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Petrographic studies of Ras Barud granitic rocks, Safaga District, Eastern Desert, Egypt

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ABSTRACT

The examined granitic batholith consists mainly of red, pink, buff, greyish-white and white granites in addition to adamellites, grey granodiorites and quartz diorites. Under the microscope, the investigated granitic rocks show 45 petrographic varieties. Myrmekite intergrowths are studied in these granitic rocks including normal and intergranular myrmekitic textures. These intergrowths are formed due to the action of exsolutions, replacements and metasomatic processes in addition to the simultaneous crystallization which took place between quartz and feldspar minerals. The classification of these granitic rocks was attempted on the basis of modal analyses and was found to agree to a great extent with the field and petrographic classification.

INTRODUCTION

The present study deals with the petrographic characteristics of Ras Barud granitic rocks which form a conspicuous pluton situated about 30 km northwest of Safaga port (Fig. 1). Gabal Ras Barud is one of the numerous granitic bodies of the basement complex in the Eastern Desert of Egypt. The batholith is dissected by Wadi Barud which is directed from east to west separating Ras Barud granitic pluton to two main parts. The examined granitic rocks consist mainly of red, pink, buff, greyish-white, white granites, adamellites, grey granodiorites and quartz diorites.

A geological map of the granitic rocks of Ras Barud has been constructed on the basis of field observations (Fig. 2). The rocks show a very roughly zonal form. The red granites occupy the core of the batholith, while the pink and buff granites surround the red type. Greyish white and white granites crop out at the outer margins of the pink and buff granites. Sharp contacts between the different types are observed, while chilled and gradational contacts are infrequently recorded. Porphyritic varieties are easily recognized among the granitic rocks of Ras Barud. Numerous basalt, andesite and diorite xenoliths are present throughout these granites. The shape of these xenoliths usually ranges from subrounded to oval, varying from 5 to 12 cm in length and from 2 to 7 cm in breadth. They show sharp contacts, but rarely signs of replacement are recognised between the xenoliths and their host granitic rocks.

The granitic rocks are well jointed in several directions. The dominant trends of the

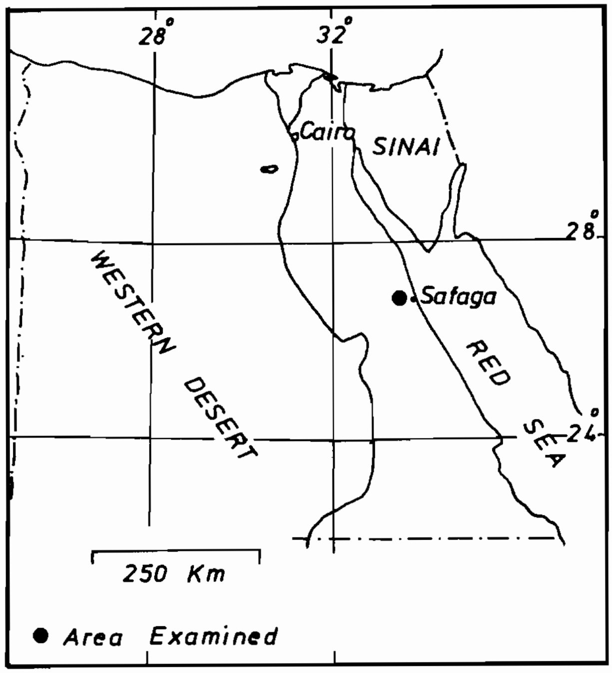


Fig. 1. Location map.

joints are N 50°E and N 10°W dipping by 30°–60° NW and 20°–50° NE respectively. Local brecciation of some buff granites is observed in which fragments of feldspar and quartz are enclosed in a fine matrix of granitic materials. Granodiorite rocks grade into grey diorities in which the mafic minerals become more abundant. The rocks are dissected by a few basic, intermediate and acidic post-granite dykes. Quartz, epidote and feldspar veins are oriented in different directions within the examined rocks.

PETROGRAPHY

The granitic types are grouped into granites and granodiorites.

1. GRANITES

Granites consist mainly of quartz, orthoclase, microcline, plagioclase, biotite and hornblende. Quartz occurs either as strained large interstitial crystals in the pink granites or as small grains enclosed in the feldspars in the leucogranites. Quartz is mainly clear and occasionally free of cracks. Orthoclase forms altered kaolinized crystals which are corroded by quartz. According to the relation between the composition of plagioclase and its extinction angle, the An content of the examined plagioclase ranges from An_5 (albite) to An_{15} (oligoclase). The plagioclase crystals show normal zoning which was formed from a magma accompanied with compositional changes in its sodium and calcium contents during decreasing temperature (Fig. 3). The presence of poikilitic albite in some granites is attributed to the action of high sodium content solution which passed through the fissures of the perthite giving rise to dissolution of

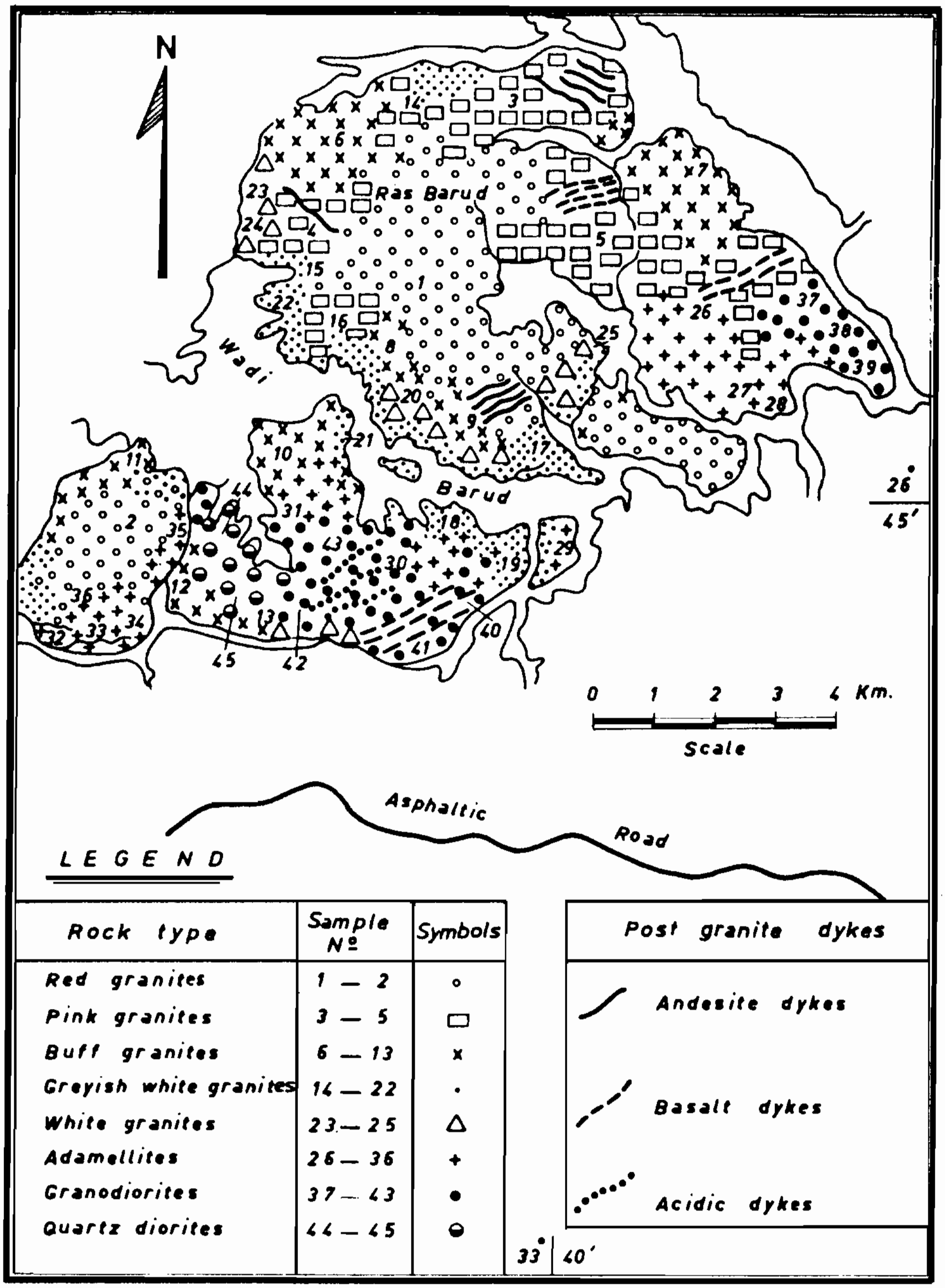


Fig. 2. Generalized geological map of Ras Barud area, showing granitic rocks and sample location.

K-feldspar and precipitation of Na-feldspar (Laves & Soldatos 1963). Some biotite flakes are corroded by quartz and feldspar and occasionally contain muscovite wisps with aggregates of epidote along their cleavage. Stout flakes of muscovite are present in some of the greyish-white varieties. The green hornblende crystals are the sole mafic

Fig. 3. Zoned plagioclase crystal showing porphyritic texture. Crossed nicols. × 40.

Fig. 4. Graphic intergrowth in the red granite between quartz and feldspar. Crossed nicols × 40.

mineral in some varities. The red and pink granites are characterized by different shapes of graphic intergrowths between orthoclase and quartz (Fig. 4), which are mainly formed during the simultaneous crystallization of magma under low-temperature and vapour-rich conditions (Vadilo 1971). The greyish-white and buff granites are characterized by graphic intergrowths between perthite, microcline perthite and quartz. These feldspars were formed due to the action of sodium- and silica-bearing solutions on the K-feldspar in which the residual silica formed quartz rods through the perthite and microcline–perthite giving rise to graphic texture (Fig. 5). Some varieties of white granite are free from mafic minerals giving rise to leucogranite. Local

Fig. 5. Perthite intergrowths with quartz rods forming graphic texture in the greyish-white granite. Crossed nicols × 40.

brecciation is observed in some varieties of the greyish-white granite in which big cracked crystals of quartz and feldspars are enclosed in a matrix consisting mainly of medium and fine grained quartz, feldspars and muscovite. The bent plagioclase crystals in the brecciated buff and greyish-white granites are characterized by mechanical twinning resulting from applying shearing stress during local deformation. The red colour of feldspar in the red granite is mainly attributed to an enrichment in iron oxide by hydrothermal solutions. On the other hand, the ferrous iron in the biotite red granites has been redeposited as ferric oxide along the cleavage planes and fractures of feldspars, biotites and quartz minerals due to the process of alteration of biotites in the investigated granites.

Several varieties of adamellites are observed within the different types of granites. Albite, quartz and muscovite are enclosed in microcline perthite of some adamellites showing that external solutions have dissolved the microcline, and that albite and quartz inclusions were later trapped during primary crystallization. Microcline was then recrystallized from the solution. The replacement of microcline by albite took place giving rise to microcline perthite (Fig. 6) which mainly contains relics of small albite crystals.

Myrmekite intergrowths are more abundant in the adamellite varieties than in the other types of the granitic rocks. Generally, these intergrowths are observed in the leucoadamellite varieties in comparison with the granitic rocks which bear mafic minerals. There are two main types of myrmekite intergrowths:

Fig. 6. Microcline perthite and perthite containing muscovite flakes, albite and quartz crystals. Crossed nicols × 40.

(*a*) *Normal myrmekite*: This type is common in the grey granites. It forms vermicular intergrowths of quartz and plagioclase which surround fresh plagioclase (Fig. 7), less commonly kaolinized orthoclase. The plagioclase crystals are represented by albite and plagioclase in which the myrmekite plagioclase is more calcic near the contact with the plagioclase phenocrysts. According to Becke (1908) the higher the An content of myrmekite plagioclase, the greater is the volume percentage of quartz. The K-feldspar is replaced by the albite and anorthite components of myrmekite plagioclase according to the following reactions:

$$KAlSi_3O_8 + Na \longrightarrow NaAlSi_3O_8 + K$$

$$2KAlSi_3O_8 + Ca \longrightarrow CaAl_2Si_2O_8 + 2K + 4SiO_2$$

The two equations show that the replacement by sodium (of albite) does not give rise to quartz, whereas the replacement by Ca (of plagioclase) does. For every mole of An, 4

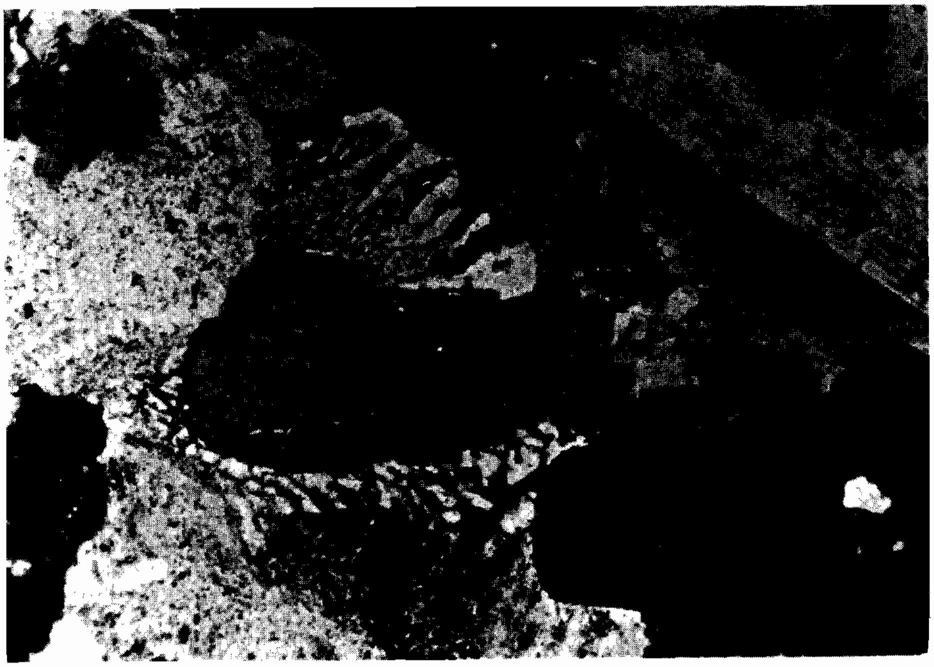


Fig. 7. Photomicrograph in the greyish-white granite showing vermicular intergrowths of quartz and plagioclase surrounding simple twinned plagioclase crystal. Crossed nicols ×40.

moles of SiO_2 are produced. The present authors are inclined to consider that the reaction of the second equation coincides completely with the fair amounts of vermicular quartz surrounding the oligoclase crystals. In the greyish-white granite, other occurrences of quartz–plagioclase myrmekite surround kaolinized potassium feldspar phenocrysts, readily originated by exsolution.

(*a*) *Intergranular myrmekite*: This type is common in the examined adamellites in which the myrmekite appears as lobates between adjacent plagioclase (An_8 to An_{20}) and potassium feldspsar (Fig. 8). In the adamellites which bear muscovite, myrmekite is present inside the plagioclase crystals and passes through connected channels. These plagioclase crystals are mainly cracked and are characterized by minor displacement across their lamellae, indicating that these plagioclase crystals were under stress. Myrmekite intergrowths occur in the interior of plagioclase following cracks and indicating that these intergrowths are formed as secondary processes after the mechanical deformation of the rock. The occurrence of muscovite and lobate myrmekite in the adamellite is explained by simultaneous replacement of potassium feldspar (Phillips, Ransom & Vernon 1972). Some myrmekite of the examined adamellites could result from the interaction of metasomatic process with the exsolution around the megacryst margins of feldspars. The exsolution hypothesis has been recently supported by many workers including Jorgart (1970), Ashworth (1972), Kennan (1972), Phillips *et al.* (1972), Ramaswamy & Murty (1972), Byerly & Vogel (1973), Phillips & Carr (1973), Phillips & Stone (1974) and Smith (1974).

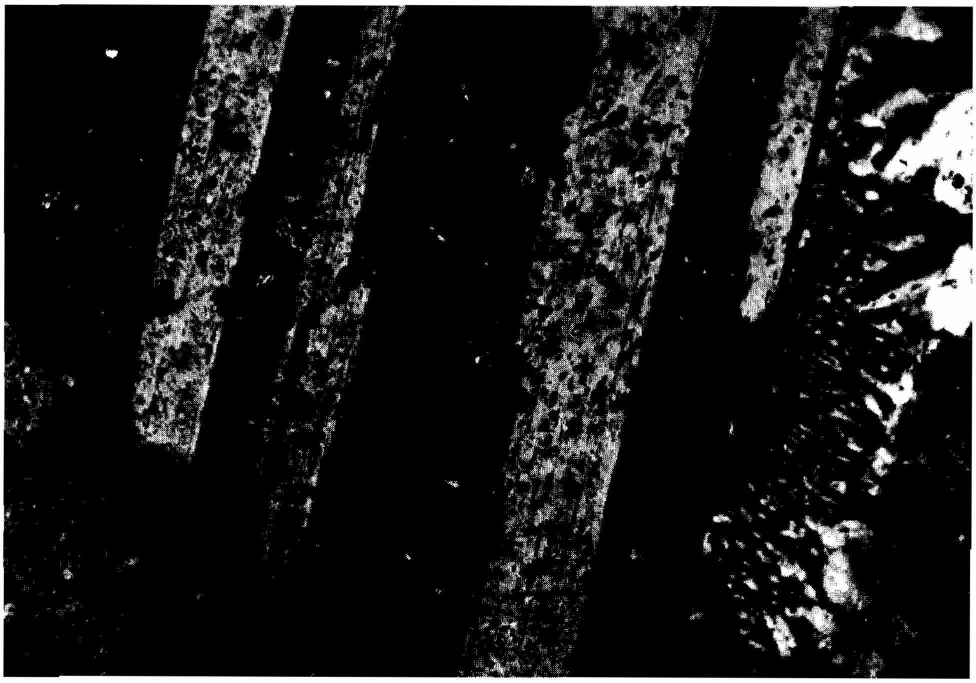
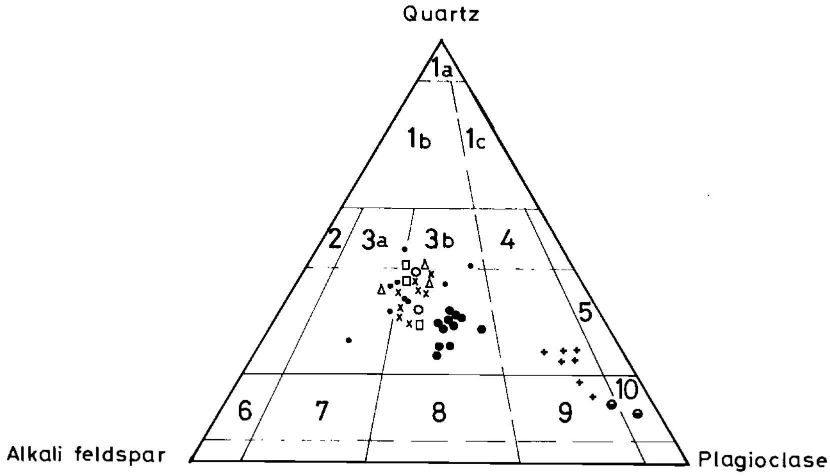


Fig. 8. Photomicrograph in adamellite showing myrmekite which appears as lobates between adjacent plagioclase and potassium feldspar. Crossed nicols × 55.

2. GRANODIORITES

Granodiorites are hard and massive, ranging in grain size from coarse to medium. In thin section the rocks show holocrystalline, hypidiomorphic granular texture. The granodiorite varieties comprise porphyritic and non-porphyritic types. Granodiorite consists of plagioclase, perthite, orthoclase, quartz, biotite, muscovite and hornblende. Plagioclase is considered the dominant feldspar and is represented by oligoclase (Ab_{82} to Ab_{90}). The oligoclase crystals form euhedral tabular plates which may be zoned. Some crystals are fresh with clear polysynthetic twinning, and others are strongly altered to sericite. Core and rim structure is common. Orthoclase is present in small amounts forming subhedral kaolinized crystals and is partially perthitic. Quartz forms irregular clear grains filling the interstices of feldspars and mafics. Hornblende constitutes the main mafic mineral in some varieties of granodiorites. It forms euhedral prismatic crystals, sometimes enclosing quartz grains, muscovite and iron ores. Hornblende is corroded by plagioclase and quartz crystals. Some of the large hornblende crystals are partially altered to chlorite. A little primary and secondary muscovite is observed in some varieties. A few dark grey patches of granodiorite contain fair amounts of biotite as the sole ferromagnesian silicate. These biotites vary from small shreds to stout flakes. Green and brown biotite clusters are mainly disseminated throughout the host rock giving rise to dark grey granodiorites rich in biotite content. Iron ores and epidote are the common accessories. Few samples of granodiorite rocks grade into grey tonalite in which the grain size of the latter type ranges from coarse to



Explanation :

ROCK TYPE	SAMPLE No.	SYMBOLS
Red granites	1 - 2	o
Pink granites	3 - 5	□
Buff granites	6 - 13	x
Greyish white granites	14 - 22	•
White granites	23 - 25	Δ
Adamellites	26 - 36	●
Granodiorites	37 - 43	+
Quartz diorites	44 - 45	⊙

Symbols and numbers of the samples from Ras Barud granitic rocks.

1a- Quartz rocks
1b- Quartz granite
1c- Quartz granodiorite
2 - Alkali granite
3a- Syeno granite
3b- Monzo granite
4 - Granodiorite
5 - Quartz diorite
6 - Alkali syenite
7 - Syenite
8 - Monzonite
9 - Monzodiorite and Monzogabbro
10- Diorite and gabbro

Fig. 9. Ras Barud granitic rocks plotted according to the classification scheme by Streckeisen (1967).

medium. Fair amounts of fresh oligoclase laths (An_{15} to An_{29}) are observed in addition to the hornblende and biotite.

MODAL VARIATION

The modal distribution of the mineral constituents of 45 granitic varieties was determined using a Swift Point Counter. A total of 90 thin sections were made. For each section, 1000 points were taken. The analytical error was always less than 2%. The results are shown in Tables 1–5.

Fig. 9 illustrates the classification given by Streckeisen (1967). It is obvious that the investigated granites and adamellites fall within the fields of syenogranite and monzogranite. The granodiorite and quartz diorite fall within the fields of granodiorite, monzodiorite and diorite. Streckeisen (1967, p. 167) stated that rocks which fall in zone 3 b (Fig. 9) are granitic rocks which are mostly crystallized from magmatic solutions. Therefore, the examined granites and adamellite are most probably of magmatic origin.

CONCLUSION

Ras Barud granitic rocks show a very roughly zonal form which comprises red granites in the core of the batholith, whereas the greyish white and white granites crop out at the outer margins of the pluton. The pink and buff granites occupy the intermediate zone of the batholith. The albite phenocrysts are characterized by simple, Carlsbad twinning. The optical features of the twinned albite phenocrysts show that its primary twinning resulted from nucleation in a liquid magma (Smith 1974). The mechanical twinning of some plagioclase phenocrysts in the buff and greyish white brecciated granites took place under shearing stress during local deformation. The presence of normal zoning in the plagioclase crystals shows that the magma was accompanied by compositional changes in its Na and Ca contents during decreasing temperature.

The graphic intergrowths in the red and pink granites were mainly controlled by kinetic factors during the simultaneous crystallization of quartz and orthoclase from a magma under low temperature and vapour-rich conditions (Vadilo 1971). The K-feldspar of the grey granite was replaced by the Ca components of plagioclase giving rise to a great volume of quartz grains which surround the oligoclase crystals forming normal myrmekite. The interaction of metasomatic process with the exsolution around the margins of feldspar phenocrysts gave rise to intergranular myrmekite in some adamellites.

According to the classification given by Streckeisen (1967), the examined granitic rocks fall within the fields of syenogranite, monzogranite, granodiorite, monzodiorite and diorite. It is evident that the examined granites and adamellites are most probably of magmatic origin.

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Table 1. Modal analysis of red and pink granites

%	Red granites (Sample No.)		Pink granites (Sample No.)		
	1	2	3	4	5
Quartz	29·9	42·9	37·5	29·5	46·6
Orthoclase	28·2	30·4	29·2	22·6	28·8
Microcline				8·7	
Perthite					
Plagioclase	22·4	20·9	19·3	25·4	20·3
Biotite	13·4		11·8		
Muscovite				8·6	
Hornblende					
Accessories	6·1	5·8	2·2	5·2	4·3
Total	100	100	100	100	100
Colour index	19·5	5·8	14·0	13·8	4·3
Quartz %	37·1	45·5	43·6	34·2	48·7
Alkali feldspar %	35·0	32·3	34·0	36·3	30·1
Plagioclase %	27·9	22·2	22·4	29·5	21·2

Sample numbers referring to various granitic rocks are the same throughout the present study. See list (p. 196).

Table 2. Modal analysis of buff granites

%	(Sample No.)							
	6	7	8	9	10	11	12	13
Quartz	31·2	27·2	30·6	28·9	35·5	36·8	38·4	38·7
Orthoclase	25·4	23·9	23·4	34·7	24·1	30·6	28·9	24·2
Microcline		7·3	8·6		10·5		3·1	
Perthite		9·2						
Plagioclase	19·0	15·6	19·8	22·6	18·8	20·4	25·0	22·3
Biotite	14·2		12·5					10·3
Muscovite	5·9			7·8	6·8	9·9		
Hornblende		10·5						
Accessories	4·3	6·3	5·1	6·0	4·3	2·3	4·6	4·5
Total	100	100	100	100	100	100	100	100
Colour index	24·4	16·8	17·6	13·8	11·1	12·2	4·6	14·8
Quartz %	41·3	32·7	37·2	33·5	39·9	41·9	40·3	45·5
Alkali feldspar %	33·6	37·5	38·8	40·3	38·9	34·9	33·5	28·4
Plagioclase %	25·1	29·8	24·0	26·2	21·2	23·2	26·2	26·2

Table 3. Modal analysis of greyish-white and white granites

	Greyish-white granites (Sample No.)									White granites (Sample No.)		
%	14	15	16	17	18	19	20	21	22	23	24	25
Quartz	33·2	30·7	32·4	33·3	25·1	43·4	31·2	30·0	43·5	33·9	33·5	43·8
Orthoclase	20·6	35·9	25·3	25·4	47·6	27·9	35·6	33·6	19·9	35·2	27·4	31·4
Microcline	10·1			6·8								
Perthite									12·6			
Plagioclase	16·0	18·3	20·2	15·4	13·8	15·5	20·4	19·0	17·5	16·3	19·5	21·2
Biotite	10·9	9·8	12·9	10·0				11·5		9·3	11·6	
Muscovite			5·3	4·6	9·3	9·9					4·0	
Hornblende	4·7						8·8					
Accessories	4·5	5·3	3·9	4·5	4·2	3·3	4·0	5·9	6·5	5·3	4·0	3·6
Total	100	100	100	100	100	100	100	100	100	100	100	100
Colour index	20·1	15·1	22·1	19·1	13·5	13·2	12·8	17·4	6·5	14·6	19·6	3·6
Quartz %	41·6	36·1	41·6	41·2	29·0	50·0	35·8	36·3	46·5	39·7	41·7	45·4
Alkali feldspar %	38·4	42·3	32·5	39·8	55·0	32·1	40·8	40·7	21·3	41·2	34·0	32·6
Plagioclase %	20	21·6	25·9	19·0	16·0	17·9	23·4	23·0	32·2	19·1	24·3	22·0

Table 4. Modal analysis of adamellites

%	(Sample No.)										
	26	27	28	29	30	31	32	33	34	35	36
Quartz	26·5	25·5	23·4	24·3	29·7	21·7	24·4	25·9	33·0	20·8	26·1
Orthoclase	27·6	24·7	20·8	20·6	25·2	23·2	21·3	27·0	29·5	22·6	24·5
Microcline		5·4	6·3			9·2		6·4		7·0	
Perthite						6·2	7·1	11·2		3·3	
Plagioclase	27·4	27·6	24·8	26·1	33·9	25·2	25·3	25·5	32·0	27·1	30·3
Biotite	11·6	12·8	14·2							15·3	
Muscovite			6·0	5·3	7·6	8·7	7·1				
Hornblende				13·4			10·1				12·6
Accessories	6·9	4·0	4·5	4·3	3·6	5·8	4·7	4·0	5·5	3·9	6·5
Total	100	100	100	100	100	100	100	100	100	100	100
Colour index	18·5	16·8	24·7	23·0	11·2	14·5	21·9	4·0	5·5	19·2	19·1
Quartz %	32·5	30·6	31·1	31·6	33·4	25·4	31·2	27·0	34·9	25·7	32·3
Alkali feldspar %	33·9	36·2	36·0	34·5	28·4	37·9	27·3	34·8	31·2	36·7	30·3
Plagioclase %	33·6	33·2	32·9	33·9	38·2	36·7	41·5	38·2	33·9	37·6	37·4

Table 5. Modal analysis of granodiorites and quartz diorites

	Granodiorites (Sample No.)							Quartz diorites (Sample No.)	
%	37	38	39	40	41	42	43	44	45
Quartz	16·9	17·1	10·3	15·9	20·3	17·7	18·6	9·3	7·8
Orthoclase	7·4	11·7	8·6	9·8	10·5	10·3	10·5	5·6	4·3
Microcline									
Perthite				12·0					
Plagioclase	45·4	40·6	47·9	44·5	47·2	48·4	49·6	51·0	60·6
Biotite	24·6		14·4			19·7		9·8	
Muscovite		9·3							
Hornblende		17·3	12·8	14·9	15·2		15·6	16·9	22·8
Accessories	5·7	4·0	6·0	2·9	6·8	3·9	5·7	7·4	4·5
Total	100	100	100	100	100	100	100	100	100
Colour index	30·3	30·6	33·2	17·8	22·0	23·6	21·3	34·1	27·3
Alkali feldspar %	10·6	16·9	12·9	11·9	13·5	13·5	13·4	8·5	5·9
Plagioclase %	65·1	58·5	71·7	68·8	60·5	63·3	63·0	77·4	83·4
Quartz %	24·3	24·6	15·4	19·3	26·0	23·2	23·6	14·1	10·7

List of samples

Sample No.	Rock type
	Red granites
1	Biotite granite
2	Porphyritic leucogranite
	Pink granites
3	Biotite granite
4	Porphyritic muscovite microcline granite
5	Porphyritic graphic leucogranite
	Buff granites
6	Biotite muscovite granite
7	Hornblende microcline perthite granite
8	Biotite microcline granite
9	Muscovite granite
10	Muscovite microcline granite
11	Brecciated muscovite granite
12	Microcline leucogranite
13	Porphyritic biotite granite
	Greyish-white granites
14	Microcline hornblende biotite granite
15	Biotite granite
16	Biotite muscovite granite
17	Muscovite biotite microcline granite
18	Muscovite granite
19	Brecciated muscovite granite
20	Hornblende granite
21	Porphyritic biotite granite
22	Porphyritic perthite leucogranite
	White granites
23	Biotite granite
24	Biotite muscovite granite
25	Leucogranite
	Adamellites
26	Biotite adamellite
27	Biotite microcline adamellite
28	Biotite muscovite microcline adamellite
29	Hornblende muscovite adamellite
30	Muscovite adamellite
31	Muscovite microcline perthite adamellite
32	Hornblende muscovite perthite adamellite
33	Leucoadamellite
34	Perthite microcline leucoadamellite
35	Porphyritic biotite perthite microcline adamellite
36	Porphyritic hornblende adamellite
	Granodiorites
37	Biotite granodiorite
38	Hornblende muscovite granodiorite
39	Biotite hornblende granodiorite
40	Hornblende perthite granodiorite
41	Hornblende grandodiorite
42	Porphyritic biotite granodiorite
43	Porphyritic hornblende granodiorite
	Quartz diorites
44	Hornblende biotite quartz diorite
45	Hornblende quartz diorite

دراسات بتروجرافية للصخور الجرانيتية براس بارود ، منطقة سفاجا ، الصحراء الشرقية ، مصر

عادل محمد رفعت
معهد التربية للمعلمين ،
العديلية ، الكويت

محمود لطفي كابش
معمل علوم الارض ،
المركز القومي للبحوث ،
الدقي ، القاهرة

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معهد التربية للمعلمات ،
الشامية ، الكويت

خلاصة

يتكون الباثوليث الجرانيتي المدروس غالبا من صخور الجرانيت ذات اللون الاحمر والوردي واللحمي والرمادي الاشهب والابيض بالاضافة الى صخور الاداماليت والجرانوديوريت والكوارتزديوريت . ولقد اتضح من الفحص الميكروسكوبي ان هذه الصخور الجرانيتية تتضمن ٤٥ نوعا بتروجرافيا .

تمت دراسة النمو المتداخل الميرميكيتي للصخور الجرانيتية واتضح انه يتضمن النسيج الميرميكيتي العادي وبين الحبيبي . ولقد تكون هذا النمو المتداخل نتيجة تأثير المحاليل غير الممتزجة وعمليات الاحلال والتحول بالاحلال ، هذا بالاضافة الى عملية التبلور المتزامن التي حدثت بين معدني الكوارتز والفلدسبار . وقد تم تقسيم الصخور الجرانيتية على اساس التكوين المعدني الفعلي ووجد ان هذا التقسيم يتفق الى حد بعيد مع التقسيم الحقلي والبتروجرافي .