HBRC Journal (2012) 8, 64–68

Housing and Building National Research Center

HBRC Journal

http://ees.elsevier.com/hbrcj

Mineralogical and radioactive properties of some Egyptian granitoid rocks and their suitability for ornamental stones

Nasser G. Abd El-Ghafour [a], Marvat H. Khalil [b], Moustafa E. Gharib [c], Mahmoud L. Abd Latif [a,*]

[a] *Department of Raw Building Materials & their Processing, HBRC, Egypt*
[b] *Department of Building Physics, HBRC, Egypt*
[c] *Department of Geology, Helwan University, Egypt*

Received 13 October 2011; accepted 14 December 2011

KEYWORDS

Radioactive properties;
Egyptian granitoid;
Ornamental purposes

Abstract Granitoid rocks are widely distributed all over the Egyptian Shield, constituting approximately 60% of its plutonic assemblage. Granitoid ornamental stones could be commercially defined as a visibly granular, igneous rocks ranging in color from pink to light or dark grey. Detailed mineralogical composition was investigated by using polarizing microscope (Olympus BX50, Japan) and X-ray diffraction (XRD) X-ray model X' Pert ProPhillips MPD PW 3050/60 X-ray diffractometer. Radiometric measurement is recommended before utilizing the decoration stones which could be used in different purposes of construction especially indoor purposes. Twelve selected representative samples from some Egyptian granitoids rocks were examined by using Inductive Coupled Plasma Mass Spectrometer (ICP-MS) in Acme Analytical labs, Canada. The measured values were in ppm and would be transformed to Bq/kg which normally used to measure it in construction or building materials. Based on radiation measurement of (U and Th) for the studied granitoids of Gabal Shawab and Gabal Abu Shieh El-Atshan granites lie within the world-wide safety limits of constructing building materials, while Gabal El-Sibai and Gabal Homrit El-Gergab granites not realize these safety requirements. Homrit El-Gergab granitoids represented the highest concentration of the studied granitoids while Gabal Shawab represented the lowest one. Ornamental stones of G. Shawab and Wadi Abu Shieh El-Atshan are suitable for all construction weather indoor or outdoor decoration purposes.

* Corresponding author. Tel.: +2 01095482285.
E-mail address: marvat56@yahoo.com (M.L. Abd Latif).

Peer review under responsibility of Housing and Building National Research Center

ELSEVIER Production and hosting by Elsevier

Introduction

Granitoid rocks are widely distributed all over the Egyptian Shield, constituting approximately 60% of its plutonic assemblage. Their colors are often white, pink, rose, grey, red, black and their derivatives. They range in composition from quartz

1687-4048 © 2012 Housing and Building National Research Center. Production and hosting by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.hbrcj.2012.08.008

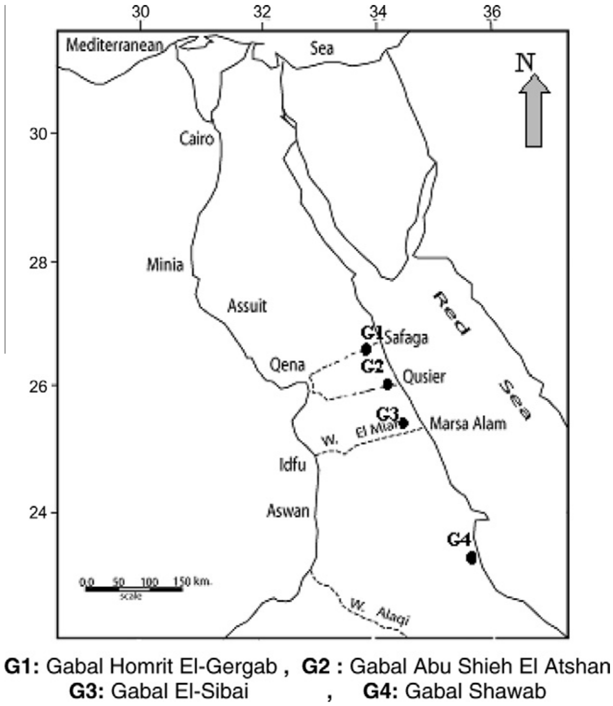

Fig. 1 Location map of the studied ornamental granitoids, Eastern Desert.

diorite and tonalite, through granodiorite and quartz monzonite to normal granites and alkaline–peralkaline granites [1]. Granites as general name for granitoids are widely employed as dimension stones, foundations of walls, flooring tiles, kitchen countertops and curling rocks ASTM [2]. Egyptian granitoids have more than one classification according to their relative age (old and younger granites), and their dominant color (grey, pink and red granites). Four different localities of granitic rocks have been chosen for this study Wadi Abu Shieh El-Atshan and Gabal Shawab areas to represent the older granites, while Gabal El-Sibai and Gabal Homrit El-Gergab to represent younger granitoids. It should be reported that the geology, mineralogy and geochemistry of the Egyptian granitoids have been studied by many researchers, for instance [3–10] and others. Granitoids as one of most well known the ornamental stones are characterized by radioactive elements occurrences by presence of U and Th and their bearing components.

Experimental work

Materials

The studied granitoids involved white granite of Gabal Shawab and grayish pink granites of Gabal Abu Shieh El-Atshan areas to represents the ornamental stones of the older

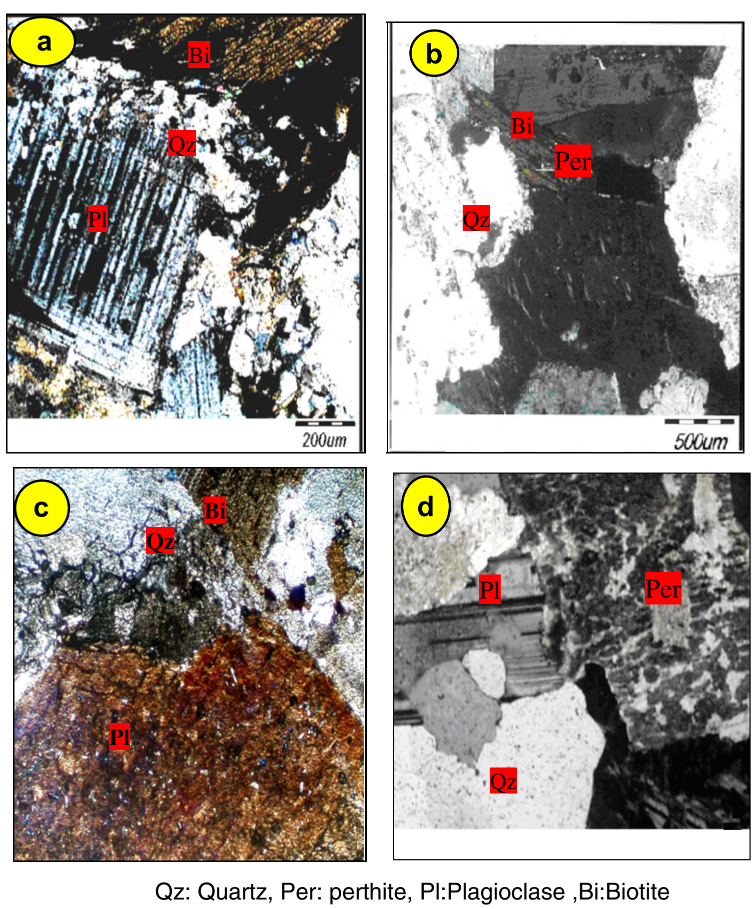

Fig. 2 Photomicrographs of the studied granitoids.

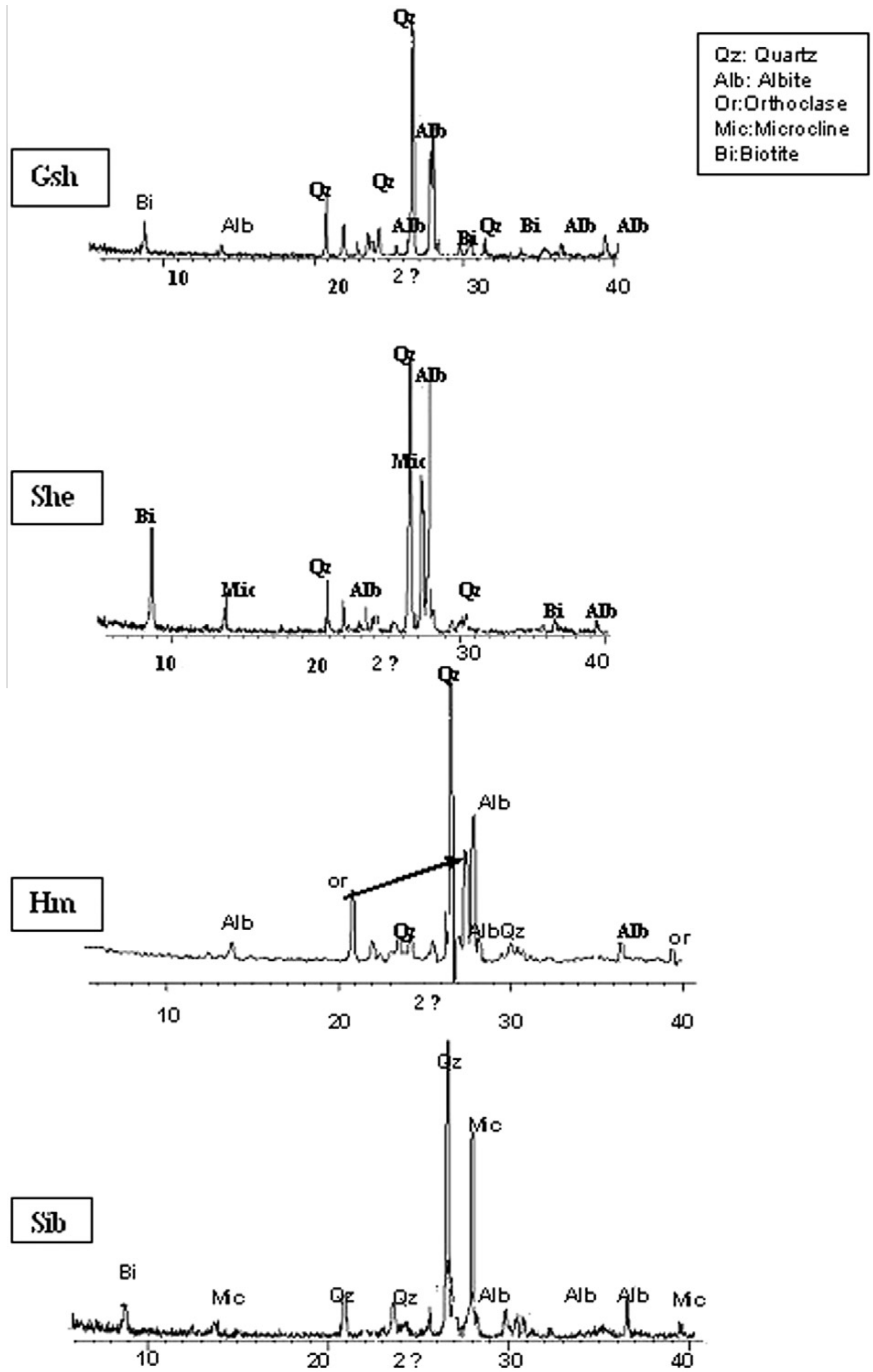

Fig. 3 X-ray diffraction patterns of the studied granitoids.

granitoids in the Eastern Desert of Egypt. On the other hand, the younger granitoids were represented by the pinkish and red granites of Gabal El-Sibai and Gabal Homrit El-Gergab respectively, Fig. 1. Twelve samples for this study were collected from fresh quarry surfaces. Three fresh representative samples namely (She1, She2 and She3) were collected from Gabal Abu Shieh El-Atshan, while (GSh1, GSh2 and GSh3) from Gabal Shawab.(Hm1, Hm2 and Hm3) from Gabal Homrit El-Gergab and finally, three samples were collected from Gabal El-Sibai, (Sib1, Sib2 and Sib3).

Laboratory techniques

Detailed mineralogical composition was investigated by using polarizing microscope (Olympus BX50, Japan) and X-ray diffraction (XRD) X-ray model X' Pert ProPhillips MPD PW

Table 1 Chemical analysis of the studied granitoids.

Major oxides%	Samples			
	Gsh	She	Hm	Sib
SiO_2	73.23	72.26	73.01	74.45
Al_2O_3	17.35	12.5	10.48	11.79
Fe_2O_3	1.32	3.43	0.29	2.64
CaO	0.94	1.66	1.03	1.32
MgO	0.38	0.66	0.24	0.13
Na_2O	4. 54	4.5	5.35	3.2
K_2O	0.75	2.44	7.47	4.74
Ti O_2	0.28	0.03	0.01	0.28
P_2O_5	0.02	0.03	0.01	0.02
MnO_2	0.03	0.02	0.02	0.02
LOI	0.40	1.6	0.40	0.59
Total	99.15	99.13	99.03	99.18

3050/60 X-ray diffractometer. On the other hand, chemical analysis for major oxides was determined for studied representative samples the using X-ray Fluorescence (XRF) model (Phillips PW 1400 Spectrometer, Holland). U and Th were detected for twelve ornamental granitic powder samples using Inductive Coupled Plasma Mass Spectroscopy (ICP-MS) in Acme Analytical laboratory Ltd., Canada. The measured values were in ppm and would be transformed to Bq/kg unit Table 2 (1 ppm by weight of ^{238}U equal to 12.35 Bq/kg while, 1 ppm by weight of ^{232}Th equal to 4.06 Bq/kg) which normally used to measure it in construction or building materials [16].

Results and discussion

Mineralogical composition

Petrographical description and XRD data analysis of the studied older and younger granitoids reveled that; Gabal Shawab granitic rocks composed mainly of coarse-grained crystals of plagioclase, quartz and biotite. It can be classified as tonailte Fig. 2a. G. Abu Shieh El-Atshan grayish pink granite essentially consists of quartz, Plagioclase (An9-17), microcline, perthite, and biotite. It can be classified as granodiorite Fig. 2b. G. El-Sibai granitic rocks mainly consist of microcline perthite, microcline, plagioclase (An6-16) quartz and biotite. It ranged from granite to granodiorite Fig. 2c. The red granite of G. Homrit El-Gergab area composed of quartz and K-feldspar (orthoclase), orthoclase perthite together with variable amounts of plagioclase (An3-9) and subordinary a mounts of biotite. It can be classified as alkali feldspar field Fig. 2d. Four representative granitoid samples were chosen and examined by X-ray diffraction Fig. 3. The obtained results show a complete agreement with the Petrographical description

Chemical analysis of studied granitoids

Chemical analysis data of major oxides in the studied granitoids are shown in Table 1. SiO_2 is the main major oxide of the studied granitoids with narrow range. Al_2O_3 is the second major oxide. Both of the studied younger granitoids characterized by somewhat enrichment in alkalis (K_2O + Na_2O) with relatively enrichment in G. Homrit El-Gergab granite which attributed to the relatively high contents of alkali feldspar. The relatively high Fe_2O_3, MgO and K_2O contents in Abu Shieh El-Atshan granitoids attributed to the abundance of biotite and microcline compared with Gabal Shawab granitoids. The relatively high Fe_2O_3, MgO and K_2O contents in Abu Shieh El-Atshan granitoids attributed to the abundance of biotite and microcline compared with Gabal Shawab granitoids. The relatively high content of Fe_2O_3 in G. El-Sibai granites are due to the presence of appreciable amounts of biotite. Chemical composition of the studied granitoids can be in a quiet agreement with their mineralogical composition.

Radioactivity of the studied granitoid rocks

The measured values of U and Th in ppm and the corresponding concentration in (Bq/kg) for the studied granitoids are shown in Table 2. The lowest average of radioactivity concentration for ^{238}U and ^{232}Th (2.46 & 0.54 Bq/kg, respectively) are recorded in Gabal Shawab tonalite samples, while the highest values with an average of 89.74 Bq/kg for ^{238}U and 103.12 Bq/

Table 2 Activity concentration (Bq/Kg) and equivalent (ppm) of two radionuclides ^{238}U and ^{232}Th of the studied granitic rocks.

Area	Sample code	^{238}U in ppm	^{238}U Bq/Kg	^{232}Th ppm	^{232}Th Bq/Kg	World-wide average concentration
Wadi Abu Shieh El-Atshan (*She*)	She1	0.8	9.8	3.5	14.61	World-wide average concentration of ^{232}Th and ^{238}U are about 40 Bq/Kg according to Mustonen et al (1999)
	She2	0.6	7.41	2.59	10.55	
	She3	0.69	8.64	3.09	12.58	
	Average	0.69	8.61	3.06	12.58	
Gabal Shawab (*Gsh*)	G.sh1	0.2	2.47	0.19	0.81	
	G.sh2	0.29	3.7	0.098	0.4	
	G.sh3	0.09	1.23	0.098	0.4	
	Average	0.19	2.46	0.12	0.54	
Gabal Homrit El Gergab (*Hm*)	Hm1	6	75.33	25.39	103.12	
	Hm2	8.4	103.74	33.39	135.6	
	Hm3	7.28	90.15	27.39	111.24	
	Average	7.22	89.74	26.26	106.65	
Gabal EL-Sibai (*Sib*)						
	Sib1	6	74.1	22	89.32	
	Sib2	5.8	72.86	20.69	84.04	
	Sib3	5.4	66.69	18.59	75.5	
	Average	5.73	71.21	20.42	82.95	

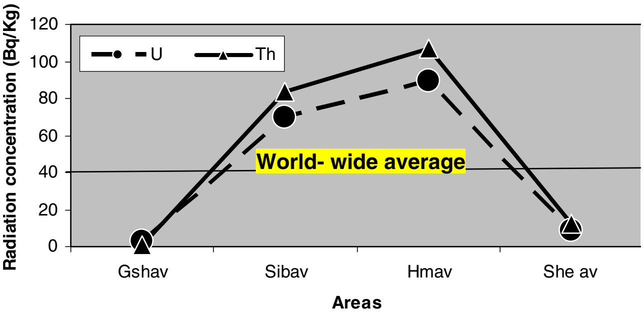

Fig. 4 Activity Concentration (Bq/Kg) of two radionuclides ^{238}U and ^{232}Th of the studied granitic rocks compared with the world-wide average concentration.

kg for ^{232}Th are recorded in Gabal Homrit El-Gergab alkali-granite samples.

Comparing the measured values of U and Th in the studied granitoids with the world-wide safety limits for concentration of these elements granitic building material which detected by the value of 40 Bq/Kg after [17] as in Fig. 4. It is clearly noticed that granitic samples of G. Shawab and Wadi Abu Shieh El-Atshan areas are below this limit while, G. Homrit El-Gergab and G. El-Sibai granitoids are more higher than that limit.

Conclusions

From the above results, it can be conclude that:

- Quartz, feldspars (both of albite and k-feldspars represented by orthoclase and microcline) and biotite represented the main constituents of all studied granitoids.
- The measured values of Th and U are higher in studied younger granitoids than the older type.
- Homrit El-Gergab granitoids represented the highest concentration of the studied granitoids while Gabal Shawab represented the lowest one.
- Ornamental stones of G. Shawab and Wadi Abu Shieh El-Atshan are suitable for all construction weather indoor or outdoor decoration purposes.
- Ornamental stones of El-Sibai and Homrit El-Gergab granites not realize the world–wide safety requirements of radiation and must be not used for indoor decoration purposes.
- In the case of using one of the studied younger granitoids in interiors decoration purposes aeration is required as much as possible.

References

[1] M.F. El-Ramly, M.K. Akaad, The basement complex in the central Eastern Desert, Geological Survey Egypt 8 (1960) 35–45.
[2] ASTM., Terminology relarted to Dimension stones. Annual Book of ASTM standards Vol 04.07. (2004).
[3] S. El-Gaby, M.S. Habib, Geology of the area southwest of port Safaga with special emphasis to granitic rocks, Eastern Desert, Egypt, Annual Geological Survey of Egypt 12 (1982) 47–71.
[4] A.M. Noweir, B.M. Sewifi, A.M. Abu El Ela, Geology, petrography, geochemistry and petrogenesis of the Egyptian younger granites, Qatar University Science Bulletin 10 (1990) 363–393.
[5] A.A. Khudeir, S. El-Gaby, G.M. Kamal El-Din, M.H. Asran, R.O. Greiling, The pre-Pan-African deformed granite cycle of Gabal El-Sibai swell, Eastern Desert, Egypt, Journal African Earth Science 21 (3) (1995) 395–406.
[6] Gharib, M. E. & Ahmed, A.F., Petrology and geochemistry of Late Precambrian granitoid rocks of Abu Idam area, North Eastern Desert, Egypt, 3rd International Conference on the Geology of Africa, Assiut University, 2003, pp. 441–446.
[7] Gharib, M.E., Mineral chemistry, zircon typology and geochemistry as Guides to petrogensis of El Shayib area A-Type granites, North Eastern Desert, Egypt, 6th internernational Conference.on Geochemistry, Alexandria University, 2004, pp. 365–395.
[8] E.S. Farahat, M.E. Gharib, A.F. Ahmed, Chemical characteristics of some I and A-Type granitoids from Eastern Desert of Egypt. Petrogentic and geotectonic implications, Journal of Egyptian Mineralogy 16 (2006) 1–23.
[9] F. Finger, W. Dörr, A. Gerdes, M.E. Gharib, M. Dawoud, U Pb zircon ages and geochemical data for the Monumental Granite and other granitoid rocks from Aswan, Egypt: Implications for the geological evolution of the western margin of the Arabian Nubian Shield, Mineralogy & Petrology 93 (3–4) (2008) 153–183.
[10] B.H. Ali, S.A. Wilde, M.M.A. Gabr, Granitoids evolution in Sinai, Egypt, based on precise shrimp U-Pb zircon geochronology, Gondwana Research 15 (2009) 38–48.
[16] International Atomic Energy Agency (IAEA), Construction and Use of Calibration Facilities for Radiometric Field Equipment, Technical Reports Series No. 309, IAEA, Vienna, 1989.
[17] Mustonen R., Pennanen M., Annanmäki M. and Oksanen E., (1997), Enhanced Radioactivity of Building Materials. Final report of the contract No 96-ET-003 for the European Commission. Radiation and Nuclear Safety Authority–STUK, Finland, Radiation Protection 96, Luxembourg, 1999.

Further reading

[11] M. Al-Jarallah, Radon exhalation from granites used in Saudi Arabia, Journal of Environmental Radioactivity 53 (2001) 91–98.
[12] B.A. Bertrand, V. David, K. Becker, J.G. Stanley, G.P. Bennett, K. Ken, R. Henry, B. Edward, Silberstein, W. Edward, Radon update: Facts concerning environmental radon levels, mitigation strategies, dosimetry effects and guides, Journal of Nuclear Medicine 35 (2) (1994) 368–385.
[13] E. Standen, Radon in houses utilizing stone magazines for heat accumulation, Health Physics 41 (1981) 29–33.
[14] S. Pavlidou, A. Koroneos, C. Papastefanou, G. Christofides, S. Stoulos, M. Vavelides, Natural radioactivity of granites used as building materials, Journal of Environmental Radioactivity 89 (2006) 48–60.
[15] E. Maureen, D.C.M. Younga, Urquhartb, R.A. Lainga, Maintenance and repair issues for stone cleaned sandstone and granite building facades, Building and Environment 38 (2003) 1125–1131.