Науки о Земле Earth sciences

УДК 552.31: 552.08 + 550.4.02

<https://doi.org/10.21440/2307-2091-2020-4-7-18>

Geological and geochemical studies on El-Missikat granites, Central Eastern Desert, Egypt

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Abstract

Objective. The present work deals with the detailed investigations of the geology, geochemistry, and tectonic setting of the studied granitic rocks.

Research methods. This work involves both field work (Collection samples and drawing of a new geological map) and laboratory work (preparation of thin sections for petrographic studies by polarizing microscope), Atomic absorption, X-ray Fluorescence analysis (XRF) in the Central Laboratories of the Acme in Canada and Mass-Spectrometer with Inductively Coupled Plasma (ICPMS).

Result. The study area restricted in the Central Eastern Desert of Egypt between the Red sea and the Nile Valley. El-Missikat pluton is covered by island arc related rock (as xenolith), older granites, and younger granites, in addition to different types of dikes and veins swarms. Petrographically older granites are classified into quartz diorite, tonalite and granodiorite, whereas the younger granites are divided into monzogranite, syenogranite and altered granites. The geochemical studies suggest the granitic rocks are calc-alkaline affinity. The quartz diorite, tonalite and granodiorite are related to volcanic arc granites, while the monzogranite and syenogranite are similar to the infinity of the within plate granites behavior. The quartz diorite, tonalite, granodiorite and monzogranite are belonging to I-type granite, otherwise the syenogranite has A-type granites.

Conclusion. According to geological and petrographical studies the investigated granites are represented by quartz diorite, tonalite and granodiorite, whereas the younger granites are divided into monzogranite, syenogranite and altered granites that are traversed by different types of dikes and veins swarms. Generally, the older granites have low content of LILE, most probably due to the relatively low content of K-feldspars and HFSE. The younger granites exhibit a fractionated pattern from LREE to HREE with negative Eu anomaly.

Keywords: El-Missikat area, geochemistry, Eastern Desert and Egypt.

Introduction

El-Missikat area located in the Central Eastern Desert between latitude 26°23' and 26°33' N and longitudes 33°15' and 33°30' E (Fig. 1). It covers about 350 km², the study area is characterized by medium to relatively high topography reliefs. It forms a part of Neoproterozoic evolution of the North Arabian-Nubian Shield in the NE Africa which is belonging to the East African Orogeny (EAO) and it is results of accretion plateaus in the course of consolidation of the Gondwana [2–8]. Particularly the investigated area recently become one of the Most Important occurrence area in the central eastern desert of bearing Ur-mineralization by two main processes of the mineralization have been concerned, one of syn-genetic

origin by recent uranium leaching of the granite and other by post magmatic processes accompanied with uranium – bearing red, black and jasperoid silica veins [9]. The present study deals mainly with the relationship of different exposed rock units, anew modified geologic map at scale 1: 100,000 is given in (Fig. 1). More than thirty rock samples were collected and subjected to petrographic studies and chemical analyses for detect the behavior pattern of geochemical investigation of the different granitic rocks in the study area.

Methodology

The major oxides of the examined granites were determined by X-ray Fluorescence analysis (XRF) in the Central

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Figure 1. Geologic map of El-Missikat area [1].
Рисунок 1. Геологическая карта района Эль-Миссикат [1].

Figure 2. Photographs showing. a – The felsite dike swarms (FsD) extruding the syn-extensional granites (S. Gr); b – Migmatized granodiorite characterizing the studied the syn-extensional granites; c – fracturing in El-Missikat late to post granites (L. Gr) intruding through the syn-extensional granite (S. Gr).

Рисунок 2. Фотографии показывают: а – рой фельзитовых даек (FsD), выдавленных син-экстенциональными гранитами (S. Gr); б – мигматизированный гранодиорит, характеризующий исследуемые син-экстенциональные граниты; в – трещиноватость в поздних постгранитах Эль-Миссиката; г – общий вид северной периферии Гейбл Эль-Миссиката поздних постгранитов (L. Gr), выдавленных через син-экстенциональные граниты (S. Gr).

Figure 3. Modal composition of the investigated granites plotted in QAP diagram, after [14] (a); photo showing anhedral flakes of biotite (Bt) associated with plagioclase (Pg) and hornblende (Hb) in the quartz diorite (b); photo showing flaky biotite crystals (Bt) associated with plagioclase (Pg) and anhedral crystals of quartz (Qz) in the tonalite (c); microcline perthite (Pt) enclosing biotite crystals (Bt) in the granodiorite (d); fine grained of quartz (Qz) associated with deformation of tilted plagioclase (Pg) with microcline perthite (Pt) in the monzogranite (e); microcline perthite (Pt) surrounded by fine-grained albite crystals in the shape like rapakivi texture in the monzogranite (f); crystals of microcline (Mc) bounded by others plagioclase (Pg) in the syenogranites (g); subhedral microcline perthite (Pt) surrounded by fine and medium grains of wavy quartz (Qz) in the altered granite (h).

Рис. 3. Модальный состав исследованных гранитов, нанесенный на диаграмму QAP, по [14] (a); фотография, показывающая ксеноморфные чешуйки биотита (Bt), в ассоциации с плагиоклазом (Pg) и роговой обманкой (Hb) в кварцевом диорите (b); фотографии, показывающие чешуйчатые кристаллы биотита (Bt), в ассоциации с плагиоклазом (Pg) и ксеноморфные кристаллы кварца (Qz) в тоналите (c); микроклин пертит (Pt), содержащий кристаллы биотита (Bt) в гранодиорите (d); мелкозернистый кварц (Qz), в ассоциации с деформированным двойникованным (Pg) и микроклин пертитом (Pt) в монцограните (e); микроклин пертит (Pt), обрамлен мелкозернистыми кристаллами альбита по форме, подобной текстуре рапакиви в монцограните (f); кристаллы микроклина (Mc), в обрамлении зерен плагиоклаза (Pg) в сиеногранитах (g); субгедральный микроклин пертит (Pt), окруженный мелкими и средними зернами волнистого кварца (Qz) в измененном граните (h).

Laboratories of the Acme in Canada, while trace and rare earth elements were measured by ICP-MS and Atomic absorption at the Central Laboratories of the Nuclear materials Authority in Egypt. On the other hand, thin sections are determined by microscope modal analyses.

Geological Setting

El-Missikat area is mainly covered by the Neoproterozoic rock units represented by metavolcanic as big xenolith in the older granites and felsite dikes, as well as younger magmatic granites (monzogranite, syenogranite and altered rich quartz granites) in addition to different types of dikes and quartz veins as arranged as given in Fig. 1.

The older granites (syn-extensional granites). The older granites represent a part of huge pluton extending westward and north ward beyond the limits of the area with an age ranging from 930–850 Ma [10, 11] to 711 Ma [12]. They are uncomfortably capped by the Nubian Sandstones and invaded by NE–SW Late-tectonic of felsite dike swarms and younger granites. The felsite dikes cut only through the older granites ranging from few meters to more than 10 Km length and up to 5 meters width (Fig. 2, a), to suggest that they had been emplaced before the emplacement of the younger granites. Generally, the older granites from low to moderate outcrops, characterized by ex-foliation and gneissose texture are common, sometimes they occur as migmatized rocks of well alternated dark and white bands, particular at the northern side of the area (Fig. 2, b).

The younger granites (Late to post magmatic granites). They are represented by oval like pluton of late-post magmatic

intrusions (Fig. 1), they are comprising essentially of monzogranite and syenogranite, in addition to high quartz altered granites, with an age dated 568 ± 17 Ma [13] and 603 ± 575 Ma [12]. They had been emplaced during the post tectonic episode of the Eastern Desert. They form moderate to high NW–SE granites pluton traversed by some NW–SE faults in addition to NE–SW mineralized shear zone (Fig. 2, c). These granites are more or less suffered alteration, particular along the fault planes and shear zone, represented by silicification, sericitization, hematization, greisenization, kaolinization and fluoritization either as patches or altered granite zones, as well as they are talented by manganese mineralization as dendritic like forms. The NE–SW shear zone represents the main mineralized zone for the radioactive mineralization. It is represented by tabular and elongated NE–SW crushed and brecciated granites, displaced by parallel fractures and joints traced over 2 Km in length and 4 Km in width.

The younger granites intruded directly in the older granites with sharp contact along several hundred of meters (500–750 m), Fig. 2, d, they are characterized by presence of some oval dark color xenoliths and some lenticular pegmatite bodies, siliceous and quartz veins as well as aplite sheets and dikes swarms. The smoky and jasperoid NE–SW silica veins show often radiometric anomalies due visible secondary uranium mineralization. Quartz veins are generally milky-white and occasionally grayish or reddish in color, commonly include vugs, some of which filled with iron, carbonates and clay minerals.

Table 1. The complete silicate analyses of major oxides of the investigated granites.
Таблица 1. Полный силикатный анализ основных оксидов исследуемых гранитов.

Major elements											
Quartz diorite											
Number of sample	SiO ₂	Fe ₂ O ₃	FeO	CaO	MgO	TiO ₂	P ₂ O ₅	Al ₂ O ₃	Na ₂ O	K ₂ O	T
34	54.80	6.00	5.600	6.40	4.37	0.98	0.30	14.40	4.30	1.08	99.96
16	63.50	3.90	3.700	3.60	2.80	0.30	0.09	13.60	4.80	1.60	99.70
23	63.60	4.00	3.800	3.50	2.80	0.30	0.08	13.40	4.70	1.50	99.40
24	64.00	4.00	3.800	3.50	2.90	0.30	0.09	13.80	4.50	1.30	99.90
25	63.57	3.95	3.800	3.52	2.70	0.36	0.09	13.50	4.90	1.60	100.00
27	63.70	3.60	3.500	3.90	1.80	0.60	0.10	14.00	5.00	1.50	99.52
36	63.67	3.20	3.012	4.20	1.20	0.60	0.11	15.20	5.30	1.41	100.00
37	63.60	3.30	3.000	4.30	1.50	0.60	0.40	15.10	5.20	1.40	100.06
Av	63.60	3.70	3.500	3.80	2.20	0.40	0.14	14.00	4.90	1.50	99.80
<i>Granodiorite</i>											
2	67.80	1.50	1.400	4.60	1.20	0.10	0.09	14.90	3.60	2.90	100.00
3	67.00	1.50	1.600	4.50	1.10	0.10	0.09	15.00	4.00	3.00	100.00
17	67.74	1.96	1.820	4.44	1.00	0.30	0.10	13.40	4.60	2.40	100.00
20	68.40	1.80	1.700	3.16	0.63	0.30	0.13	14.03	5.40	2.40	100.00
26	67.80	1.90	1.800	4.40	1.10	0.30	0.10	13.10	4.60	2.30	99.70
Av	67.50	1.70	1.650	4.20	1.00	0.20	0.10	14.00	4.40	2.60	100.00
<i>Monzogranite</i>											
4	75.40	0.90	0.800	0.40	0.40	0.10	0.10	11.70	4.70	3.60	99.53
5	75.00	1.00	0.880	0.39	0.35	0.09	0.12	11.90	4.70	3.70	99.50
6	74.00	1.30	0.960	0.54	0.33	0.10	0.13	11.94	4.70	3.66	99.13
7	73.50	1.20	0.900	0.40	0.40	0.10	0.14	12.30	4.88	3.76	99.44
8	73.00	1.22	0.970	0.50	0.50	0.11	0.10	12.60	4.90	3.80	99.71
10	75.40	1.02	0.960	0.40	0.36	0.10	0.11	11.86	4.60	3.70	99.80
11	74.30	1.00	0.900	0.40	0.40	0.10	0.10	12.10	4.80	3.60	99.30
12	74.97	1.04	0.960	0.35	0.80	0.09	0.10	12.60	3.70	3.60	100.00
14	74.60	1.10	0.900	0.70	0.50	0.12	0.08	11.65	4.70	3.40	100.00
19	71.00	1.70	1.600	2.00	0.70	0.20	0.10	13.00	4.10	3.20	99.20
21	73.50	1.10	1.000	1.40	0.40	0.50	0.10	12.20	4.60	3.70	100.00
22	73.71	1.20	1.080	1.40	0.33	0.60	0.09	12.00	4.50	3.50	100.00
13	70.20	1.40	2.000	1.72	1.00	0.70	0.24	12.86	4.70	3.50	100.00
Av	73.70	1.20	1.000	0.80	0.60	0.90	0.10	12.30	4.70	3.60	100.00
<i>Syenogranite</i>											
9	74.67	0.82	0.710	0.66	0.20	0.11	0.07	12.45		4.90	4.00
15	74.40	0.84	0.720	0.65	0.18	0.10	0.08	12.33	5.10	4.40	99.38
39	74.50	0.90	0.700	0.70	0.25	0.10	0.06	12.50	4.90	4.10	100.00
Av	74.50	0.80	0.700	0.70	0.20	0.10	0.07	12.40	5.00	4.20	100.00

Table 2. The trace elements of the investigated granites.
Таблица 2. Микроэлементы исследованных гранитов.

Trace elements													
Number of sample	Quartz diorite												
	Cr	Ni	Cu	Zn	Zr	Rb	Y	Ba	Pb	Sr	Ga	V	Nb
34	155.0	92.10	3.80	85.1	22.8	8.2	18.5	332.0	10.57	738.0	21.04	132.0	6.320
16	21.0	4.20	9.30	44.2	41.8	23.4	2.2	391.0	6.80	542.0	18.80	32.0	1.170
23	22.0	4.22	9.40	44.2	41.8	23.4	2.2	392.0	6.79	541.0	18.78	32.0	1.160
24	21.0	4.30	9.20	44.3	42.0	23.2	2.3	392.0	6.90	540.0	18.80	31.0	1.180
25	20.0	4.20	9.29	44.4	41.8	23.2	2.2	391.0	6.82	540.0	18.78	30.0	1.016
27	20.0	4.30	9.30	44.1	41.8	23.4	2.2	390.0	6.80	542.0	18.60	31.0	1.160
36	48.0	11.20	5.19	53.2	35.8	17.2	8.9	372.0	7.88	695.0	20.97	52.0	3.740
37	49.0	11.30	5.20	54.0	35.9	17.3	8.9	372.0	7.87	696.0	20.97	53.0	3.740
Av	28.7	6.20	8.10	46.9	40.1	21.6	4.1	385.7	7.10	585.1	19.40	37.3	1.700
2	13.0	1.60	2.59	39.8	38.2	42.0	6.2	530.0	8.00	632.0	18.00	22.0	5.120
3	12.0	1.50	2.60	39.2	38.2	43.0	6.3	532.0	8.20	630.0	18.00	22.0	5.100
17	12.0	3.50	5.28	38.2	37.2	39.5	5.5	590.0	8.76	651.0	18.68	24.0	3.390
20	17.0	3.60	3.34	46.1	39.8	56.2	8.4	527.0	9.51	632.0	19.60	23.0	5.140
26	18.0	3.40	3.34	46.0	40.0	56.2	8.4	528.0	9.50	633.0	19.80	24.0	5.140
Av	14.0	2.70	3.50	41.9	39.0	47.4	7.0	541.0	8.80	636.0	18.80	23.0	5.000
4	10.0	1.60	2.12	54.1	103.3	404.7	57.4	19.0	40.30	15.0	36.00	1.0	49.800
5	72.0	13.20	2.19	23.0	103.2	268.5	169.5	33.0	34.20	22.0	31.40	22.0	64.890
6	71.0	13.40	2.20	23.1	103.0	268.1	169.1	32.0	34.50	21.0	31.36	22.0	64.850
7	14.0	7.50	1.40	32.0	149.7	263.8	154.0	12.0	29.62	10.0	33.09	3.0	71.960
8	16.0	7.60	1.40	31.4	149.6	263.4	155.0	13.0	29.50	9.0	33.20	4.0	71.970
10	9.0	1.50	2.11	54.8	102.0	404.3	57.7	19.0	40.30	16.0	35.60	1.0	49.900
11	10.0	1.40	2.10	54.5	103.2	404.9	58.0	18.0	40.20	17.0	35.50	1.0	50.000
12	71.0	13.40	2.18	23.0	102.1	268.5	169.3	32.0	34.30	22.0	31.36	20.0	64.860
14	15.0	7.60	1.39	31.3	149.7	263.4	154.0	12.0	29.81	9.0	33.09	3.0	71.960
19	57.0	4.80	2.40	13.7	109.3	168.4	62.4	56.0	27.93	44.0	24.50	7.0	72.300
21	56.0	4.70	2.60	13.7	109.2	168.6	62.2	55.0	27.94	43.0	24.40	9.0	72.100
22	56.0	4.70	2.40	13.6	109.2	168.4	62.3	56.0	27.94	43.0	24.50	7.0	72.300
13	58.0	7.30	4.67	56.0	109.0	168.7	62.0	52.0	27.90	48.0	23.50	7.0	60.640
Av	39.6	6.80	2.10	32.6	114.4	268.0	107.0	27.3	33.20	21.2	30.80	8.2	64.400
9	20.0	1.90	5.18	50.0	53.1	699.5	19.8	11.0	56.97	13.0	47.17	1.0	70.610
15	21.0	1.80	5.12	51.0	53.0	699.4	19.6	10.0	56.90	12.5	46.20	0.9	70.500
39	20.0	1.70	5.18	50.0	53.1	699.5	19.8	11.0	56.80	13.0	46.30	1.0	71.000
Av	20.0	1.80	5.14	50.0	53.0	699.4	19.7	10.0	56.90	12.8	46.50	1.0	70.700

Table 3. The rare earth elements (REE), of the investigated granites.
Таблица 3. Редкоземельные элементы (РЗЭ) исследуемых гранитов.

Rock Type	Quartz diorite		Tonalite		Granodiorite			Monzogranite			Syenogranite	
	34	23	25	27	17	20	26	10	12	14	9	15
La	11.00	13.00	12.80	12.60	7.10	7.10	7.0	10.60	18.10	8.40	6.8	6.3
Lu	0.30	0.11	0.10	0.11	0.10	0.10	0.1	2.30	2.80	3.20	1.4	1.3
Sm	4.50	2.20	2.10	2.10	1.90	2.30	2.2	6.00	16.50	8.50	3.1	3.3
Eu	1.10	0.40	0.40	0.30	0.40	0.40	0.4	0.10	0.10	0.10	0.1	0.1
Ce	33.09	30.20	30.18	30.10	18.34	19.08	18.2	36.74	25.38	28.42	23.5	23.5
Nd	21.70	14.00	13.00	13.00	9.00	10.20	10.0	20.80	47.40	19.50	11.7	11.8
Yb	2.30	0.30	0.30	0.30	0.60	1.10	0.5	14.80	20.30	20.30	9.3	9.3
Dy	4.30	0.60	0.50	0.50	1.20	1.70	1.1	8.40	24.50	20.00	4.9	4.8
Gd	4.70	1.10	1.10	1.20	1.70	1.80	1.7	5.50	21.60	11.40	2.6	2.6
Tb	0.60	0.12	0.10	0.10	0.20	0.20	0.2	1.00	3.20	2.50	0.5	0.5
Pr	4.60	3.70	3.30	3.30	0.60	1.00	0.6	7.30	16.10	15.50	4.1	4.2
Tm	0.30	0.12	0.10	0.11	0.10	0.10	0.1	1.60	2.60	2.80	0.9	0.9
Ho	0.70	0.13	0.10	0.10	2.30	2.30	2.3	5.00	9.00	4.40	3.6	3.5
Er	2.40	0.10	0.20	0.20	0.20	0.30	0.2	1.70	4.70	4.10	1.0	0.9
ΣREE	91.60	66.00	64.30	63.90	43.74	48.30	45.5	121.50	212.30	149.10	73.7	73.6

Petrography

The older granites (Syn-extensional granites). They are classified into quartz diorite, tonalite and granodiorite according to their modal composition QAP diagram of Streckeisen (Fig. 3, a) [14]. Actually, the quartz-diorite has the less quartz content (8 %), high plagioclase content (38 %) of andesine composition (An_{30-36}) and less alkali feldspars content (2 %), the mafic minerals are represented by hornblende (18 %) augite (13 %) and biotite (12 %), Fig. 3, b. Both tonalite and granodiorite have moderate quartz content up to 38 % and 39 % respectively, alkali feldspars are varying from 6 % to 12 %. Plagioclase is mainly andesine in composition (An_{24-35}) and content up to 58 % in tonalite, while it decreases to 39 % in granodiorite with an average of content oligoclase (An_{15-20}) to andesine (An_{25-35}) in composition. Also, biotite decreases from 20 % in tonalite to 13 % in granodiorite and showing relaxes of uranophane mineral along there cleavage. Hornblende is relatively rare up to 1 % for both (Fig. 3, c, d).

The younger granites (Late to post magmatic granites). They are classified into monzogranite, syenogranite and altered rich quartz granites (Fig. 3, a), accordingly, these varieties show a quite difference in the main minerals' constituents. The monzogranite has the less quartz content (51 %), followed by the syenogranite (59 %) and altered granite (82 %). Plagioclase gradually decreases from the monzogranite (39 %) to the syenogranite (16 %) and altered granite (5 %) with a different in composition from albite to oligoclase (An_{8-20}), (An_{10} to An_{19}) for monzogranite and syenogranite respectively and particularly albite in composition (An_{10}) for altered granite, as well as K-feldspars represent by microcline and microcline-perthite and varying in content from altered granite (9.8 %) to syenogranite (39.3 %) passing by monzogranite (35 %), sometimes alkali-feldspar surrounded by albite to show well developed rapakive texture, while muscovite is increasing in content from altered granite (up to 1.6 %) to monzogranite (up

to 8.5 %) passing by syenogranite (up to 2.9 %), on the other hand biotite decreases from the monzogranite (6 %) to the syenogranite (1 %) as shown in Fig. 3, e, f, g, h.

Geochemistry of the investigated granitic rocks

The results of the complete silicate analyses of the major oxides and trace elements of twenty-nine samples were represented by one sample for quartz diorite, seven samples for tonalite, five samples for granodiorite and 16 samples for the younger granites are given (Tables 1, 2).

Geochemical classification. A lot of parameters are used hereunder to classify and follow up the chemical affinity of the investigated older and younger granites. According to R1-R2 discrimination diagram of De La Roche et al. [15], the examined samples plot within the fields of monzodiorite, tonalite, granodiorite and the field of granite (Fig. 4, a) coinciding well with the petrographic classifications (Fig. 3, a).

The magma type of the granitic rocks. According to Irvine and Baragar [16], the quartz diorite, tonalite, granodiorite and younger granites have sub alkaline nature as shown in (Fig. 4, b). However, the older granites and the younger granites tend to be calc-alkaline according to AFM diagram of Irvine and Baragar (Fig. 4, c) [16]. On the other hand, the quartz diorite, tonalite and granodiorite are mainly metaluminous in nature, while monzogranite and syenogranite tend to be mainly per alkaline in nature (Fig. 4, d).

Tectonic setting of granitic rocks. According to Nb-Y diagram of Pearce et al. [17], it is clear that quartz diorite, tonalite and granodiorite are related to volcanic arc granites (VAG), while monzogranite and syenogranite are falling in within plate granites (WPG) as shown in (Fig. 4, e). On the other hand, Collins et al. [18] and Whalen et al. [19] discriminated between two groups of granitic rocks: A-type granites and I-S- and M-types granites by using Zn-SiO₂ diagram. According to this diagram the majority of the investigated granitic rocks fall in the field of S, I and M-type granites ex-

Figure 4. Plots of investigation samples on R1–R2 discrimination diagram [15] (a); TAS diagram of Irvine and Baragar of the granitic rocks [16] (b); AFM diagram of the samples of granites [16] (c); Maniar and Piccoli diagram of the granite samples [21] (d); Plots of the investigated granites on Nb–Y binary diagram of Pearce et al. [17] (e); SiO_2 versus Zn variation diagram for the study granites [18, 19] (f); chondrite-normalized REE for the investigated granites [20] (g).

Рисунок 4. Графики исследуемых образцов на диаграмме R1–R2 [15] (a); TAS–диаграмма Ирвина и Барагара гранитных пород [16] (б); АСМ–диаграмма образцов гранитов [16] (в); диаграмма Маньяра и Пикколи образцов гранита [21] (г); графики исследуемых гранитов на бинарной диаграмме Nb–Y Пирса и др. [17] (д); вариационная диаграмма SiO_2 против Zn для исследуемых гранитов [18, 19] (е); хондрит-нормализованный РЗЭ для исследуемых гранитов [20] (г).

cept the syenogranite related to A-type granites as shown in (Fig. 4, f).

Rare earth elements. The distribution of the rare earth elements in the older granites varies in the spectrum (La to Lu), which show slightly fractionated LREE pattern (La to Eu) and slightly fractionated HREE (Gd to Lu) with a significant negative Eu-anomalies as shown in chondrite –normalized REE diagram of Taylor and McLennan [20]. The Σ REE averages of the older granites are 91.6 ppm for quartz diorite, 63.9 ppm to 66 ppm for tonalite and 43.74 ppm to 48.3 ppm for granodiorite. They also show a high depletion of fractionated pattern from LREE to HREE with slightly negative Eu anomaly from quartz diorite to granodiorite (Table 3). On the other hand, Σ REE contents show some variation in all types of the investigated younger granites. The monzogranite is varying from 121.5 to 212.3 ppm and in the syenogranite from 73.6 to 73.7 ppm. However, Eu/Sm ratio is varying from 0.006 to 0.016 in the monzogranite and from 0.01 to 0.03 in the syenogranite (Table 3). They also show high Eu negative anomaly according to the normalized REE diagram (Fig. 4, g).

Conclusion

Gable El-Missikat is located in a long shear zone of Qena–Safaga road in the Central Eastern Desert of Egypt. The

study area is represented by metavolcanics rock as big xenoliths and older granites are intruded by the younger granites, as well as NE–SW felsite dike swarms. The younger granites have been considered younger than the felsite dike swarms, whereas they are only invaded by some basalt dikes in addition to pegmatite and quartz veins particular along NE–SW dissected shear zone, situated the northern part of El-Missikat granitic pluton. **Petrographically**, the investigated older granites are classified into quartz diorite, tonalite and granodiorite that show quite different of their content in plagioclase, quartz, hornblende, augite and biotite. The younger granites are represented by monzogranite, syenogranite and altered granite. For both monzogranite and syenogranite, plagioclase is varying from oligoclase to albite, K-feldspars, quartz and muscovite are relatively abundant in the syenogranite. The altered granite contains abundant quartz content up to 82 % of mineral composition. **Geochemically**, both the older granites and the younger granites have calc-alkaline affinity. **Tectonically**, the older granites are I-type granite, while the younger granites are varying from I-type to A-type granites. Generally, the older granites have low content of LILE, most probably due to the relatively low content of K-feldspars and HFSE. The younger granites exhibit a fractionated pattern from LREE to HREE with negative Eu anomaly.

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The article was received on January 16, 2020

Геологические и геохимические исследования гранитов Эль-Миссикат, Центрально-Восточная пустыня, Египет

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Аннотация

Цель. Настоящая работа посвящена детальным исследованиям геологии, геохимии и тектонического строения изучаемых гранитных пород.

Методы исследования. Эта работа включает как полевые работы (сбор образцов и составление новой геологической карты), так и лабораторные работы (подготовка тонких срезов для петрографических исследований с помощью поляризационного микроскопа), атомно-абсорбционный, рентгенофлуоресцентный анализ (РФА) в центральных лабораториях Акме в Канаде и использование масс-спектрометра с индуктивно-связанной плазмой (ИКПМС).

Результат. Область исследования ограничена Центральной Восточной пустыней Египта между Красным морем и долиной Нила. Эль-Миссикатский плутон покрыт породами, связанными с островной дугой (как ксенолит), более старыми гранитами и более молодыми гранитами в дополнение к различным типам даек и системе жил. Петрографически более старые граниты подразделяются на кварцевый диорит, тоналит и гранодиорит, тогда как более молодые граниты подразделяются на монцогранит, сиеногранит и измененные граниты. Геохимические исследования показывают, что гранитные породы имеют кальциево-щелочное сходство. Кварцевый диорит, тоналит и гранодиорит относятся к вулканическим дуговым гранитам, в то время как монцогранит и сиеногранит сходны с бесконечностью поведения пластинчатых гранитов. Кварцевый диорит, тоналит, гранодиорит и монцогранит относятся к гранитам I типа, в остальных случаях сиеногранит обладает гранитами А-типа.

Вывод. По данным геолого-петрографических исследований, исследуемые граниты представлены кварцевым диоритом, тоналитом и гранодиоритом, тогда как более молодые граниты подразделяются на монцогранитовые, сиеногранитовые и измененные граниты, пересеченные различными типами даек и системой жил. Как правило, более старые граниты имеют низкое содержание LILE, скорее всего, из-за относительно низкого содержания К-полевых шпатов и HFSE. Более молодые граниты проявляют фракционированный рисунок от LREE к HREE с отрицательной EU аномалией.

Ключевые слова: район Эль-Миссикат, геохимия, Восточная пустыня, Египет.

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Статья поступила в редакцию 16 января 2020 года