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MINERALOGY, RADIOACTIVITY AND GEOCHEMISTRY OF WADI ABU EL-HASSAN STREAM SEDIMENTS, CENTRAL EASTERN DESERT, EGYPT

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ABSTRACT

Gabal Abu El-Hassan area is a part of the Egyptian Pan-African belt located at the Central Eastern Desert, Egypt. The metavolcanics, serpentinites, gabbros, older granites, Dokhan volcanics, Hammamat sedimentary rocks, younger granites and post granitic dykes represent the main rocks of the basement complex outcropped in this area. About thirty five Wadi sediment samples were collected from the floor of three major Wadis and their tributaries at Gabal Abu El-Hassan area. Some radioactive and radioactive-bearing heavy minerals were recorded in the concerned sediments such as uranothorite, thorite, columbite, allanite, monazite, fluorite, sphene, zircon in addition to garnet, ilmenite and rutile as accessory minerals. The relative enrichment of uranium in the three Wadis indicate that the surrounding granites of Wadi Abu El-Hassan are responsible for the high radioactivity of the area.

INTRODUCTION AND GEOLOGIC SETTING

The studied area of Wadi Abu El-Hassan is located between Lat. 26°50´ and 27°00´N and Long. 33°10´ and 33°20´E covering an area of about 230 Km^2 (Fig. 1). The metavolcanics, serpentinites, gabbros, older granites, Dokhan volcanics, Hammamat sediments and younger granites represent the main rocks of the basement complex. The field relationships between the granite and the country rocks demonstrate high level intrusions with clearly defined contacts.

The concerned area was previously studied by several authors as Zalata (1972), Dawoud (1995), Ayoub (1996), Hilmy et al. (2003), Abdel Monem et al. (2004), Hilmy et al. (2004), El-Sherif (2005), El-Sundoly (2008), El-Dabe (2010), Khamis (2012) and Mahdy (2015).

The studied area is a mountainous region characterized by rugged topographic features and high to moderate relief. The exposed Precambrian rocks generally form structurally controlled steep slopes against the Wadis, which follow the fault planes and drain in different directions (El-Sundoly, 2008). The drainage pattern in the area is southwards either to the east or to the west, but there is local drainage to the north in the most northern part of the area separated by a water divide southwards at Gabal Abu Samyuk.

Gabal Abu El-Hassan area is dissected by various faults and fractures, their lengths range from few meters to five kilometers. The prevalent fault sets trend to NE-SW, NW-SE and N-S directions. Zalata (1972) recognized two major fault sets trending generally

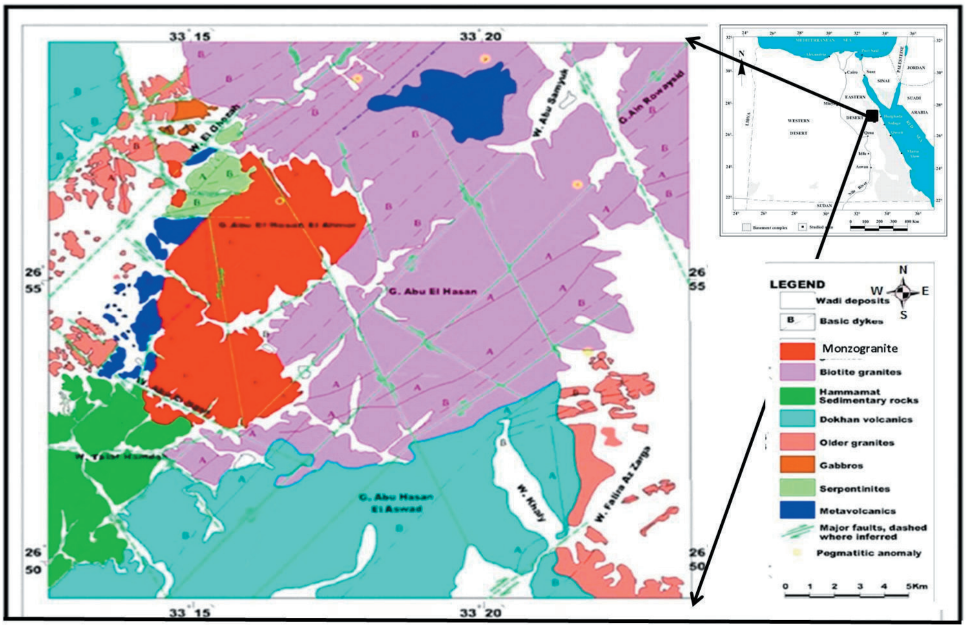

Fig. 1: Geologic map of Gabal Abu El-Hassan area, Central Eastern Desert, Egypt (El-Sundoly, 2008)

NNW-SSE and NE-SW and the less abundant faults trending N-S and E-W. He added that the NNW-SSE group is believed to be younger than the NE-SW. Dawoud (1995) stated that the overall fracture pattern of the area is dominated by 6 preferred orientations trending NNE-SSW, NNW-SSE, NE-SW, NW-SE, ENE-WSW and WNW-ESE. The lineations trending NNE-SSW and NE-SW exhibit relatively longer lengths as compared to their number percent.

Gabal Abu El-Hassan area is part of the Egyptian Pan-African belt in the Central Eastern Desert. There are three main peaks in the present area; Gabal Abu El-Hassan in the southeast reaching about 1558 m above sea level, Gabal Abu Samyuk in the north reaching about (1572 m) and Gabal Abu El-Hassan El-Ahmar in the center (1234 m). The younger granites which are intruding all the pre-existing rocks, acquired their importance from the fact that they comprise some promising targets for uranium mineralization in Egypt such as El Erediya (El-Kassas, 1974), El Missikat (Bakhit, 1978), Um Ara (Abdel Maguid, 1986) and Gabal Gattar (Salman et al., 1990).

SAMPLING AND METHODOLOGY

Thirty five Wadi sediment samples were collected at interval space of about 500 m from holes of about 70 to 100 cm in diameter and about 50 cm in depth with an average of 27 Kg in weight for each sample (Fig. 2).

They distributed as 16 stream sediment samples collected from the main Wadi (C), 12 samples from the northern tributary (N) and 7 samples from southern tributary (S).

The grain size distribution analyses were carried on the bulk stream sediment samples using the conventional dry sieving technique according to Wentworth grade scale (1922). Fine, very fine and silt fractions were subjected to geochemical, radiometrical and mineralogical investigations. The studied bulk stream sediment samples (size 1 mm) were subjected

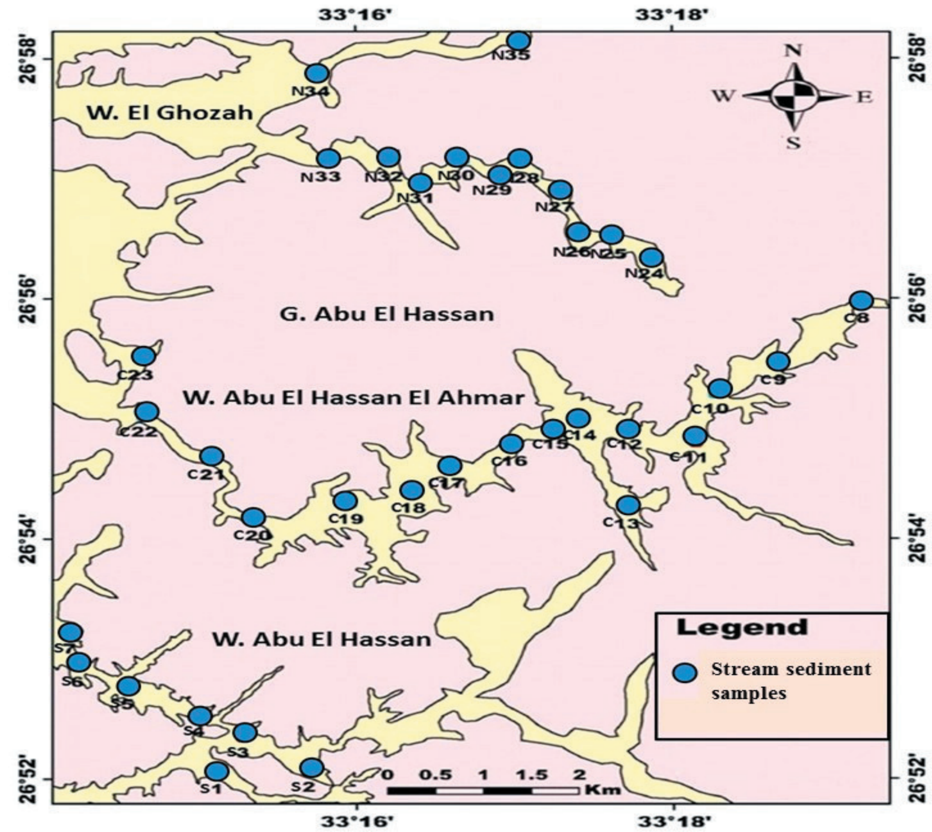

Fig. 2: Location map showing the collected stream sediment samples, Wadi Abu El-Hassan area, Central Eastern Desert, Egypt (S: Southern Wadi, C: Central Wadi , N: Northern Wadi).

to heavy liquid separation process using Bromoform liquid ($CHBr_3$) of specific gravity 2.81 g/cm^3. Also six mud samples were subjected to heavy liquid separation using Bromoform and centrifuged. Then the magnetite mineral was separated using hand magnet. On the other hand, free-magnetite fractions were magnetically sorted using isodynamic magnetic separation technique. Finally, the obtained heavy fractions were microscopically investigated using binuclear microscope as well as the Environmental Scanning Electron Microscope (ESEM). NaI (Tl) Gamma ray analyzer was used for detecting the four radioactive elements (eU, eTh, Ra and K). The trace elements content was determined using XRF technique as well as spectrophotometric techniques (using Arsenazo-III to determine U and Th elements). All analyses were performed in Nuclear Materials Authority (NMA) labs.

DISCUSSION AND RESULTS

Grain Size Study

About 200 weighted gms from each sample were subjected to mechanical analysis using an automatic vibratory shaker with sieves 4.0, 2.0, 1.0, 0.5, 0.25, 0.125 and 0.063 mm. The resulted grain size distribution is given in Table (1).

Table 1: Grain size distribution of the stream sediment samples of Wadi Abu El-Hassan area

Sample No.	Grain size distribution							
	Gravel %		Sand %					Mud %
	Pebbles	Granules	Very Coarse	Coarse	Medium	Fine	Very Fine	
	>4	4 –2	2 –1	1-0.5	0.5 –0.25	0.25 – 0.125	0.125 – 0.063	<0.063
S-1	11.20	5.35	20.35	18.44	17.11	18.76	8.73	0.06
S-2	20.34	18.22	19.69	19.21	6.78	2.74	3.98	9.04
S-3	19.70	7.57	6.10	12.61	19.52	21.98	9.77	2.75
S-4	18.67	9.23	5.18	11.24	21.56	22.11	10.21	1.80
S-5	15.19	8.64	8.10	35.29	23.36	4.57	1.24	4.60
S-6	5.30	4.79	7.01	27.44	32.76	15.45	5.05	2.20
S-7	16.39	18.12	15.0	17.00	14.28	10.81	7.29	1.11
C-8	10.18	10.39	9.45	20.41	23.68	16.55	8.22	1.12
C-9	13.70	5.97	5.70	23.55	37.69	11.10	2.29	.710
C-10	14.69	9.86	9.81	35.29	23.36	4.57	1.37	1.05
C-11	19.23	9.35	8.47	27.27	24.28	7.57	2.39	1.44
C-12	5.94	4.71	7.01	27.44	32.76	15.45	5.05	1.64
C-13	17.97	11.97	21.0	45.80	3.25	0.01	0.00	0.00
C-14	1.04	3.22	6.43	30.36	39.51	14.98	3.41	1.05
C-15	0.99	0.37	0.60	8.90	50.42	24.21	13.09	1.42
C-16	7.33	17.71	19.69	27.52	13.67	8.34	4.58	1.16
C-17	11.67	5.52	9.29	19.88	19.55	19.96	11.72	2.41
C-18	15.60	7.91	6.76	16.55	22.64	21.33	6.76	2.45
C-19	9.86	14.69	9.81	35.29	23.36	4.57	1.37	1.05
C-20	4.73	5.92	8.02	26.43	31.75	16.46	5.09	1.60
C-21	8.17	12.40	8.47	19.39	21.68	16.56	8.21	5.12
C-22	13.00	16.73	18.1	28.48	15.38	5.26	2.07	0.98
C-23	25.09	6. 01	5.26	15.45	17.86	19.35	12.67	4.32
N-24	12.39	18.12	19.00	17.00	14.28	10.81	7.29	1.11
N-25	19.23	9.37	8.47	28.25	23.28	7.56	2.40	1.44
N-26	10.66	6.63	9.04	21.98	19.45	20.11	11.74	0.39
N-27	15.19	9.66	6.79	14.24	20.63	22.11	10.36	1.02
N-28	9.50	6.91	13.96	17.55	22.64	21.23	6.76	1.45
N-29	-	-	0.25	28.87	65.03	0.03	5.68	0.14
N-30	26.08	6.01	5.27	12.54	13.76	20.35	12.67	3.32
N-31	16.29	15.22	15.00	20.01	14.27	10.81	7.29	1.11
N-32	0.89	0.86	0.07	8.89	50.45	24.31	13.09	1.44
N-33	16.94	14.64	11.01	26.47	33..01	24.44	5.06	1.44
N-34	1.07	3.20	6.43	30.36	39.51	14.98	3.44	1.01
N-35	12.96	11.97	22.00	49.80	3.25	0.01	0.01	0.00

S: Southern Wadi, C: Central Wadi , N: Northern Wadi

The sand size is the main content in the main Wadi as well as their tributaries, the mud content exhabits less values. The obtained data of different grain size distribution were represented at the ternary diagram of Folk (1954), Fig. (3). It is clear from this ternary diagram that most of the studied samples lie in gravelly sand field, few samples are located in sandy gravel and sand fields.

Mineralogical Study

All collected samples from the floor of the main Wadi and its tributaries were subjected to heavy and light fractions measurements. The obtained heavy fraction which listed in Table (2) varies between 1.07 % and 14.55% with 5.9% average content and shows higher concentration in the north tributary than the two other tributaries. This may be explained by the presence of a new source of heavy fraction in this section which is likely to be biotite granite rock unit surrounding Gabal Abu El-Hassan (Fig. 1).

From the quantitative and semi-quantitative mineralogical studies of the stream sediments using the microscopic analysis, eleven heavy minerals were identified namely uranothorite, columbite, zircon, fluorite, allanite, titanite, apatite, monazite, garnet, ilmenite and rutile (Table 3). Also, some recorded radioactive and radioactive-bearing minerals such as uranothorite, columbite and zircon have the same trend of concentration of heavy mineral higher in the north tributary than that present in the two other tributaries. This result support presence of additional source of heavy fraction in the northern tributary. Six representative mud-size samples of the studied stream sediments were also examined by the ESEM. This study revealed the presence of some radioactive bearing minerals such as zircon, monazite and allanite.

Uranothorite (Th, U) SiO_4

Uranothorite is the most common mineral from the radioactive point of view present in

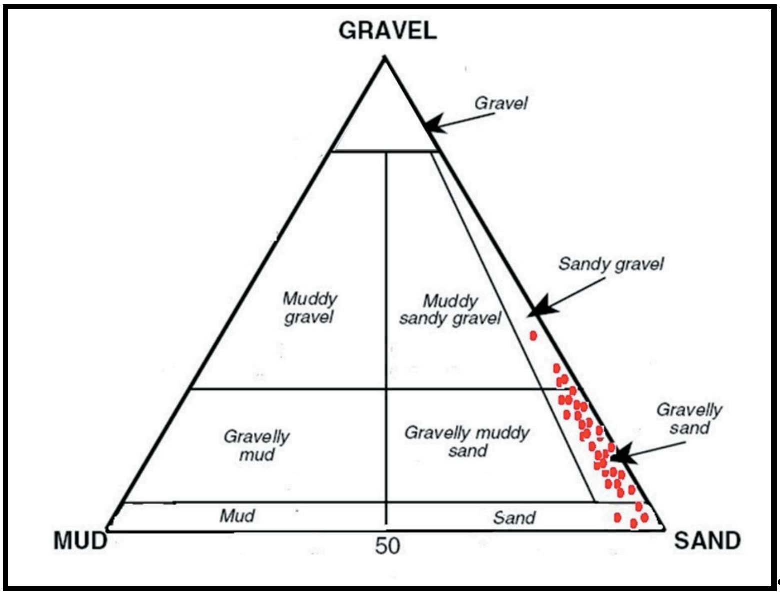

Fig. 3: Grain size distribution diagram of the stream samples of Wadi Abu El-Hassan area (Folk, 1954)

Table 2: Heavy fraction (wt.%), Light fraction (wt.%), Magnetite (wt%) and free magnetite (Mag.) (wt%) of stream samples of Wadi Abu El-Hassan area

Sample No.	Heavy fraction	Light fraction	Magnetite	Free Mag. heavy minerals
S-1	3.72	96.28	0.048	3.671
S-2	4.21	95.79	0.045	4.165
S-3	2.35	97.65	0.036	2.305
S-4	4.31	95.69	0.033	4.276
S-5	3.01	96.99	0.036	2.974
S-6	5.44	94.56	0.025	5.415
S-7	4.31	95.69	0.008	4.301
C-8	2.58	97.42	0.037	2.543
C-9	2.82	97.18	0.043	2.776
C-10	7.71	92.29	0.039	7.672
C-11	1.32	98.68	0.031	1.289
C-12	3.73	96.27	0.044	3.686
C-13	1.84	98.16	0.032	1.808
C-14	0.17	99.83	0.005	0.165
C-15	4.46	95.54	0.028	4.432
C-16	4.25	95.75	0.030	4.220
C-17	2.72	97.28	0.029	2.691
C-18	4.84	95.16	0.034	4.806
C-19	4.33	95.67	0.026	4.304
C-20	1.78	98.22	0.020	1.760
C-21	1.85	98.15	0.007	1.843
C-22	3.88	96.12	0.037	3.843
C-23	3.22	96.78	0.024	3.196
N-24	3.98	96.02	0.032	3.940
N-25	4.11	95.89	0.011	4.099
N-26	3.53	96.47	0.037	3.493
N-27	2.82	97.18	0.035	2.784
N-28	9.22	90.78	0.027	9.193
N-29	9.86	90.14	0.024	9.836
N-30	11.70	88.30	0.031	11.668
N-31	6.69	93.31	0.028	6.662
N-32	13.85	86.15	0.035	13.815
N-33	11.12	88.88	0.031	11.088
N-34	8.88	91.12	0.030	8.850
N-35	8.90	91.10	0.025	8.875
Average	4.957	95.042	0.0289	4.926

S: Southern Wadi, C: Central Wadi , N: Northern Wadi

Table 3: The frequency (wt%) of the concerned recorded heavy minerals in the studied stream sediment samples of Wadi Abu El-Hassan area

Sample	Uranothorite	Columbite	Zircon	Fluorite	Allanite	Titanite	Monazite	Apatite	Garnet	Ilmenite	Rutile	G.S.	Mag.
S-2	0.020	0.011	0.05	0.048	0.021	0.103	0.022	0.110	0.103	0.600	0.001	4.350	0.042
S-4	0.025	0.01	0.022	0.045	0.010	0.098	0.031	0.105	0.098	0.160	0.003	6.545	0.031
S-6	0.006	0.012	0.041	0.034	0.022	0.084	0.021	0.062	0.083	1.179	0.003	2.707	0.030
S-7	0.000	0.009	0.037	0.047	0.011	0.077	0.018	0.057	0.079	1.036	0.002	3.128	0.002
C-9	0.010	0.005	0.012	0.029	0.026	0.053	0.071	0.213	0.071	0.113	0.007	9.341	0.031
C-11	0.003	0.010	0.037	0.023	0.033	0.048	0.089	0.196	0.065	0.769	0.008	11.983	0.030
C-13	0.021	0.014	0.021	0.0116	0.042	0.060	0.101	0.376	0.105	0.449	0.010	2.546	0.006
C-15	0.002	0.023	0.015	0.0126	0.011	0.075	0.111	0.471	0.132	0.133	0.011	6.496	0.038
C-19	0.005	0.012	0.091	0.016	0.022	0.191	0.101	0.063	0.081	0.099	0.150	0.012	0.026
N-24	0.057	0.693	0.294	0.024	0.037	0.137	1.122	0.458	0.058	0.133	0.109	0.526	0.032
N-26	0.532	0.361	0.335	0.076	0.006	0.613	0.421	0.520	0.074	0.966	0.606	3.605	0.037
N-28	0.024	0.157	0.124	0.041	0.039	0.047	0.062	0.057	0.058	1.210	0.026	5.86	0.027
N-30	0.062	0.218	0.179	0.052	0.066	0.053	0.093	0.088	0.010	0.003	0.076	6.027	0.031
N-32	0.075	0.763	0.225	0.022	0.087	0.082	0.014	0.138	0.043	0.160	0.210	2.561	0.030
N-35	0.091	0.620	0.247	0.949	0.580	0.096	0.652	0.233	0.099	0.540	0.789	3.75	0.025
Min.	0.002	0.010	0.012	0.0116	0.006	0.047	0.014	0.057	0.010	0.003	0.001	0.012	0.002
Max.	0.532	0.763	0.294	0.949	0.580	0.191	1.122	0.520	0.132	1.210	0.789	11.98	0.042
Av.	0.062	0.164	0.115	0.095	0.0675	0.121	0.195	0.209	0.077	0.501	0.134	4.629	0.0279

G.S.: green silicate, Mag.: magnetite

Wadi Abu El-Hassan stream sediments. Uranothorite is crystallized in the tetragonal system, isomorphus and generally associated with zircon which and strongly radioactive mineral. It has well shaped short prismatic crystals and pyramidal terminations.

Its frequency ranges from 0.002 to 0.532 % with an average of 0.062%. EDX analyses of uranothorite is dominated by considerable amount of ThO_2, SiO_2, UO_2, V, Y and Zr. The REE (Ce, Nd and Sm) are invariably present in concentrations above their detection limits (Fig. 4). The XRD pattern of uranothorite were shown on Fig. (5).

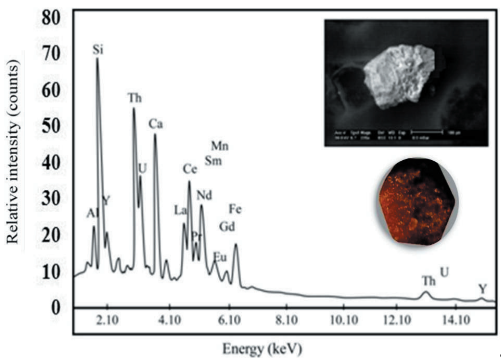

Fig. 4: EDX, BSE image and photomicrograph of uranothorite mineral from Wadi Abu El-Hassan area

Columbite (Fe, Mn) (Nb, Ta)$_2$O$_6$

Generally, the members of the columbite-tantalite family of minerals often contain significant amounts of U along with rare earth elements, Fe, Ca, and Th. The B site is either Nb or Ta like the pyrochlores. These minerals are associated with rare-earth pegmatites and are also known from placer deposits. Most of the compounds probably formed initially with U^{4+} most probably as a coupled substitution Ca^{2+} and U^{4+} for U trivalent ion.

Oxidation occurs easily, however, and most specimens contain significant amounts of U^{6+} (Smith, 1984).

The studied columbite minerals occur as black anhedral to subhedral crystals. It is translucent and has a reddish brown color along the edges. Its frequency ranges from 0.010 to 0.763% with an average of 0.164% for Wadi Abu El-Hassan stream sediment samples (Table. 3). EDX analyses for picked grains of columbite from Wadi Abu El-Hassan stream sediment samples are shown on Figure (5).

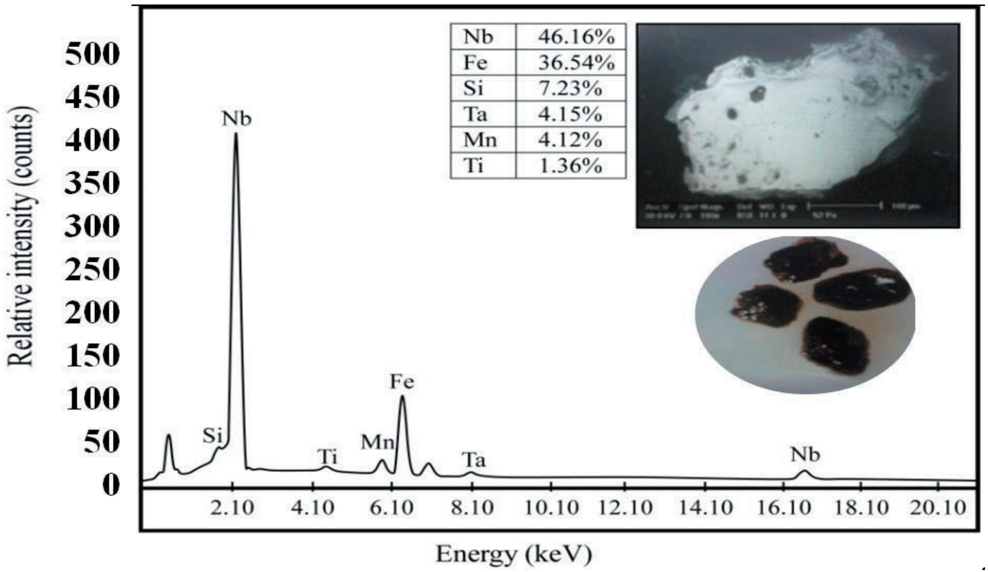

Fig. 5: EDX, BSE image and photomicrograph of columbite mineral from Wadi Abu El-Hassan area

The XRD analyses of columbite with uranothorite minerals (Fig.6) clarify different values of both ferric-columbite and uranothorite.

Zircon (Zr Si O_4)

Zircon is a common accessory mineral belonging to the group of silicates in many igneous rocks and is also chemically and physically resistant to erosion. It is non-magnetic the most frequent mineral in the studied samples. Their grains are euhedral, prismatic and bipyramidal forms. These grains are colorless and sometimes show yellow and brown colors. The crystals show adamantine luster while, metamict zircon have resinous luster. Its frequency ranges from 0.012 to 0.294 %with an average of 0.115% (Table 3), and it is concentrated in silt sizes. EDX analysis for the picked grains of zircon from Wadi Abu El-Hassan stream sediments is shown on Fig. (7).

Monazite (Ce PO_4)

Monazite occurs as well rounded oval grains of lemon to honey yellow and colorless grains. It is concentrated mainly at 0.5 ampairs in the fine and very fine sand size fraction and it has high concentration in the mud size. Its frequency ranges from 0.014 to 1.122% with an average of 0.195% for Wadi Abu El-Hassan stream sediment samples (Table 3).

The EDX analyses for the different grains of monazite reveal that most of monazite minerals are etched, corroded and/or dissoluted forming caves or vug cavities. This dissolution process appears to be happened in the granitic source rocks before disintegration and transportation. Monazite is an important heavy mineral, less stable than zircon, where it is affected by both mechanical and chemical weathering. The back scatter electron (BSE) image shows that the surface textures of their grains are pitted, with holes and rough surfaces (Fig. 8).

Allanite (Ce, Ca, Y)$_2$ (Al, Fe$_3$)$_3$ (SiO$_4$)$_3$ (OH)

Generally, allanite is a characteristic accessory mineral in many granites, granodiorites, monzonites, syenites and pegmatites. Exley

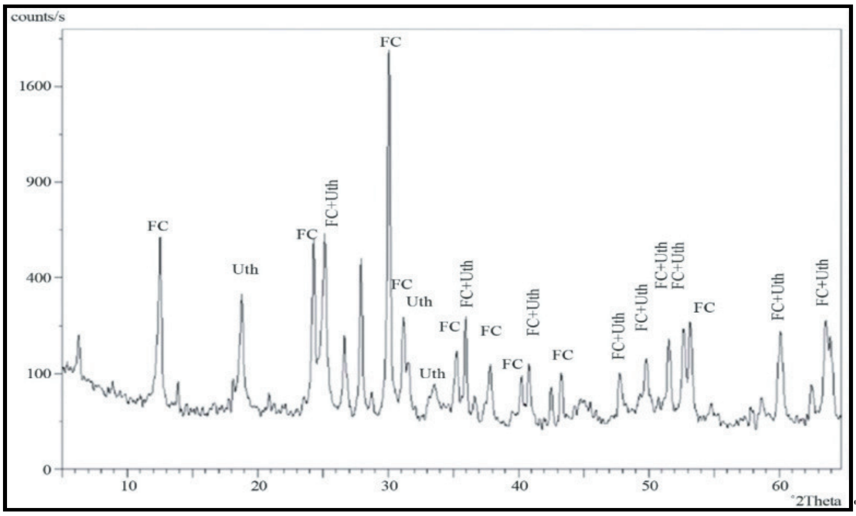

Fig. 6: XRD pattern of columbite mineral from Wadi Abu El-Hassan area

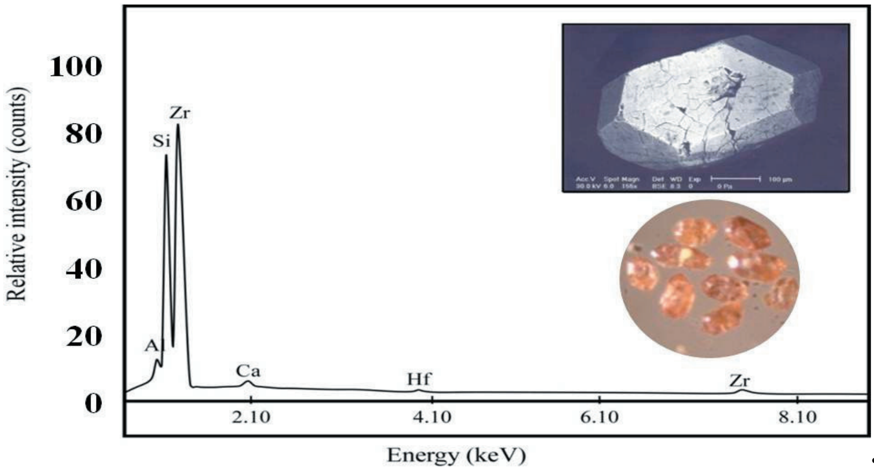

Fig. 7: EDX, BSE image and photomicrograph of zircon mineral from Wadi Abu El-Hassan area

(1980) reported allanite in hydrothermal veins associated with the skye granites suggesting that the ambient fluid was evolved in REE chemistry during crystal growth. Allanite existed as fine-grained aggregates associated with monazite and uranothorite and it is concentrated in mud size of studied samples. Its frequency ranges from 0.006 to 0.580% with an average of 0.0675% for Wadi Abu El-Hassan stream sediment samples, (Fig. 9).

Radiometric Studies

Recent loss or gain of uranium in the studied stream sediments can be indicated by eU/U ($U_{radiometric}/U_{chemical}$) ratio. If eU/U ratio is greater than unity, this indicates recent U loss

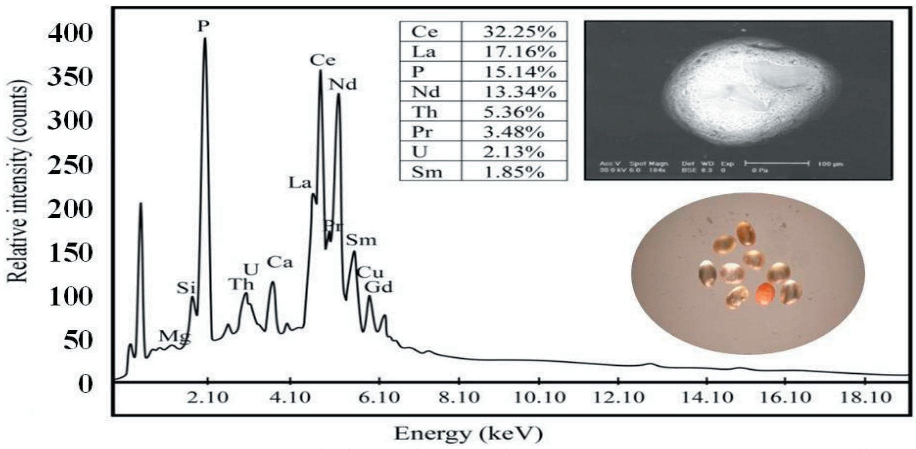

Fig. 8: EDX, BSE image and photomicrograph of monazite mineral from Wadi Abu El-Hassan area

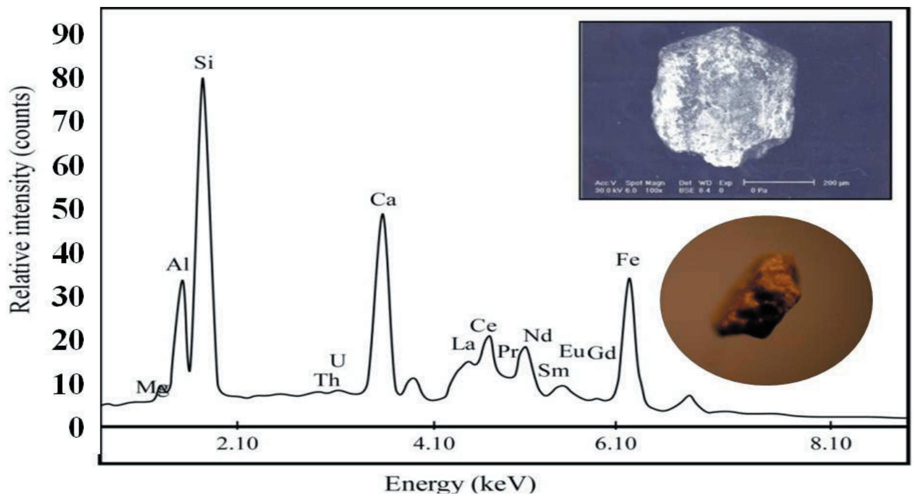

Fig. 9: EDX, BSE image and photomicrograph of allanite mineral from Wadi Abu El-Hassan area

while the U decay daughter products remain. Whereas, eU/U ratio is less than unity, this indicates recent U addition, where the Gamma emitter decay daughters of U are not produced yet or at least the decay series do not reach the equilibrium state. The studied stream sediment samples of Wadi Abu El-Hassan show eU/U average ratio less than unity indicating U enrichment, (Table 4 and Fig. 10).

From Table (4), U values of the main tributary (C) ranges between 4 to 23 ppm with an average of 12.69 ppm, and Th values ranges between 14 and 80 with an average of 42.75 ppm. In the northern tributary (N) U values ranges between 10 to 28 ppm with an average of 16.50 ppm, and Th values ranges between 31 and 76 with an average of 52.67 ppm. Southern tributary (S) has U values ranges

Table 4: Distribution of radiometric and chemical measurements of U and Th in the studied stream sediment samples, Wadi Abu El-Hassan area

Sample No.	eU (ppm)	eTh (ppm)	Ra (ppm)	K (%)	U (ppm)	Th (ppm)	eU/U	eTh/eU
S-1	5	12	5	2.72	13	49	0.4	2.4
S-2	9	12	4	3.34	11	32	0.8	1.33
S-3	4	14	5	3.05	11	29	0.4	3.5
S-4	6	16	6	3.26	10	50	0.6	2.66
S-5	7	14	6	1.18	9	45	0.8	2
S-6	2	13	5	3.8	14	58	0.1	6.5
S-7	6	13	5	3.67	10	31	0.6	2.16
Average	5.57	13.43	5.14	3.00	11.14	42.00	0.53	2.94
C-8	3	9	4	3.29	12	40	0.3	3
C-9	2	10	4	3.5	13	35	0.2	5
C-10	5	13	4	3.28	7	24	0.7	2.6
C-11	7	12	4	3.25	11	36	0.6	1.7
C-12	5	12	4	3.54	8	15	0.6	2.4
C-13	6	15	5	4.35	13	48	0.5	2.5
C-14	10	18	ULD	3.32	4	14	2.5	1.8
C-15	6	9	4	3.36	15	49	0.4	1.5
C-16	4	13	4	3.34	19	52	0.2	3.25
C-17	4	10	6	3.66	18	80	0.2	2.5
C-18	3	10	4	3.2	15	61	0.2	3.33
C-19	5	10	3	3.58	10	36	0.5	2
C-20	4	11	3	3.97	9	32	0.4	2.75
C-21	3	11	3	3.37	6	19	0.5	3.66
C-22	3	12	4	3.3	20	72	0.2	4
C-23	5	12	5	2.67	23	71	0.2	2.4
Average	4.69	11.69	4.07	3.44	12.69	42.75	0.51	2.77
N-24	8	15	6	3.48	26	63	0.3	1.87
N-25	12	26	6	3.12	17	70	0.7	2.166
N-26	7	14	4	3.7	28	76	0.3	2
N-27	6	12	4	3.43	13	48	0.5	2
N-28	15	43	9	3.04	18	53	0.8	2.86
N-29	10	20	7	3.36	20	69	0.5	2
N-30	4	13	5	3.28	12	41	0.3	3.25
N-31	6	11	5	3.55	14	38	0.4	1.8
N-32	3	13	3	3.3	13	47	0.2	4.33
N-33	2	13	5	3.44	11	31	0.2	6.5
N-34	6	11	5	3.16	10	38	0.6	1.8
N-35	6	15	4	3.38	16	58	0.4	2.5
Average	7.08	17.17	5.25	3.35	16.50	52.67	0.43	2.76

ULD: Under limit of detection

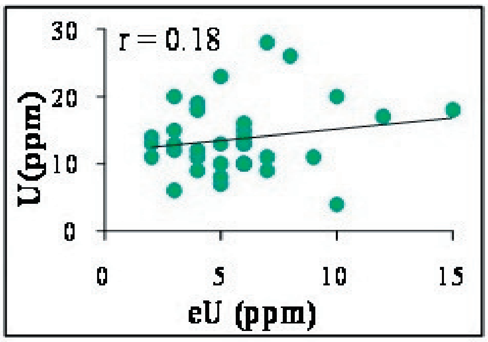

Fig. 10: eU-U variation diagram of the studied stream sediments of Wadi Abu El-Hassan area (r: correlation coefficient)

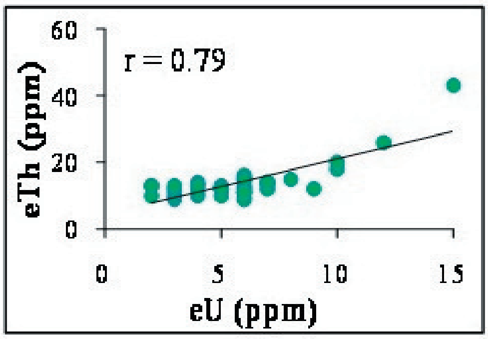

Fig. 11: eU-eTh variation diagram of the studied stream sediments of Wadi Abu El-Hassan area (r: correlation coefficient)

between 9 to 14 ppm with an average of 11.14 ppm, and Th values ranges between 29 to 58 ppm with an average of 42.00 ppm.

Thorium is more than three times as abundant as uranium in rocks (Clark value). When this ratio is disturbed, it indicates either depletion or enrichment of uranium. The eU against eTh variation diagram for the studied stream sediment samples (Fig. 11) for Wadi Abu El-Hassan has a positive correlation coefficient indicating the direct proportional relationship between the two elements. This result reflects low alteration processes effect on eU and eTh and also indicates that magmatic processes played an important role in uranium enrichment against the source of these sediments. This concept is supported by the bivariate variation diagrams of eU and eTh against eTh/eU (Figs. 12&13) that show clear negative relationship between eU and eTh/eU. This relation may reflect possible mobilization of uranium by water (flash flood).

Distribution of radioelements

From Table (4) and Fig. (14), the eU and eTh contents of samples 14, 25, 28 and 29 are the highest values controlled by their mineralogical composition. The radioelement distribution maps (Figs. 11 to 13) demonstrate the concentrations of eU, eTh, and K. The concentration of eU ranges between 2 and

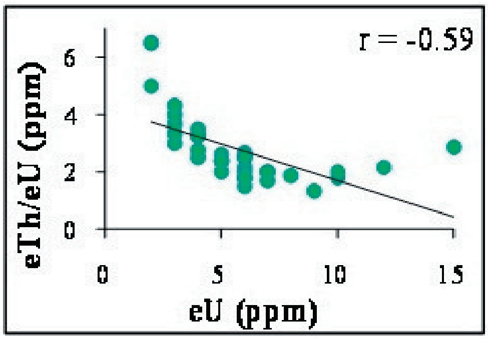

Fig. 12: eU-(eTh/eU) variation diagram of the studied stream sediments of Wadi Abu El-Hassan area (r: correlation coefficient)

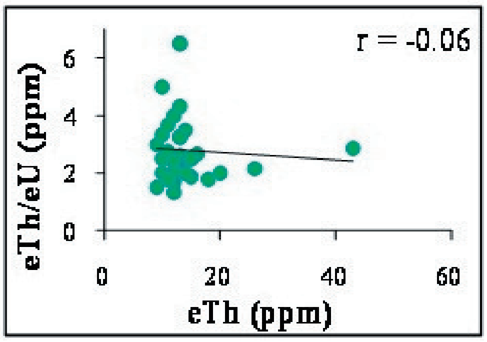

Fig. (13): eTh-(eTh/eU) variation diagram of the studied stream sediments of Wadi Abu El-Hassan area (r: correlation coefficient)

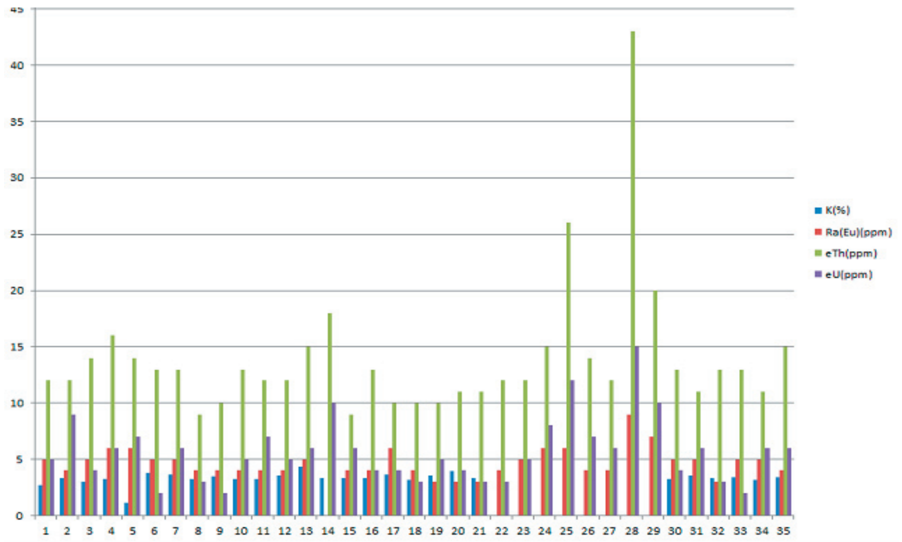

Fig. 14: Histogram showing the eU (ppm), eTh (ppm), Ra (ppm) and K(%) contents in the studied stream sediment samples, Wadi Abu El-Hassan area

15ppm with 5.8ppm average, while eTh ranges from 9 to 43 ppm with 26 ppm average. Ra ranges between 3 and 9 ppm, and K ranges from1.18 to 4.35%. The distribution map of eU in the studied area (Fig. 15) indicates lateral high values of eU in the eastern section of the studied stream sediments, moderate concentrations are present in most sample positions and low concentrations present mostly in the central section and some little positions are present in both two sides. The distribution map of eTh for the studied area (Fig. 16) indicates low concentrations of eTh present in the most samples of the studied stream sediments. The distribution map of K for the studied area (Fig.17) indicates high concentration of K present in the central section and some little positions are present in both two sides, moderate concentrations are the most common concentrations present in most sample positions of the studied stream sediment samples.

The stream sediments samples (Table 4) exhibits high values of eTh/eU ratio indicating the enrichment of eTh content relative to eU content. This reflects the presence of the radioactive bearing minerals such as zircon, monazite and allanite. The (eTh) has higher values than (eU) which optimizing natural equilibrium for U and Th. The radiometric analyses of the six studied mud fraction samples of stream sediment revealed concentration of eU and eTh content, (Table 5).

From the previous discussion, it is clear that the uranium concentration increases upstream in Wadi Abu El-Hassan El-Ahmar which referring to the presence of uraniferous granites around the Wadi. Also, the lower concentrations of radiometric uranium than the chemical uranium show that the U of Gabal Abu El-Hassan is relatively recent.

GEOCHEMISTRY

The collected samples were analyzed using XRF technique to obtain the trace elements content in order to determine the geochemical features of the studied stream sediments.

Some elements like Ba, Sr and Rb are mostly concealed in the feldspar minerals, i.e

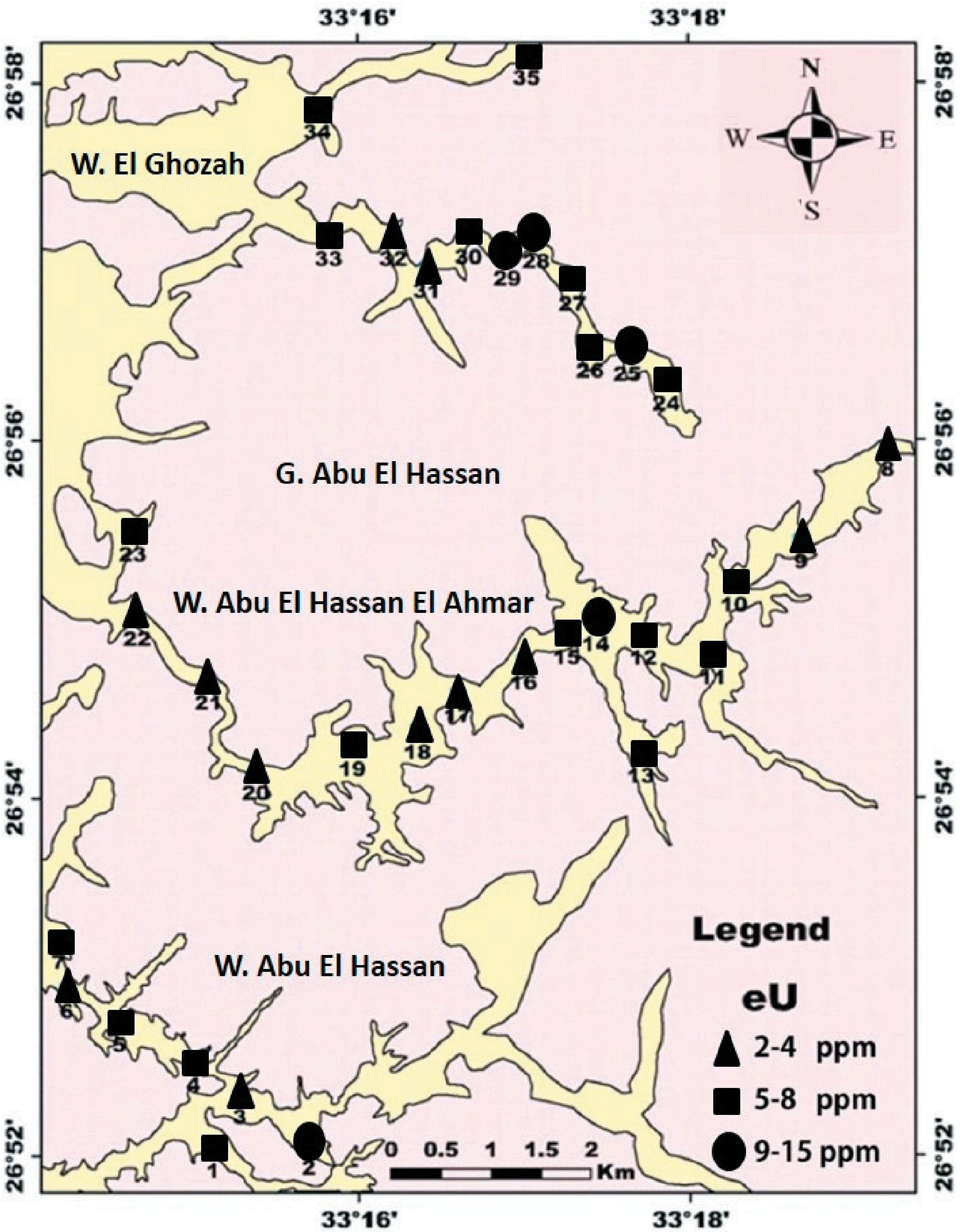

Fig. 15: eU distribution map for the studied stream sediment samples, Wadi Abu El-Hassan area

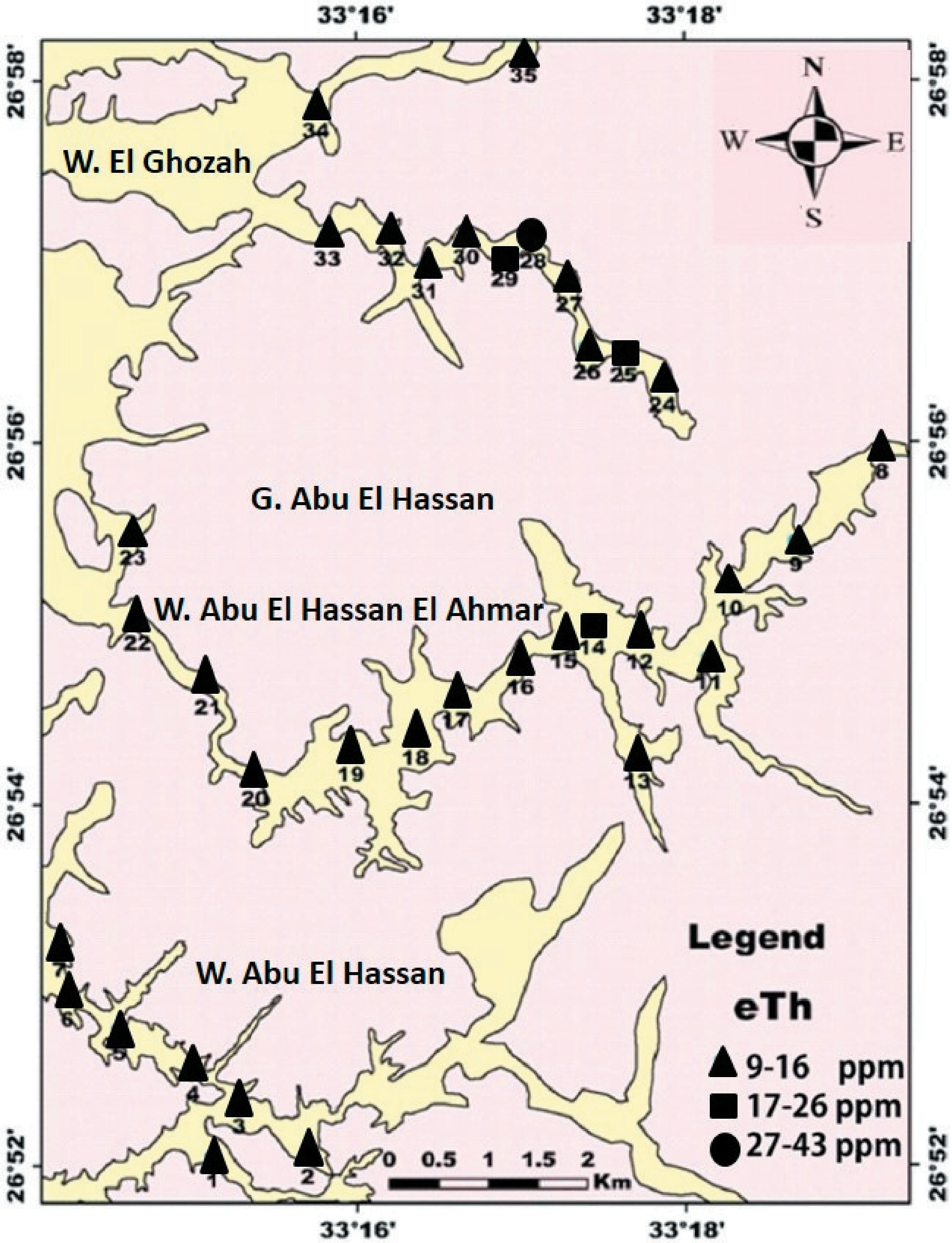

Fig. 16: eTh distribution map for the studied stream sediment samples, Wadi Abu El-Hassan area

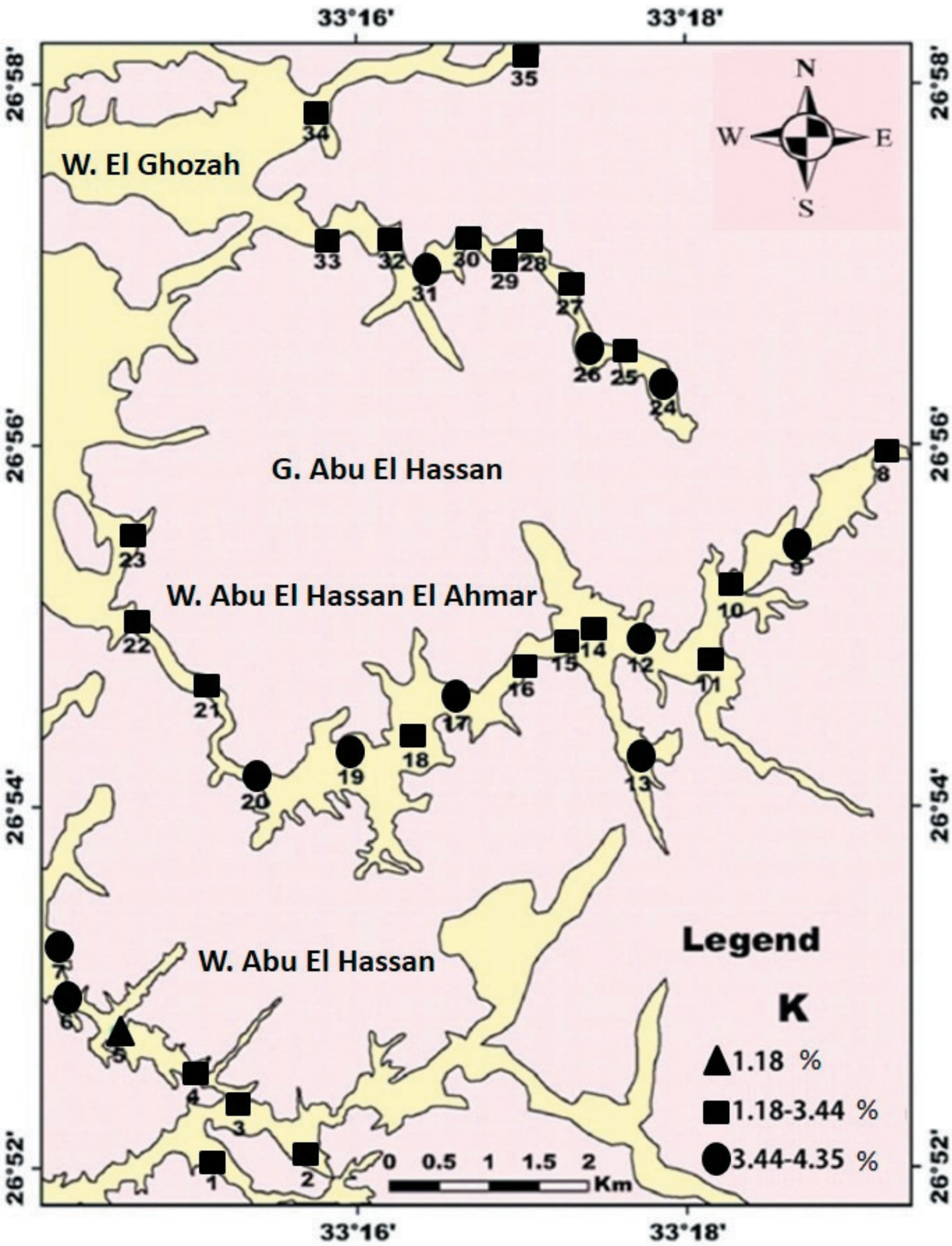

Fig. 17: K distribution map for the studied stream sediment samples, Wadi Abu El-Hassan area

Table 5: Radiometric measurements of eU, eTh, Ra and K in the studied mud-size stream samples of Wadi Abu El-Hassan area

Sample No.	eU (ppm)	eTh (ppm)	Ra (ppm)	K (%)
2	12	20	8	ND
5	34	34	4	ND
11	ND	18	3	ND
14	20	70	7	0.3
25	25	70	ND	ND
28	24	25	11	ND
Average	23	39.5	9.6	0.05

ND= Not Detected

tend to concentrate in the more acidic rocks such as granites and their equivalent volcanic rocks. Among the rock forming feldspar minerals, Ba and Rb prefers potash feldspar to plagioclase while Sr prefers the plagioclase structure (Mason, 1966). Elements such as Cr, Ni, V, Zn and Cu are more concentrated in the ferromagnesian and sulphide minerals which are common in the basic and ultra-basic rocks (Goldschmidt, 1954).

The elements, Zn, Rb and V in Table (6) are slightly enriched in the studied stream sediment. The present data of Zn and Rb are slightly higher than the average 40 ppm crustal value, (Rose et al., 1979). On the other hand, some base metals as Cr, Ni and Cu are depleted in the concerned sediments, presumably due to the absence of the basic rocks in studied area, whereas, a remarkable depletion in Pb was noticed and its deficiency may be attributed to the lack of lead-bearing minerals. The stream sediments contain relative low strontium varying from 12 to 45 ppm, which lie near the average 20 ppm crustal values, 20 ppm, (Rose et al., 1979).

Trace elements concentrations in the stream sediments of the studied area are relatively enriched particularly in Zr, Ba, Y and Nb, besides the presence of U and Th. The enrichment of barium within the study area supposes that the area was most probably affected by high intensive hydrothermal solutions (El-

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Table 6: Trace elements (ppm) in the stream sediment samples of Wadi Abu El-Hassan area

No.	Nb	V	Sr	Pb	Ba	Y	Rb	Zr	Zn	Cu	Ni	Cr
S-1	23	74	45	32	163	34	72	457	89	70	39	60
S-2	14	56	27	48	122	21	106	285	157	67	27	44
S-3	14	54	26	45	112	21	110	283	151	62	28	47
S-4	16	47	29	41	108	24	123	283	128	62	22	44
S-5	14	25	25	31	58	20	182	311	123	57	15	28
S-6	9	41	16	40	92	14	106	266	118	67	20	44
S-7	14	35	27	40	78	22	163	175	129	69	21	38
C-8	8	23	15	36	55	12	168	287	64	66	19	37
C-9	7	9	13	30	29	10	208	160	48	56	10	23
C-10	11	39	21	39	88	17	124	139	69	70	20	45
C-11	17	59	32	35	136	25	112	229	90	64	20	52
C-12	10	35	19	37	80	15	146	335	77	63	19	31
C-13	9	33	16	36	78	13	153	197	69	60	16	40
C-14	20	73	39	40	167	30	82	176	94	67	25	52
C-15	11	29	21	28	70	17	176	309	67	62	14	32
C-16	8	23	15	35	55	12	153	226	59	68	12	36
C-17	8	32	16	36	74	13	136	156	74	69	18	36
C-18	20	81	38	39	176	30	70	166	106	91	35	63
C-19	6	14	12	30	39	9	172	402	62	63	16	28
C-20	19	61	36	36	141	28	100	123	88	65	22	54
C-21	9	31	16	31	78	13	131	377	77	72	18	40
C-22	9	32	17	35	76	13	115	171	70	63	15	35
C-23	19	88	36	29	191	28	61	179	93	88	38	83
N-24	16	56	30	36	131	25	169	372	139	81	28	54
N-25	10	48	18	37	103	15	134	324	102	69	23	48
N-26	21	69	39	42	162	31	110	199	115	68	29	46
N-27	8	12	13	25	33	12	237	410	86	61	22	31
N-28	15	57	27	38	122	22	134	148	110	61	20	51
N-29	18	77	33	42	170	27	99	291	127	81	27	59
N-30	10	38	18	37	40	15	156	357	102	59	28	49
N-31	22	66	40	40	145	32	133	193	121	80	31	57
N-32	23	95	42	43	204	34	72	427	112	70	32	70
N-33	8	14	14	37	29	12	202	151	80	69	25	36
N-34	8	21	14	39	51	12	149	150	69	61	50	74
N-35	13	39	25	36	90	20	169	271	116	71	31	41
Min.	6	9	12	25	29	9	61	123	48	56	10	23
Max.	23	95	45	48	204	34	237	457	157	91	50	83
Av.	13.34	45.3	24.85	36.6	101.3	19.94	135.22	256.7	96.6	67.77	23.85	45.92

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محمود هاني شلبي، ريمون راغب أيوب، سامح زكريا توفيق و وفاء يونس بدور

تم تجميع عدد ٣٥ عينة من أرضية الوديان الرئيسية وروافدها بمنطقة جبل أبو الحسن والتي تعد جزءاً من صخور القاعدة في الحزام الإفريقي بوسط الصحراء الشرقية المصرية، وتشكل صخور البركانيات المتحولة، السربنتينات، الجابرو، الجرانيت الأقدم، بركانيات الدخان، رسوبيات الحمامات، الجرانيت الأحدث وجدد ما بعد الجرانيت المكونات الأساسية لمعقدات هذه القاعدة.

أوضحت القياسات الإشعاعية لمكافئ اليورانيوم، مكافئ الثوريوم، الراديوم والبوتاسيوم أن محتوى مكافئ اليورانيوم يتراوح بين ٢ و ١٥ جزء من المليون ويتراوح محتوى مكافئ الثوريوم من ٩ الى ٤٣ جزء من المليون بينما تراوح محتويات الراديوم والبوتاسيوم بين ٣ و ٩ جزء من المليون و١,١٨ و ٤,٣٤٪ على الترتيب.

بينت الدراسات المعدنية للعينات أن محتواها من المعادن الثقيلة يتراوح بين ٠,٩٧ و١٣,٦٦٪ بمتوسط يبلغ ٥,٥٥٪ وهي معادن الألانيت، المونازيت، الفلوريت، الاسفين بالاضافة الى اليورانوثوريت، الثوريت، الزرقون، الكولومبيت، الجارنت، الالمينيت والروتيل.

بينت الدراسة الجيوكيميائية لرواسب الوديان أنها ذات دلالة جيدة على وجود مصدر للشاذات الاشعاعية المسجلة بها كما لوحظ وجود اضافة لليورانيوم بوديان المنطقة مصدره الجرانيت الحديث. وبناءاً عليه فإنه يلزم إجراء المزيد من الدراسات الإشعاعية أعلى الوديان بإتجاه منابعها لتحديد الجرانيتات التي نشأ منها المحتوى الإشعاعي لرواسب الوديان بالمنطقة.