and to a rather extent NW-SE (Fig. 4A). The surface predominating joint trends still persist at the subsurface accompanied with the same alteration features.

Table (1): Frequency distribution and main directional trends of 1235 joints in surface and subsurface of G. Gattar granites.

Set No.	Trends	Surface joints of G. Gattar granite		Subsurface joints of GI main adit		Subsurface joints of GI first cross-cut		Subsurface joints of GI Second cross-cut		Subsurface joints of GI Third cross-cut		Total	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	N-S	83	15.66	66	17.18	20	14.8	14	12.7	15	21.4	198	16.0
2	NNE-SSW	88	16.60	80	20.51	28	20.7	26	23.7	24	34.4	246	19.9
3	NE-SW	87	16.42	40	10.25	16	11.9	12	10.9	-	-	155	12.6
4	ENE-WSW	61	11.51	29	7.44	10	7.4	10	9.1	7	10.0	117	9.5
5	E-W	56	10.57	13	3.07	8	5.9	3	2.7	-	-	80	6.5
6	NNW-SSE	29	5.47	59	15.13	17	12.6	18	16.4	7	10.0	130	10.5
7	NW-SE	52	9.81	68	17.44	15	11.1	14	12.7	5	7.1	154	12.4
8	WNW-ESE	74	13.96	35	8.97	21	15.6	13	11.8	12	17.1	155	12.6
	Total	530	100.00	390	100.00	135	100.00	110	100.00	70	100.00	1235	100.00

Figure (4)

The underground workings met the surface mineralized lens at the first cross cut (Fig. 5). There, the shear zone is about 3m in width, striking N 20°E and dipping 63° ESE showing visible secondary uranium mineralizations associated with intense hematitization and silicification. The uranium content of the subsurface samples ranges from 300 ppm to 400 ppm.

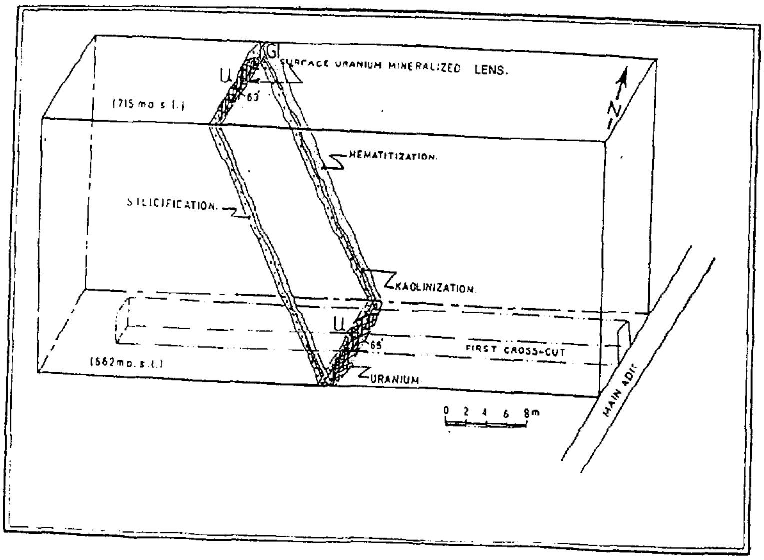


Figure (5) : Relation between surface and subsurface uranium mineralization at the southern parts of GI shear zone.

- GII Uranium Occurrence

GII uranium occurence is located along a shear zone more or less parallel to GI shear zone, striking N10° E to N20° E and dipping 60° to 70° ESE.

The surface mineralized joints predominete in the NNE-SSW N-S, NE-SW when intersecting with the ENE-WSW and E-W. The average uranium content of the surface meneralized samples ranges from 288 ppm to 1600 ppm.

An open pit was excavated at GII occurrence (Fig. 6) which dimensions are 15m x 5m x 5m. The intensity of uranium mineralizations greatly increase with depth accompanied with strong silicification and hematitization. Fluoritization is always escorting the uranium mineralizations.

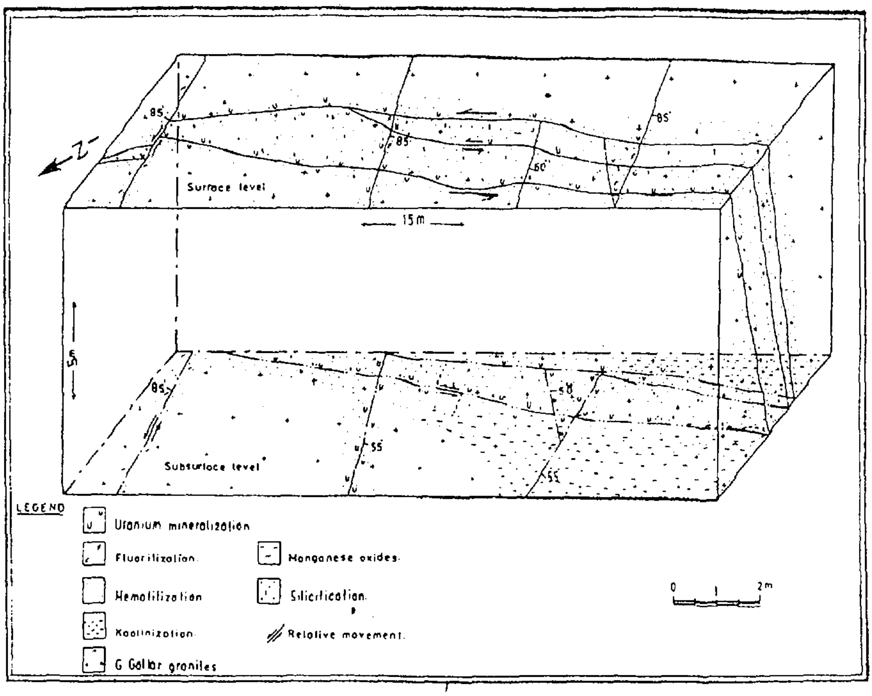


Figure (6) : Block Diagram of GII Open Pit

The predominant trends of the mineralized joints in the open pit are the NW-SE, WNW-ESE, NE-SW and NNE-SSW (Fig. 4C). The uranium content of the subsurface varying from 154 ppm to 2170 ppm (Table 2).

Table (2) : Uranium content determined radiometrically for regular spot samples from GII open pit

Ser. No.	Sample No.	U ppm	Alteration features associated with uranium
1	S_1	288	Kaoline, MnO, hematite
2	S_2	154	Hematite, MnO, SiO_2, fluorite
3	S_3	1076	Hematite, SiO_2, MnO.
4	S_4	1326	Hematite, SiO_2, MnO.
5	S_5	2171	Kaoline, hematite
6	S_6	181	Kaoline, hematite

- GV Uranium Occurrence

This uranium occurrence lies at the contact of the Hammamat sediments with Gabal Gattar at the southern bank of Wadi Balie. It is controlled by a local reverse fault between the granites and the sediments. The uranium mineralizations are mainly confined to the Hammamat sediments rather than the episyenitized granites [16].

An open pit was dug at this occurrence in order to clarify the nature of the granite - Hammamat contact and the distribution of uranium mineralizations. The common alteration features are mainly expressed by the bleaching of the dark Hammamat sediments, hematitization, fluoritization and episyenitization of the adjacent granite. The predominant uranium mineralized joints at GV open pit are the NE-SW, NNE-SSW, N-S, ENE-WSW and E-W (Fig. 4D). The uranium content of the surface mineralized samples are shown in (Table 3).

Table (3) : Radiometric analysis for spot samples collected from surface and bottom of GV open pit

Ser. No.	Sample No.	U ppm	Th ppm	Th/U
1	GV-1-1	1363	537	0.39
2	GV-1-2	935	550	0.59
3	GV-1-3	1163	300	0.26
4	GV-1-4	1107	--	--
5	GV-1-5	2608	--	--
6	GV-1-6	3197	--	--
7	GV-b-1	3734	--	--
8	GV-b-2	4092	--	--
9	GV-b-3	5572	--	--
10	GV-b-4	2094	--	--
11	GV-b-5	5160	--	--
12	GV-b-6	7150	--	--

Samples 1 to 6: First level
7 to 12: Last level 5m depth.

- G VI Uranium Occurrence

This is a shear zone which runs parallel to GI shear zone (Fig. 1). It is striking NNE-SSW and is steeply dipping to the ESE direction with an angle of dip of about 70°. The mineralizations extends about2 km in length and their widths vary from 1m to more than 3m, in addition to a mineralized flat topped area of about 500 m2 (Figs. 7 and 8). The uranium mineralization occur within and around the shear zone filling fractures and joints mainly trending in the NE-SW, N-S, NNE-SSW and E-W direction (Fig. 4B). The highest concentrations of visible secondary uranium mineralizations are located at the intersection of more than one of the previously mentioned trends (Fig. 8). The radiometric analysis of the collected surface mineralized samples are shown in (Table 4). The average Th/U ratio is around 0.05 indicating a strong enrichment in uranium [12].

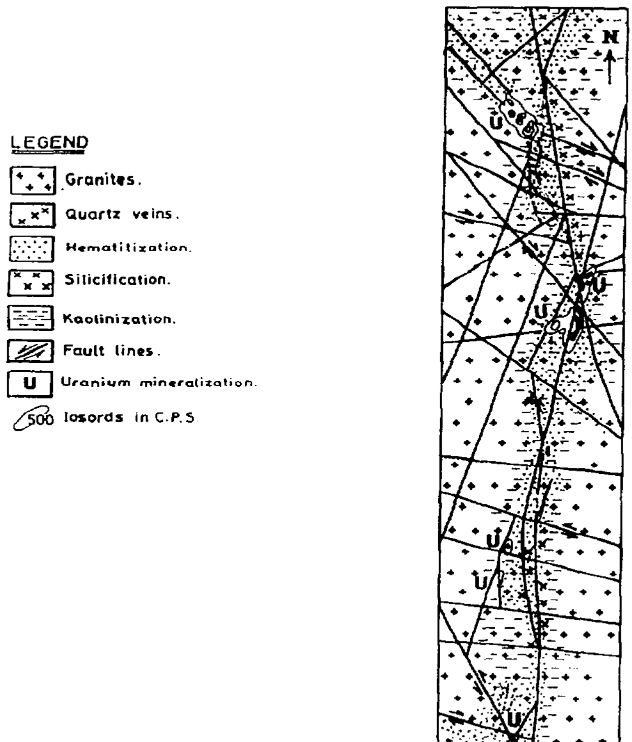
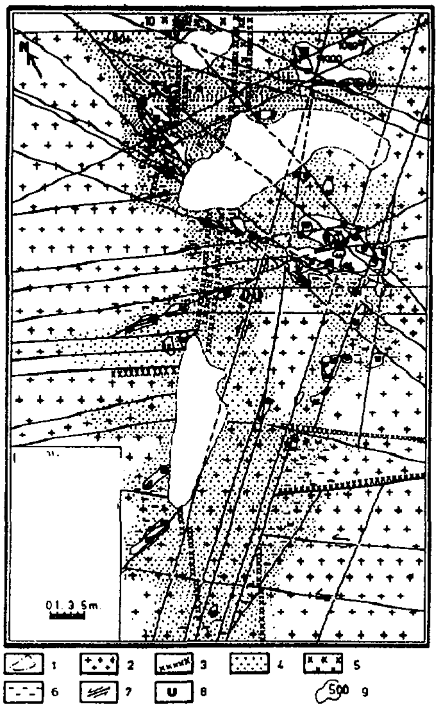


Figure (7) : Geological, Structural and Radiometric Map of the Shear zone, G VI Uranium Occurrence



1- Rock debris, 2- G. Gattar granite, 3- Quartz veins,
4- Hematitization, 5- Silicification, 6- Kaolinization,
7-Faults, dashed where inferred, arrows show relative displacement, 8- Uranium mineralization and 9- Isorads in cps

Figure (8) : Geological Structural and Radiometric Map of Flat Top Area, G VI Uranium Occurrence

Table (4) : Uranium and thorium content of radiometrically analysed grab samples from GVI uranium occurrence, G. Gattar prospect

Ser. No.	Sample No.	U ppm	Th ppm	Th/U
1	GVI, 1	2652	86	0.03
2	GVI, 3	1068	68	0.06
3	GVI,.4	3404	332	0.10
4	GVI, 7	1596	104	0.07
5	GVI, 8	6568	196	0.03
6	GVI, 9	1536	76	0.05
7	GVI, 10	1076	136	0.13
8	GVI, 30	30560	1520	0.05
9	GVI, 31	174	40	0.30
10	GVI, 34	4556	180	0.04
11	GVI, 35	6024	152	0.03
12	GVI, 36	8868	402	0.05
13	GVI, 38	9784	404	0.04
Average		5990	267	0.05

Discussion

The comparison between surface and subsurface uranium mineralizations indicates that the distribution of secondary uranium mineralizations greatly increase with depth associated with strong alteration features and the various uranium occurrences are strongly structurally controlled. Most of the mineralized lenses are concentrated on the hanging wall of the different faults.

It is also noticed from the relation between structures and uranium mineralizations whithin the highly promissing shear zones of GI, G VI and G II that they are all embraced within a large pull apart basin having about 2 Km length and 500 m average width.

The presence of uranium mineralizations associated with strong alteration features of the host granites depths confirm, to a certain axtent, the role of ascending hypogene mineralizing solutions with their various alteration features which affected Gabal Gattar granites and their adjacent Hammamat sediment which render the studied area as an area of high potentialities for a workable uranium deposit. Salman et al., [15], classified Gabal Gattar prospect as a hydrothermal vein type uranium.

Refferences

[1] Grothaus, B., Eppler, D. and Ehrlich, R. 1979: Depositional environment and structural implication of the Hammamat Formation,Egypt: Ann. Geol. Surv. Egypt. VIX, P. 564 - 590.

[2] Stern, R.J., Gottfried, D. and Hedges, C.E., 1984: Late Precambrian rifting and crustal evolution in the north Eastern Desert of Egypt: Geology, V. 12, P. 168 - 172.

[3] Stern, R.J. and Hadge, C.E., 1985: Geochronologic and isotopic constraints on Late Pre- cambrian crustal evolution in the Eastern Desert of Egypt: Amer. J. Sci. V. 285, P. 67-127.

[4] M.L El Rakaiby, and M.H. Shalaby, 1992: Geology of Gebel Gattar batholith, central Eastern Desert, Egypt: Int.J. Remote Sensing. Vol. 13, No. 12, P. 2337 - 2347.

[5] Stern, R.J. and Gottfried, D., 1986: Petrogenesis of a Late Precambrian (575-600Ma) bimodal suite in northeast Africa: Contr. Miner. Petrol., 92, P. 492 - 501.

[6] Jackson, N.D., 1986: Petrogenesis and evolution of Arabian felsic plutonic rocks: J. Afr. Earth. Sci., V.4, P. 47 - 59.

[7] Sylvester, P.J., 1989: Post collisional alkaline granites: Jour. Geology, Vol. 97, P. 261 - 280.

[8] M. Y., Attawiya, 1990: Petrochemical and geochemical studies of granitic rocks from gebel Gattar area, Eastern Desert, Egypt. Arab J. Nucl. Sci. Appl. Cairo, V. 23, No. 2, p.13-30.

[9] Keary, P. and Vine, F.J., 1990: Global tectonics. Geoscience Texts: Blackwall Scientific Publications, Oxford, London and Australia, 302P.

[10] Reading, H.G., 1980: Charateristics and recognition of strike - slip fault systems, in Ballance, P.F. and Reading H.G., eds. Sedimentation in oblique - slip mobile zones: Int. Assoc. Sed. Spec. Pub., P. 7-26.

[11] Said, R., 1962: The Geology of Egypt: Elsevier Puble. Co., Amsterdam - New york, 377P.

[12] Abu Zaid, M.M., 1995: Relation between surface and sulsurface uranium mineralization and structural features, Gebel Gattar, North Eastern Desert, Egypt: M. Sc. Thesis, Fac. Sc., Ain Shams Univ., Cairo, Egypt, 208 P.

[13] Youssef, M. I., 1968: Structural pattern of Egypt and its interpretation, U. A. R. Ammer. Assoc. Petro. Geol. Bull., V. 52, No. 4, p. 601-614.

[14] Shalaby, M.H., 1996: Structural controls of uranium mineralization at Gabal Qattar, north Eastern Desert, Egypt: The Egyptian Academy of sciences Proceedings,(In press).

[15] Salman, A.B., El Assy, I.E. and Shalaby, M.H., 1990: New occurrence of uranium mineralization in Gebel Gattar, northern Eastern Desert. Egypt: Ann. Geol. Surv. Egypt. V. XVI, P. 31 - 34.

[16] Shalaby, M.H., 1990: Uranium mineralization in northern Gebel Gattar locality, northern Eastern Desert: 7 th Conf. Phanerozoic and Develop. Al Azhar Univ. Cairo,(In press).