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A New Uranium Occurrence, Gabal El-Missikat Prospect, Central Eastern Desert, Egypt

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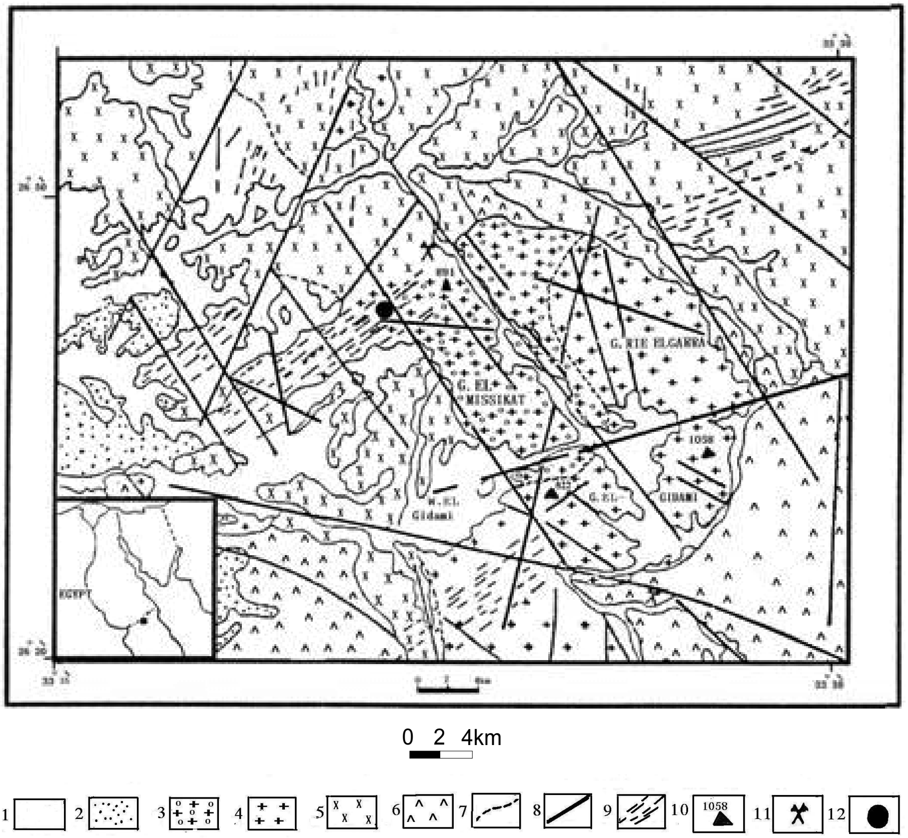
Abstract. Gabal El-Missikat post-tectonic granites represent one of the most promising examples of the fracture-filling uranium occurrences in the central Eastern Desert of Egypt. It includes several radioactive anomalies in which some are associated with U-minerals. These radioactive anomalies are controlled mainly by ENE-WSW trending shear fractures. In the present work, a new uranium occurrence (M-III) has been discovered in the north-western border of G. El-Misskat granitic mass. It is associated with jasperoid materials, occupying a NW-SE trending reactivated shear zone with tensile properties. The granites were subjected to intensive alteration, including silicification, sericitization, and kaolinization. In addition, a mixture of massive hydrated iron oxides (probably goethite and limonite) occurs as mammillae and botryoidally form in the centre of the shear zone. These hydrated iron oxides show colloform texture. They are resulted from the oxidation and hydration of magnetite and pyrite. Faults and their feathers, which are associated with the shear zone, structurally control the uranium mineralization at M-III occurrence. Visible secondary uranium minerals (mainly uranophane) are recorded as micro-fracture fillings. They are associated with deep violet-to black-fluorite in the highly brecciated and intensely ferruginated parts. The granites surrounding the shear zone are enriched in U and Th (mean 16 and 45 ppm, respectively).

Introduction

The uranium mineralization at Gabal El-Missikat (G. El-Missikat) occurrences is represented essentially by pitchblende and uranophane as secondary product (Attawiya, 1984; Abu-Deif, 1985, Ahmed, 1991 and Amer *et al*., 2005). The associated gangue minerals are small amounts of sulphides and fluorite. The uranium mineralization is mainly associated with smoky and/or red jasperoid materials in reactivated shear fractures (M-I and M-II) crossing the granites in NE-SW to ENE-WSW directions and dipping steeply toward SE. It belongs to the vein-type uranium deposits (Hussein *et al.,* 1986) and relates to poly-metallic vein type probably formed in reducing condition (Abu-Deif *et al*., 1997). Since its discovery (Ammar, 1973), G. El-Missikat prospect attracted the attention and subjected to several geologic and radiometric studies in both surface (Bakhit 1978, Abu-Deif, 1985 and Rabie *et al.* 1996), and sub-surface (Abu-Deif, 1985, Bakhit, *et al*. 1985, Hussein et al. 1992, El-Kattan, et al. 1995 and Abdallah, 1998). However, El-Missikat uranium prospect still needs more investigations. Abu-Deif (1999) pointed to the presence of some sites of high niobium content in G. El-Missikat. These sites seem to be in close association with uranium localities. Investigation of one of these sites led to the discovery of this present new occurrence (refer here as to M-III), which includes visible secondary uranium minerals. The uranium mineralization at M-III U-occurrence is associated with smoky and jasperoid siliceous materials in reactivated tension fractures of a shear zone affecting the granites in NW-SE direction and dipping steeply toward NE. The present study is concerned with the geologic features and radiometric potentiality of this new occurrence as revealed from the field. Also the delineation of the uranium mineralization and its relation to the different geologic and structural features of the area.

Geologic Setting

G. El-Missikat granitic pluton (891 m above mean sea level) lies midway along Qena-Safaga road. It was emplaced during the post-tectonic episode in Egypt, about 600 Ma (Hashad, 1980 and Greenberg, 1981). It lies at a distance of about three kilometres to the south of km 85 station (Fig. 1). It is developed in the western margin of the Red Sea rift, just across the major litho-tectonic discontinuity that forms the border contact between the central and north Eastern Desert tectonic blocks of Stern *et al*., (1984). The granite mass of G. El-Missikat with the northern parts of both G. Rei El-Garra and G. El-Gidami (Fig. 1), form the highly differentiated and more sodic supplementary phase of this composite granite pluton. This phase includes the most important U-bearing shear fractures. It is composed mainly of medium-grained leucogranite, which is rich in sodic plagioclase (albite) and poor in ferromagnesian and alkali feldspars; relative to the preliminary phase, which comprises the rest of the pluton (Abu-Deif, 1999). It intrudes the syntectonic granitoids and older rocks (metamorphosed ophiolitic rocks), mostly with sharp intrusive contacts. It is commonly massive and encloses some xenoliths from the older country rocks, indicating emplacement at structurally high level. Pegmatite in the form of small lenses and vein like bodies and sheets are encountered near the contacts, some of which contain magnetite.



1- Wadi deposits, 2- Nubian Sandstones, 3- Supplementary phase of younger granites, 4- Preliminary phase of younger granites, 5- Syntectonic granitoids, 6- Metamorphosed ophiolitic rocks, 7- Gradational contact, 8- Fault, 9- Dyke Swarms, 10- Triangulation point, 11- Mine, 12- M-III Uranium occurrence

Fig. 1. A Geologic Map of Gabal El-Missikat Prospect.

The granite of G. El-Missikat is a U-enriched, medium-to coarse-grained with reddish pink colour. It is speckled with some milky white plagioclase feldspars and smoky quartz grains. The major rock forming minerals are quartz, sodic plagioclase (oligoclase and albite), alkali feldspar (mainly perthite) and biotite. Accessory minerals are apatite, sphene, ilmenite, fluorite, rutile, muscovite, magnetite, tantalum bearing minerals and zircon. Very rare uraninite, allanite, uranothorite, xenotime and monazite, are also present (Nagy, 1977; Bakhit, 1978; Attawiya, 1984; Abu-Deif, 1985 and 1992; Mohammed, 1988; El-Kammar et al, 1997; Oraby, 1999 and Ibrahim, 2002, Amer *et al.,* 2005). This granite is locally altered, especially along the fractures. The alteration types are silicification, ferrugination, sericitization and kaolinization. Microclinization and albitization are characteristic of these granites (Greenberg, 1981; Ahmed, 1991). Repeated silicification (Abu-Deif, 1985), albitization and potassium metasomatism (Abu-Deif *et al.,* 1997) were also recorded.

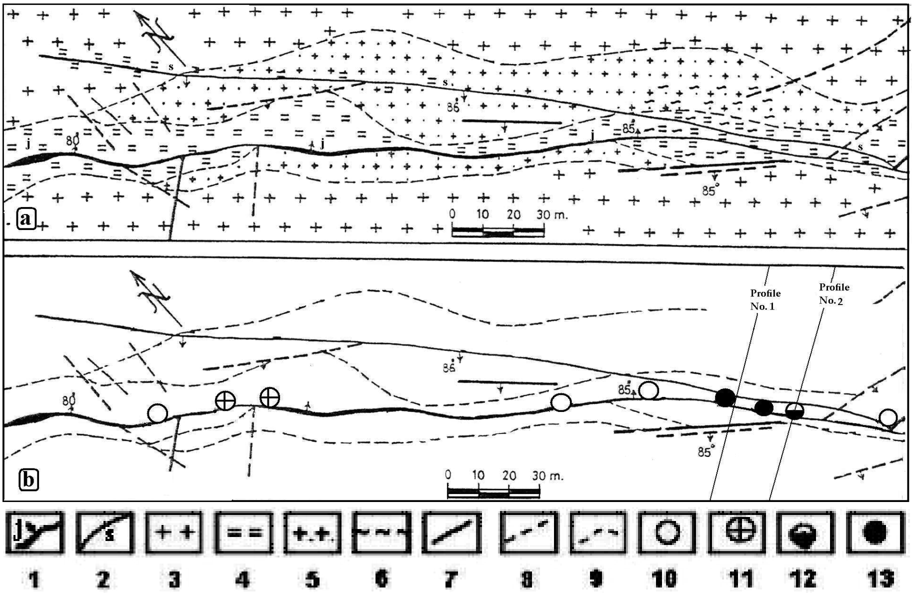
The age of the pluton is 568 ± 17 Ma (Rb/Sr age reported by Fullagar, 1980) with low initial Sr^{87}/Sr^{86} ratio of 0.7020.

Present Exploration Work

The area that includes the most significant radioactive anomalies and uranium minerals at M-III has been delineated for detailed geologic and radiometric investigation. A geologic map (Fig.2.a), of scale 1:2000, was constructed on a grid pattern of 40 m intervals. The main geologic and structural features were delineated. Radiometric measurements were statistically treated and radioactive anomaly spots were delineated (Fig.2b).

Geology of M-III U-Occurrence

Figure 2 (a) shows a geologic map of M-III U-occurrence. The surface area of the map is about 24000 m^2 (300 m*80 m). It has a level of about 125m or more above mean wadi level, and about 675 m above mean sea level (Fig.3 a and b). The geologic map shows a major fault zone, trending NW-SE direction, passes through the whole mapped area and extends out side. The post-tectonic biotite granite, of late Precambrian age, and the main rocks which are exposed in the area are characterized by high radioactivity and radioelements enrichment.



1- Mineralized jasperoid vein, 2- White silica vein, 3- Younger granite, 4- Sericitized granite, 5- Kaolinized granite, 6- Ferrugination, 7- Fault, 8- Fracture, 9- Gradational geologic boundary, 10- Spot anomaly < 100, 11- Spot anomaly< 200, 12- Spot anomaly< 300 ch/sec., 13- Secondary U-minerals.

Fig. 2: a. A geologic map of a part of M-III U-occurrence, El-Missikat prospect, b. Distribution of radioactive anomalies.

The granite at M-III U-occurrence represents a part of the north-western margin of G. El-Missikat. In general, the granite has a pink colour, medium to coarse grains. It is composed of potash feldspars, smoky quartz, and intermediate to sodic plagioclase. The ferromagnesian minerals are mostly biotite. A small amount of muscovite is present. Iron oxides occur as spots of hematite and limonite. Potash feldspars are present as micro-perthite.

The fracture plains are stained with iron oxides and black manganese oxides in the form of patches and dendrites. Mixtures of hydrated iron oxides (probably goethite and limonite) are present as mammillae and botryoidally forms, giving the shear zone a remarkable feature (Fig.3 c and d). These hydrated iron oxides display colloform texture. They are resulted from the oxidation and hydration of magnetite and pyrite. The granite is partially altered, especially along the fracture surfaces and nearby the jasperoid vein. Within the shear zone, the granite is highly brecciated and intensely altered. Furreginated fine-grained granite, in places sheared and silicified, is noticeable close to the jasperoid vein.

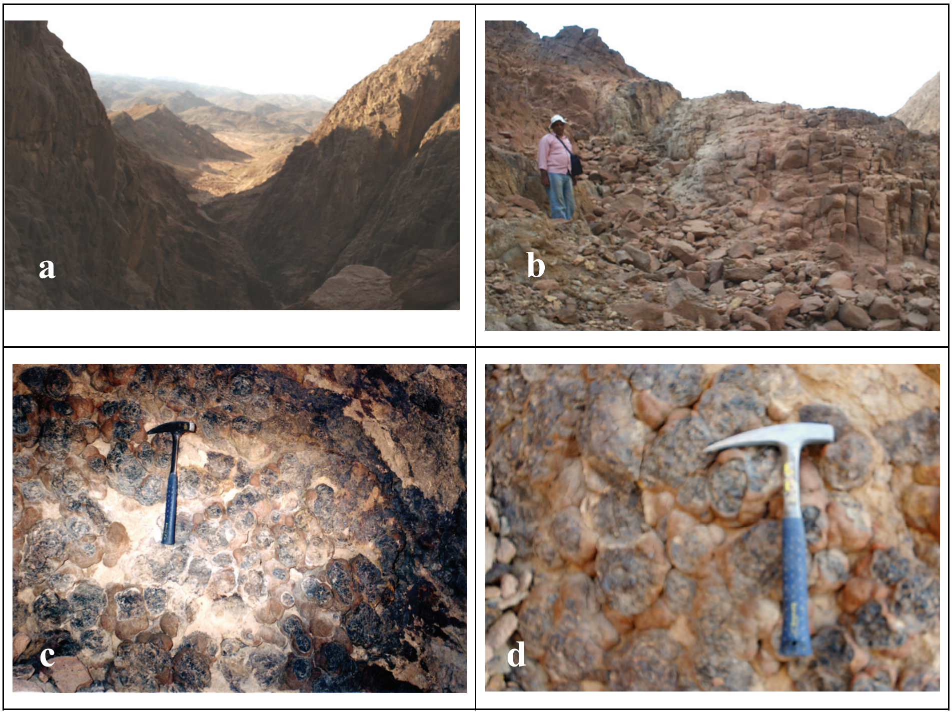


Fig. 3. M-III shear zone crossing G. El Missikat younger granites, a)- near wadi level, b)- at a higher level; looking NW, c) & d)- hydrated iron oxides as mammillae and botryoidally forms.

Two siliceous veins were detected in the map area (Fig.2 a). The first is a jasperoid vein mineralized with uranium. It is occupying the centre of the shear zone. It has a general N50^{o}W trend and dips steeply (75^{o}-85^{o}) toward NE. The second is non- mineralized white coloured quartz vein running in N40^{o}W direction and dipping steeply toward SE. The mineralized jasperoid vein is the youngest; it cut the non-mineralized quartz vein. There are some other veinlets, mainly quartz, filling the fracturs within and between these two veins.

The mineralized jasperoid vein, in general, is irregular in shape and varies in thickness from few cm to more than 1.5m. The siliceous materials that occupy the mineralized shear zone occur mainly as amorphous and cryptocrystalline jasperized chalcedony. Brecciation of the granites and jasper as well as the mammillae forms of goethite are common, indicating multi-rejuvenation of the structure. In some parts, silica filling fractures in the shear zone form intricate and dense networks of relatively short veinlets. A strong hematitization is usually observed filling the spaces between brecciated rocks and along fractures. Mammillae goethite commonly occupy the footwall of the fault. Away from the centre of the shear zone, silica is found filling the fractures and forming thin veinlets running mostly in NW- SE to NWW-SSE directions, where some are radioactive.

Wall Rock Alteration

The granitic rocks of the prospect are highly altered, especially along the fractures. The common alterations are silicification and ferrugination, sericitization, and kaolinization. An intense hematitization and manganese oxide staining are common along the extension of the silicieous veins and fractures. In addition, goethite is present as mammillae and botryoidal forms (Fig. 3c and 3d).

Arrangement of the alteration zones is observed. All gradations from intensely altered to unaltered granite were recorded (Fig. 2a). Near the fractures, which are occupied by silica, especially at their contacts, the granite becomes siliceous and stained by hematite. The silicification decreases gradually away from shear zone. In addition, very dark brown to yellowish brown colour with sub-metallic lustre goethite is present as mammillae and botryoidal forms (Fig. 3 b). The sericitized zone occurs directly in contact with the silicification. The width of sericitized zone ranges from few cm up to more than 20 meters on both sides of the siliceous veins (Fig. 2a). In sericitized granite, the feldspars are mostly altered to sericite, and the rock becomes green in colour. The kaolinized zone follows outward the sericitized zone and passes gradually to the unaltered granite (Fig. 2a). The width of the kaolinized zone ranges from few cm to more than 30m on both sides. In kaolinized granite, feldspars are mostly altered to kaolinite; and the rock becomes light in colour and more brittle. It is noticed that alteration is wide and more intense toward the dip direction of the mineralized vein (toward NE). Due to the significant importance of wall-rock alteration in relation to uranium mineralization at M-III, further detailed study will be presented later in a separate work.

Radioactivity

Radiometric investigation was carried out systematically along a grid pattern of 40 meters intervals using a portable French gamma-meter Geiger counter, model GMT-3T. The number (No.) of radioactivity measurements recorded over each rock exposure (in chock per second; ch/sec.) have been statistically treated (Table 1). The arithmetic mean ($X^{\backslash}$), standard deviation (S.D) and coefficient of variation (C.V) are calculated. Locations of the radioactive anomaly spots as well as uranium mineralization were delineated (Fig. 2 b).

Table 1. Statistical values of radioactivity measurements (ch/sec.) for the different rock exposures at M-III uranium occurrence.

Rock unit	No.	Min.-Max. ch/sec.	($X^{\backslash}$) ch/sec.	S.D	C.V
Unaltered granites	84	40-60	46.0	6.8	14.8
Kaolinized granites	46	40-50	45.5	5.0	11.0
Sericitized granites	31	40-60	47.5	8.5	17.9
Jasperoid vein	34	40-500	96.0	100.6	104.8

It is clear from Table 1 that the sericitized granite is slightly higher in radioactivity than the other types of granites. The jasperoid vein contains most of the significant radioactive anomalies. Some spots with abnormal radioactivity ranges contain visible secondary uranium mineralization.

Distribution of the Radioactive Spots

The radioactivity measurements on the grid pattern displayed some of 9 abnormal radioactive spots with radioactivity higher than 70 ch/sec. ($X^{\backslash}$+3* S.D). The majority of these spots (4 spots) show radioactivity lower than 100 ch/sec. Two spots have radioactivity lower than 200ch/sec., while the highest reached 500 ch/sec., (Fig. 2 b).

The recorded spot anomalies have disconnected lensoidal shapes with limited dimensions, elongated generally in the direction of the mineralized fractures (Fig. 2 b). All of these anomalies are lithologically and structurally controlled. They are related to jasperoid silica occupying the fractures in the main shear zone. Some of these anomalies are associated with lemon yellow secondary uranium minerals (probably uranophane) and deep violet -to black- fluorite.

The radioactive anomaly in the southeastern part of the map is the most important one. It has considerable dimensions and contains visible secondary U-minerals. It extends more than 20m, with gamma radioactivity varies mainly between 70 and 500 ch/sec.

Distribution of Radioelements

Multi-channels gamma-ray spectrometer; model GS-256, was used to investigate the distribution of radio-elements. This was carried out along two profiles that cross two uranium mineralized spots (Fig. 2 b). These profiles are extended perpendicular or nearly so, to the general strike of the japeroid vein. The instrument was calibrated in equivalent uranium (eU) in part per million (ppm), equivalent thorium (eTh) ppm, and potassium (K %), as well as total count (T.C.) in Ur (unit of radioactive concentration). The results of the statistical treatments of the recorded radiometric data of the rock are summarized in Table (2), from which some radioelement parameters were determined.

Although the limited number of data, Table (2) shows that both the unaltered granite and kaolinized granite exhibit the lowest radioactivity content compared with the sericitized granite. Although there is no obvious difference in T.C. radioactivity between the two alteration types, the unaltered granite possesses slightly higher eU and eTh content than the kaolinized granite. The sericitized unit possesses the highest radioactivity and the highest content of eU and eTh. The siliceous jasperoid vein hosts most of the significant recorded radioactive anomalies. The unaltered granites show slightly lower eU/eTh ratio than the altered granites. The sericitized granite shows the highest eU/K and eTh/K ratios, whereas the kaolinized granite is the lowest (Table 2).

Uranium Mineralization

Uranium mineralization is connected mainly to the jasperoid silica filling the fractures zone. It is discontinuous with high radioactivity, and is structurally controlled where it occurs along fracture zone. It is preferably localized along the contacts of the siliceous veins, along the secondary fractures, and at the intersections of fractures. Visible secondary U-minerals, probably uranophane, were encountered in several radioactive parts. They occur along micro-fracture surfaces, and coating cavities and vugs as thin films and fine clots. U-minerals are always found in association with black fluorite, and iron oxides and manganese oxides.

Table 2. Statistical values of radioelement parameters for the different granite exposures at M-III U-occurrence.

Variable		Unaltered Gr.	Kaolinized Gr.	Sericitized Gr.
No. of measurements		11	10	16
T.C Ur	Min.-Max.	44-58	42-59	42-82
	$X^{\backslash}\pm$S.D	51±4.9	50±5.9	60±9.3
	C.V	9.6	12.6	15.9
eU Ppm	Min.-Max.	14.5-25.8	12.7-21.3	15.3-46.7
	$X^{\backslash}\pm$S.D	18.5±2.9	16.9±2.7	26.1±8.1
	C.V	15.7	17	31
eTh ppm	Min.-Max.	38.4-54.8	34-55.2	32.4-62.6
	$X^{\backslash}\pm$S.D	45±5.7	44.8±6.5	48±8.2
	C.V	12.7	14.5	17.1
K %	Min.-Max.	3.6-5.8	4.2-7.1	4.1-8.8
	$X^{\backslash}\pm$S.D	4.9±0.6	5.3±1.0	5.1±1.2
	C.V	12.9	18.9	23.5
eU/eTh	Min.-Max.	0.3-0.6	0.3-0.5	0.4-1.0
	$X^{\backslash}\pm$S.D	0.4±0.07	0.5±0.09	0.5±0.1
	C.V	17.8	19.3	29.3
eU/K	Min.-Max.	2.8-4.9	2.3-4.3	2.7-9.7
	$X^{\backslash}\pm$S.D	3.8±0.6	3.2±0.6	5.3±2.0
	C.V	16.9	19.8	38.5
eTh/K	Min.-Max.	7.8-11.3	6.9-9.6	6.2-11.5
	$X^{\backslash}\pm$S.D	9.2±1.1	8.5±0.9	9.5±1.3
	C.V	12.2	11.0	14.2

No. = number of data, Min. and Max. = minimum and maximum values.
The ratios eTh/K and eU/K are multiplied by 10^4.

Conclusion

The M-III uranium occurrence is located at the northwestern margin of G. El-Missikat, Central eastern Desert, Egypt. It contains visible secondary uranium minerals. The uranium mineralization is commonly associated with jasperoid siliceous materials in reactivated extension fractures trending NW-SE and dipping steeply toward NE. The granite is more or less altered, especially along the fracture surfaces and nearby the siliceous materials. The main alterations are silicification and ferrugination, sericitization, and kaolinization. An intense hematitization and manganese oxide staining is common along the extension of the silicieous veins and fractures. In addition, hydrated iron oxides show colloform textures are present as mammillae and botryoidal form. They are resulted due to the oxidation and hydration of magnetite and pyrite. Some of 9 abnormal radioactive spots are recorded. These anomalies occur as disconnected lensoidal shapes with limited dimensions, where all these anomalies are structurally controlled. They are elongated generally in the direction of the main fracture zone. Some of these anomalies are associated with lemon yellow secondary uranium minerals (probably uranophane) and fluorite with deep violet -to black-colour.

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تواجد جديد لليورانيوم في صخور الجرانيت بجبل المسيكات، وسط الصحراء الشرقية، مصر

على أبو ضيف أحمد و محمد علي الطاهر*

هيئة المواد النووية – ص ب ٥٣٠ المعادى – القاهرة

** كلية العلوم – جامعة جنوب الوادي – قنا – جمهورية مصر العربية*

المستخلص. تعتبر تمعدنات اليورانيوم المصاحبة لعروق الجاسبر الموجودة فى شقوق نطاقات القص والتمزق بكتلة الجرانيت بعد البنائي لجبل المسيكات بوسط الصحراء الشرقية واحدة من أهم تواجدات اليورانيوم في مصر. غالبًا ما ترتبط هذه التمعدنات بعروق السليكا والجاسبر المالئة لنطاقات القص والتمزق الضاربة شمال شرق – جنوب غرب. المستكشف الجديد يرتبط بعروق السليكا والجاسبر المالئة لنطاق قص شدي يضرب في اتجاه شمال غرب – وجنوب شرق. كشفت هذه الدراسة عن وجود معادن اليورانيوم الثانوية من النوع المالىء للشقوق في بعض الصدوع القصية والريشية المرتبطة بالصدع الرئيس داخل نطاق التمزق. ووجد أن الجرانيت على طول نطاقات القص غالبًا ما يكون متغيرًا، ومن الظواهر الأساسية لهذا التغير السلكتة وتكوين معادن السيريسيت والتغير الطيني. يتميز الصدع الرئيس في نطاق القص موضوع الدراسة بوجود خليط من أكاسيد الحديد المائية (جوثيت وليمونايت) في شكل عقد على الحوائط السفلية للصدع.