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REMARKS ON THE PETROCHEMISTRY OF THE GRANITIC ROCKS OF UMM NAGGAT, EASTERN DESERT, EGYPT

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Abstract. Twenty one new chemical analyses of the granitic rocks of Umm Naggat, Eastern Desert, Egypt, are presented and discussed. Chemical data are processed into several parameters which indicate that these rocks show pronounced potassic characters with some sodic tendencies. The granitic rocks are calcic to calc-alkaline with a suite index between 1 and 3, and a calc-alkali index of about 60. These rocks show chemical variation trends suggesting a highly differentiated magma. It is argued that the Umm Naggat pluton is possibly of magmatic origin. A chemical classification of the granitic rocks based on their normative feldspars is also advanced.

INTRODUCTION

Umm Naggat forms a crudely oval granitic complex covering about 95 km² in the central Eastern Desert of Egypt (Fig. 1). The pluton is a composite body consisting dominantly of pink and red granites associated with less abundant trondjhemites and quartz monzonites (Fig. 2).

Twenty one new chemical analyses of Umm Naggat granitic rocks which were collected to give as wide a range of compositional types as possible are given in Tables 1 & 2. The rock samples were prepared by cutting slabs washed in dilute HCl followed by distilled water. The whole slab was then crushed to pass through a 30-mesh sieve using a hand mortar. The sample was split to yield 20 to 30 g and ground in agate mortar to pass a 120-mesh sieve. The procedures followed in the chemical analysis are mainly drawn from the gravimetric and volumetric methods of Groves (1937), the standard methods of chemical analysis (Welcher 1963) and Kolthoff and Sandell (1964).

PETROCHEMICAL STUDIES

In order to study the petrochemical characters of the granitic rocks, the chemical data are re-calculated in terms of Rittmann's suite index, Peacock's calc-alkali index, mafic and felsic indices, CIPW norms and Niggli values. In the following, a discussion of these petrochemical values is given.

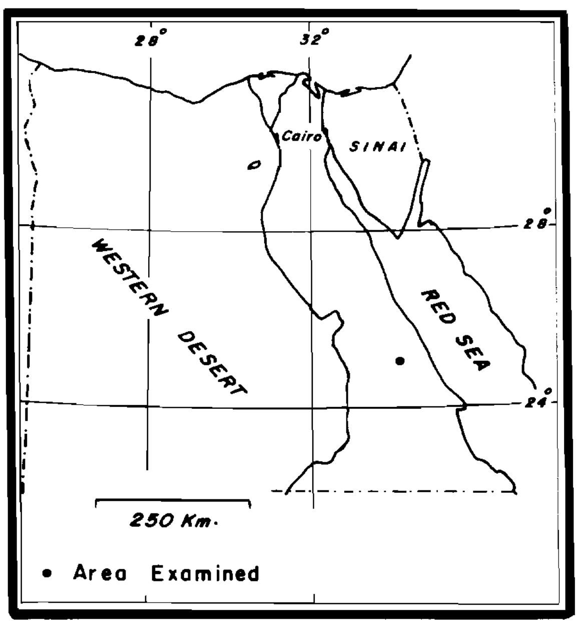

FIG. 1. Location map

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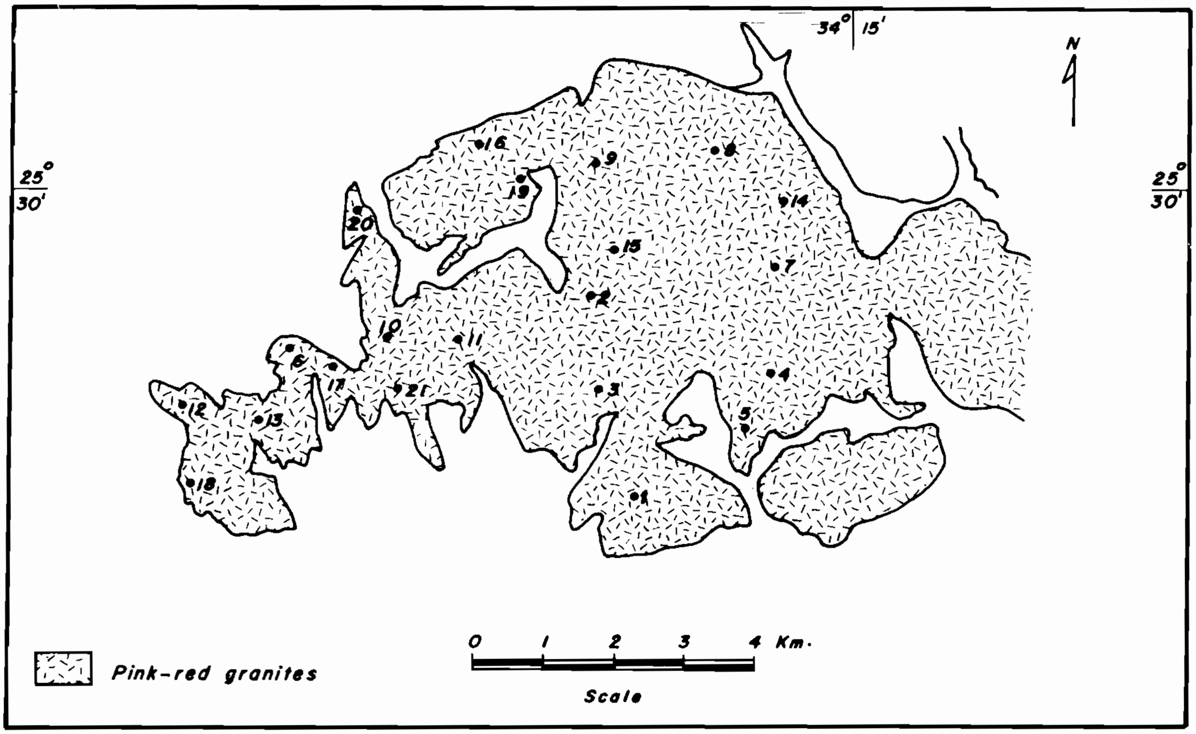

FIG. 2. Generalized geological map of Umm Naggat granitic rocks with sample location

The relation between K_2O and Na_2O of the granitic rocks is shown (Fig. 3). It is noticed that K_2O/Na_2O ratios of the granites are mostly potassic but other varieties have sodic tendencies. Generally, the K_2O/Na_2O ratios of the granitic rocks are mainly > 1, being on the average 3/2.

Rittmann (1957) introduced a constant known as the "suite index".

$$= \frac{(\text{Total alkalies})^2}{SiO_2 - 43}$$

The relationship between the sum of the alkalies ($Na_2O + K_2O$) and SiO_2 is illustrated in Fig. 4. The parabolic curves in this figure represent loci of equal suite index. It is evident that the granitic rocks of Umm Naggat have generally a suite index between 1 and 3. According to the quantitative subdivisions of Rittmann, rocks with the suite index 1 - 3 range between strong pacific and medium pacific.

The relationship between the weight percentages of SiO_2 and the weight percentages of CaO and alkalies (Na_2O and K_2O) is illustrated in Fig. 5.

The SiO_2 value for which calcium oxide = $Na_2O + K_2O$, i.e. the value at the point of intersection of the curves of alkalies and CaO represents a suitable figure which can be used to describe the character of the rocks. According to Peacock's four classes (Peacock 1931), the calc-alkali index of Umm Naggat granitic rocks is about 60, i.e. these rocks have generally a calc-alkaline character.

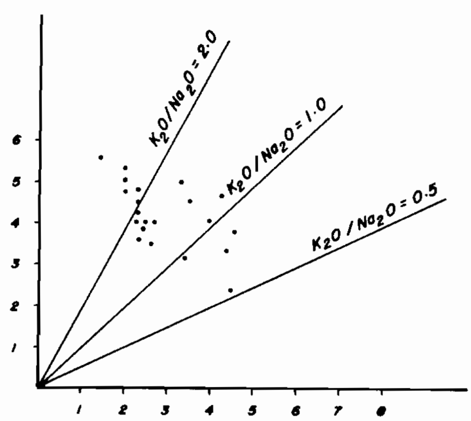

FIG. 3. Variations in alkalies of the granitic rocks

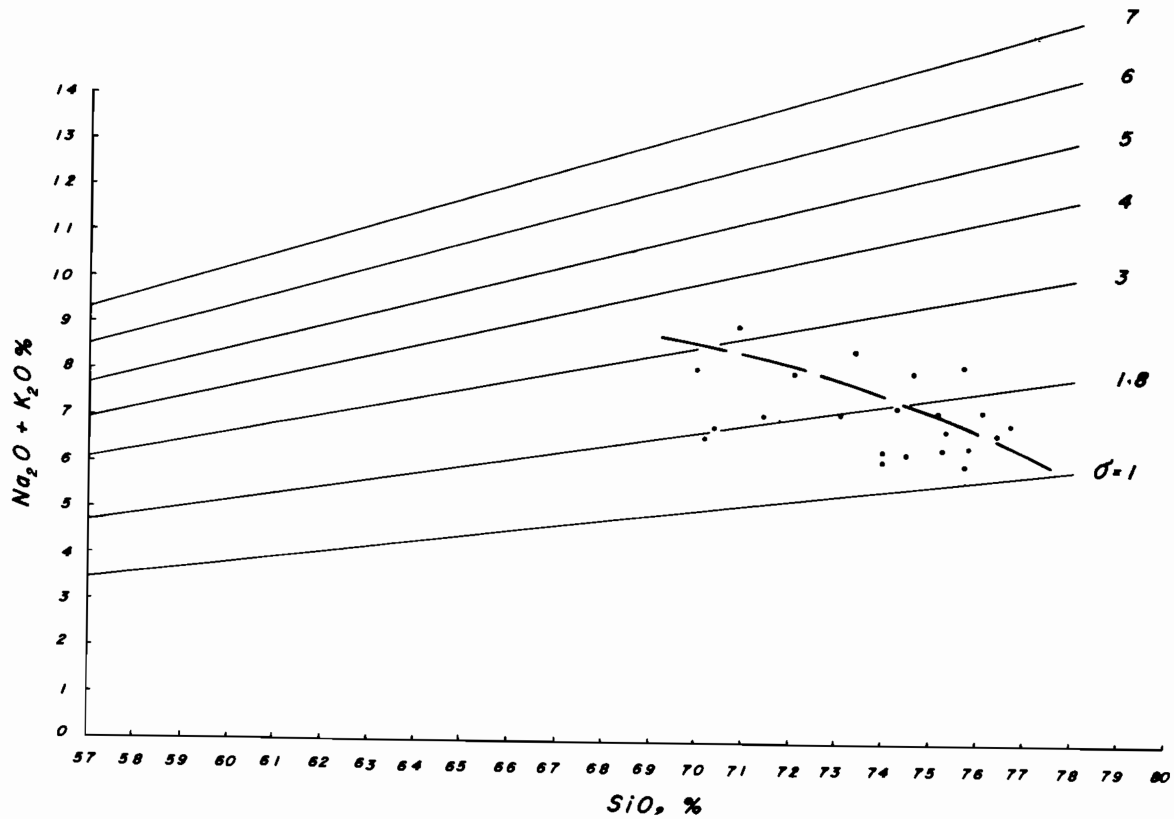

FIG. 4. SiO_2— Alk ($Na_2O + K_2O$) diagram

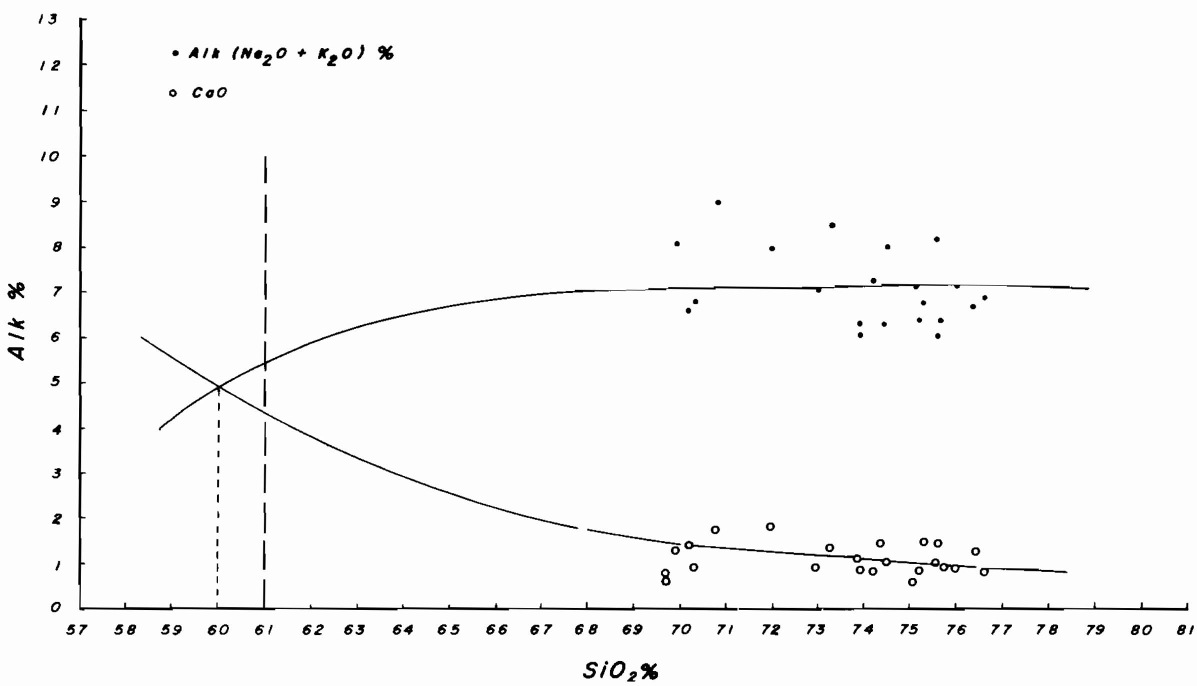

FIG. 5. SiO_2— Alk & CaO diagram

The relationship between mafic index:

$$M = \frac{(FeO + Fe_2O_3) \times 100}{(FeO + Fe_2O_3 \times MgO)}$$ and felsic index:

$$F = \frac{(Na_2O + K_2O) \times 100}{(Na_2O + K_2O + CaO)}$$

of the granitic rocks examined (Tables 1 & 2) is illustrated in Fig. 6. This relation is based on the modification of Simpson's ratio (Simpson 1954). The general trend for average igneous rocks (Nockolds 1954) is also shown on the diagram. It is roughly divided into 2 fields: a lower field for intermediate differentiates and an upper field for acid differentiates. It is evident that the granites examined fall in the upper field of acid differentiates and have mainly high felsic and low mafic indices.

The differentiation index (DI) has been advanced by Thornton and Tuttle (1960). It is the sum of the weight percentages of normative Quartz + Orthoclase + Albite + Nepheline + Leucite + Kalsilite. In the granitic rocks examined SiO_2 and K_2O increase and Al_2O_3, FeO, MgO and CaO decrease with increasing DI. Na_2O shows no obvious trend (Fig. 7). It is evident that the differentiation index of the granitic rocks ranges from 81.5 to 92.0 (Tables 3 and 4), indicating a highly differentiated magma.

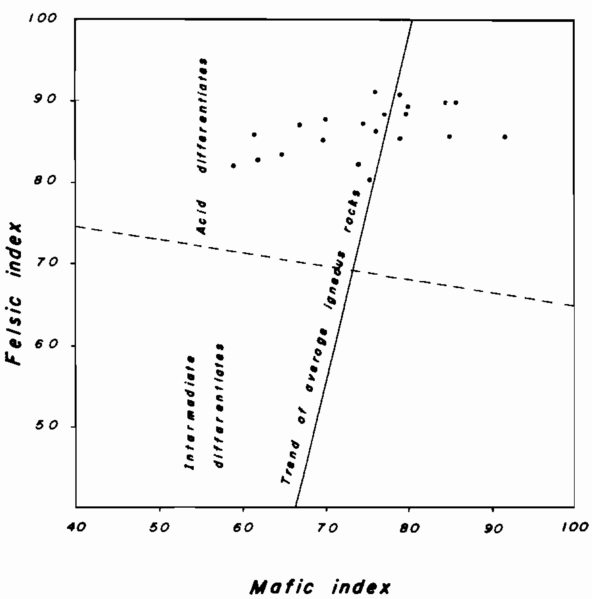

FIG. 6. Mafic index - Felsic index relation in the granitic rocks

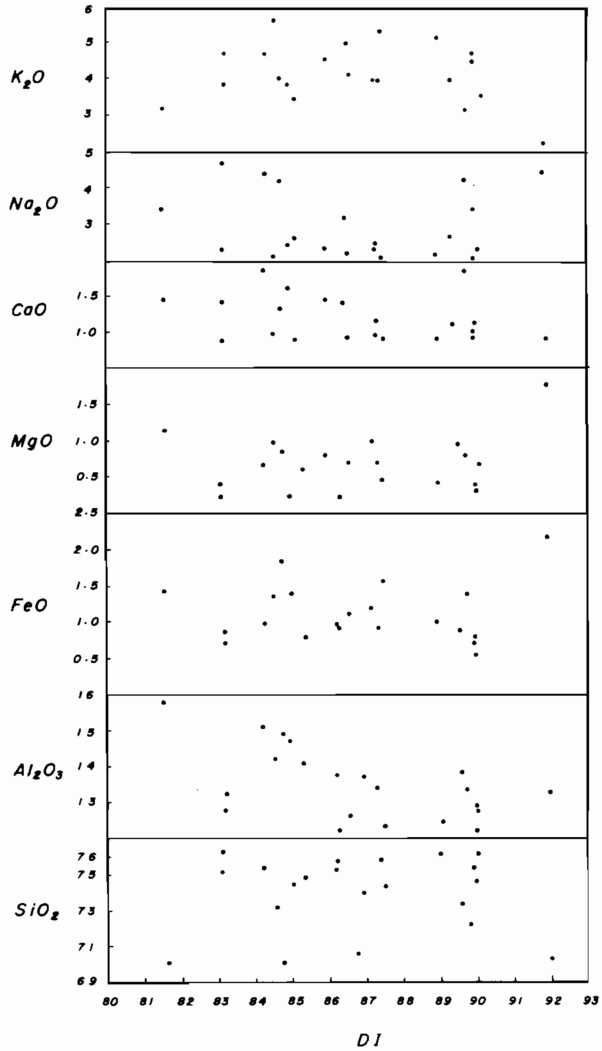

FIG. 7. Plot of percentages of major oxides vs. Thornton and Tuttle's differentiation index

CIPW norms were calculated in the usual way (Barth 1962). Tables 3 and 4 give the norm values for the granitic rocks whose chemical analyses are cited in Tables 1 and 2.

The normative albite, orthoclase and quartz, calculated to 100% for the granitic rocks, are plotted on the triangular diagram (Fig. 8). They are compared with the contoured distribution of the plutonic rock that contains 80% or more of these normative constituents as presented by Tuttle and Bowen (1958). It is significant that the normative content Albite + Orthoclase + Quartz of the granitic rocks of Umm Naggat plot in the centre of the area of concentration of granites.

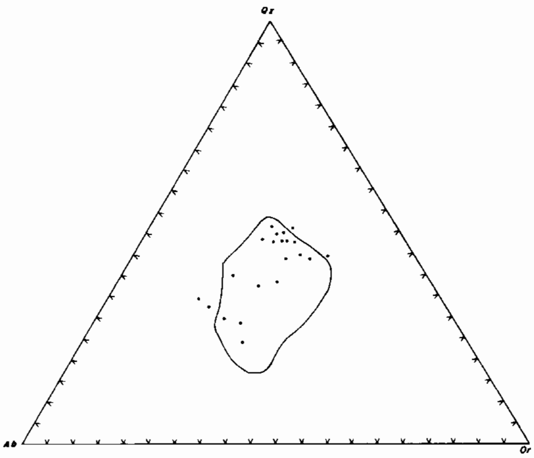

FIG. 8. Plot of the CIPW normative albite, orthoclase and quartz of the granitic rocks of Umm Naggat, compared with the contoured distribution (after Tuttle and Bowen, 1958, p 79), of analysed plutonic rocks which contain 80% or more of these normative (CIPW) constituents.

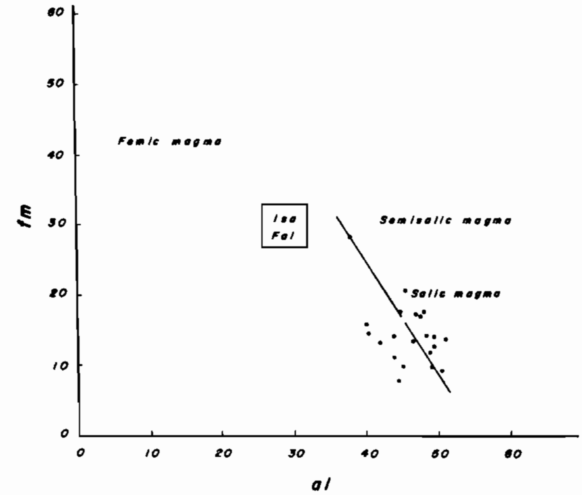

FIG. 9. al - fm diagram of Niggli

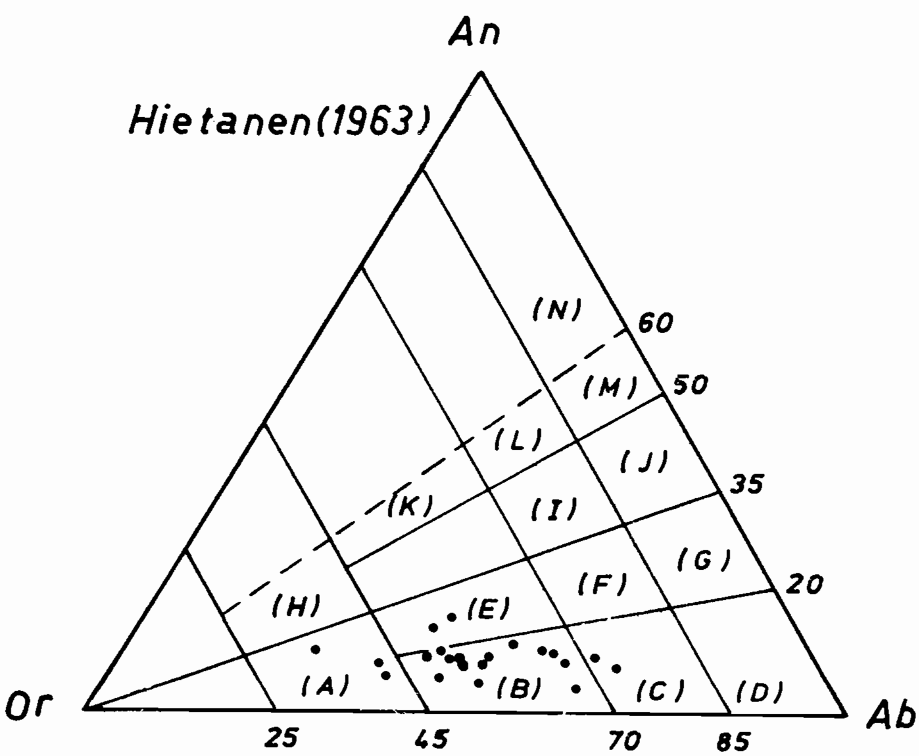

FIG. 10. Triangular diagram for An, Ab and Or normative ratio in the granitic rocks

(A) Kali granite
(D) Trondjhemite
(G) Tonalite
(J) Quartz diorite
(M) Gabbro
(B) Granite
(E) Quartz Monzonite
(H) Calci Granite
(K) Calci Monzonite
(N) Mafic Gabbro
(C) Granite trondjhemite
(F) Monzonite
(I) Granodiorite
(L) Granogabbro

According to Tuttle and Bowen (1958), "the concentration of the analyses near the centre of the diagram is readily explained if a magmatic history is involved in the origin of most granites". It is evident from the diagram that the granitic rocks of Umm Naggat are most likely considered to possess a magmatic history.

The calculated Niggli values of the granitic rocks are given in Tables 5 and 6, following the well known method of Niggli (Barth 1962) in which the chemical analysis of the rock is the basis for such calculations.

The values of al are plotted against fm values of Niggli (Fig. 9), and this shows that the character of the magma is salic according to Niggli's classification (Burri 1959).

Chemical Classification.

A chemical classification of the granitic rocks of Umm Naggat is presented in Fig. 10. It is based on their normative feldspars as suggested by Hietanen (1963). According to this ternary diagram, the majority of the granitic rocks fall within the field of granite, with few plotting in the fields of kali granite, granite-trondjhemite and quartz monzonite.

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TABLE 1. Chemical analyses of the pink granitic rocks

	1	2	3	4	5	6	7	8
SiO_2	75.63	75.34	76.46	73.90	75.78	73.35	69.73	70.12
Al_2O_3	12.50	12.07	13.13	13.98	13.32	13.86	16.50	15.87
Fe_2O_3	0.51	0.44	0.65	0.86	0.55	0.46	0.97	1.86
FeO	0.90	0.80	0.60	0.77	0.85	0.88	1.91	1.43
MnO	0.00	0.10	0.18	0.14	0.15	0.00	0.23	0.00
MgO	0.13	0.76	0.22	0.63	0.67	0.93	0.86	1.11
CaO	1.38	1.45	1.13	1.11	0.98	1.38	0.78	1.42
Na_2O	3.30	2.31	2.69	2.35	2.40	4.66	4.13	3.46
K_2O	4.91	4.51	4.02	3.98	4.08	3.84	3.17	3.11
H_2O	0.43	0.76	0.37	0.43	0.47	0.22	0.45	0.35
TiO_2	0.24	0.00	0.00	0.21	0.13	0.33	0.23	0.22
P_2O_5	0.00	0.00	0.15	0.09	0.00	0.00	0.24	0.27
Total	99.93	98.54	99.60	98.45	99.38	99.91	99.20	99.22
Mafic Index	91.50	62.00	85.00	79.10	70.00	59.00	77.00	74.70
Felsic Index	85.61	82.46	85.58	85.00	86.90	86.00	90.34	82.30

1. Coarse-grained perthite biotite granite
2. Coarse-grained microcline muscovite granite
3. " " leuco granite
4. " " hornblende granite
5. " " biotite muscovite granite
6. " " biotite granite
7. " " perthite microcline biotite adamellite
8. " " biotite hornblende adamellite

TABLE 2. Chemical analyses of the red granitic rocks

	9	10	11	12	13	14	15	16	17	18	19	20	21
SiO_2	73.08	75.63	74.56	76.03	69.74	75.15	76.69	74.24	74.40	72.08	66.60	70.80	70.20
Al_2O_3	14.20	13.82	12.81	12.39	18.74	12.97	12.81	12.39	14.76	13.44	16.31	15.10	14.93
Fe_2O_3	0.66	0.45	0.54	0.60	0.90	0.56	0.50	0.92	0.80	0.72	0.55	0.42	0.98
FeO	1.32	0.97	0.79	1.01	1.22	0.88	0.53	1.58	1.42	1.40	1.73	1.00	1.79
MnO	0.00	0.00	0.00	0.13	0.29	0.10	0.00	0.07	0.00	0.05	0.00	0.30	0.00
MgO	0.97	0.68	0.40	0.47	0.36	0.44	0.36	0.47	0.28	0.72	1.46	0.75	0.83
CaO	0.98	1.00	1.06	0.99	0.88	0.64	0.88	0.84	1.56	1.82	1.52	1.79	1.32
Na_2O	1.54	2.34	3.55	2.10	3.22	2.36	2.04	2.96	2.45	4.79	5.91	4.31	4.15
K_2O	5.62	3.65	4.51	5.11	4.13	4.87	4.87	5.34	3.90	3.21	3.42	4.77	3.97
H_2O	0.53	0.34	0.74	0.63	0.45	0.13	0.63	0.12	0.43	0.31	0.37	0.29	0.49
TiO_2	0.00	0.08	0.12	0.00	0.10	0.05	0.28	0.37	0.09	0.48	0.34	0.27	0.53
P_2O_5	0.17	0.13	0.00	0.17	0.00	0.00	0.32	0.10	0.09	0.11	0.35	0.13	0.00
Total	99.07	99.09	99.08	99.53	100.03	98.15	99.91	99.40	100.09	99.12	98.92	99.93	99.19
Mafic Index	67.00	70.00	70.00	80.50	85.50	76.50	74.00	84.00	88.80	76.80	60.90	65.90	76.90
Felsic Index	87.80	85.30	88.30	89.00	89.30	91.86	87.50	89.60	80.00	80.60	85.99	83.20	86.00

9. Coarse-grained hornblende granite
10. Coarse-grained muscovite granite
11. " " perthite microcline granite
12. Porphyritic biotite granite
13. " " perthite muscovite granite
14. Coarse-grained microcline granite
15. " " leuco granite
16. " " biotite granite
17. " " perthite granite
18. " " microcline biotite muscovite adamellite
19. " " muscovite adamellite
20. " " biotite adamellite
21. " " microcline biotite hornblende adamellite

TABLE 3. Norm values of the pink granitic rocks

	1	2	3	4	5	6	7	8
Quartz	35.13	41.84	43.02	42.00	42.91	27.52	30.30	34.91
Orthoclase	29.02	24.63	23.73	23.51	24.13	22.68	18.73	18.34
Albite	27.87	19.49	22.68	19.85	20.22	39.35	34.89	29.23
Anorthite	4.75	7.17	4.67	4.97	4.89	5.53	2.39	5.28
Corundum	0.00	0.75	2.64	3.96	3.15	0.00	5.38	4.86
Diopside	1.57	0.00	0.00	0.00	0.00	0.94	0.00	0.00
Hypersthene	0.42	3.15	1.44	1.94	2.85	2.57	4.47	3.50
Magnetite	0.71	0.62	0.92	1.22	0.78	0.65	1.39	2.69
Ilmenite	0.45	0.00	0.00	0.39	0.24	0.62	0.42	0.41
Apatite	0.00	0.00	1.10	0.63	0.00	0.00	1.78	2.11
Orthoclase %	47.00	48.00	47.00	49.00	49.00	34.00	34.00	35.00
Albite %	45.00	38.00	44.00	41.00	41.00	58.00	62.00	55.00
Anorthite %	8.00	14.00	9.00	10.00	10.00	8.00	4.00	10.00
Differentiation Index	92.02	85.96	89.43	85.30	87.20	89.50	83.92	81.50

1. Coarse-grained perthite biotite granite
2. Coarse-grained microcline muscovite granite
3. " " leuco granite
4. " " hornblende granite
5. " " biotite muscovite granite
6. " " biotite granite
7. " " perthite microcline biotite adamellite
8. " " biotite hornblende adamellite

TABLE 4. Norm values of the red granitic rocks

	9	10	11	12	13	14	15	16	17	18	19	20	21
Quartz	38.42	44.90	33.48	41.12	31.68	40.28	43.99	31.85	41.38	30.45	14.19	22.26	24.25
Orthoclase	33.19	21.57	26.63	30.19	24.40	28.80	28.80	32.50	23.01	18.95	20.18	28.18	23.50
Albite	12.99	19.75	29.97	17.71	27.19	18.19	17.23	27.00	20.69	40.45	49.78	36.41	38.00
Anorthite	4.86	4.14	5.25	4.42	4.36	3.16	3.75	3.50	7.72	5.67	5.33	8.00	7.00
Corundum	3.79	4.48	0.15	1.77	7.46	2.74	2.68	0.50	3.67	—	0.95	—	1.40
Diopside	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.31	0.00
Hypersthene	4.29	2.96	1.69	22.58	3.01	2.28	1.08	2.80	2.44	2.97	5.81	3.41	4.10
Magnetite	0.95	0.64	0.76	0.85	0.89	0.75	0.74	1.05	1.16	1.04	0.78	0.60	1.05
Ilmenite	0.00	0.15	0.12	0.18	0.09	0.09	0.53	0.60	0.16	0.88	0.63	0.50	0.80
Apatite	1.20	0.97	0.00	1.34	0.00	0.00	0.73	0.30	0.00	0.77	2.65	0.97	0.00
Orthoclase %	65.00	48.00	43.00	53.00	44.00	58.00	58.00	51.00	45.00	29.00	27.00	39.00	34.00
Albite %	25.00	43.00	48.00	34.00	48.00	36.00	34.00	43.00	40.00	62.00	66.00	50.00	56.00
Anorthite %	10.00	9.00	9.00	8.00	8.00	6.00	8.00	6.00	15.00	9.00	7.00	11.00	10.00
Differentiation Index	84.60	86.20	90.00	89.00	83.27	87.27	90.00	87.40	85.00	89.80	84.15	86.80	85.75

9. Coarse-grained hornblende granite
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19. " " muscovite adamellite
20. " " biotite adamellite
21. " " microcline biotite hornblende adamellite

TABLE 5. Niggli values of the pink granitic rocks

	al	fm	c	alk	si	k	mg	qz
1	44.64	7.98	8.96	38.41	459.36	0.49	0.14	+205.72
2	44.45	13.86	9.69	31.98	471.85	0.56	0.51	+243.93
3	49.67	9.37	7.75	33.15	491.81	0.49	0.22	+259.21
4	49.67	14.06	6.17	29.07	446.55	0.52	0.40	+230.27
5	48.78	13.94	6.57	30.61	472.14	0.52	0.44	+249.70
6	42.79	12.92	7.74	36.52	385.28	0.35	0.56	+139.20
7	47.68	18.63	4.09	29.57	342.70	0.33	0.34	+124.42
8	45.69	20.77	7.43	26.09	344.70	0.37	0.37	+140.34

1. Coarse-grained perthite biotite granite
2. Coarse-grained microcline muscovite granite
3. " " leuco granite
4. " " .ornblende granite
5. " " biotite muscovite granite
6. " " biotite granite
7. " " perthite microcline biotite adamellite
8. " " biotite hornblende adamellite

TABLE 6. Niggli values of the red granitic rocks

	al	fm	c	alk	si	k	mg	qz
9	47.68	17.36	5.99	28.94	417.26	0.70	0.47	+161.50
10	50.96	13.54	6.69	28.79	474.40	0.50	0.47	+259.24
11	45.30	9.92	6.82	37.94	448.59	0.45	0.36	+195.83
12	46.63	13.40	6.10	33.84	461.50	0.61	0.33	+226.14
13	53.05	14.62	4.51	27.80	333.89	0.45	0.17	+122.69
14	48.95	12.05	4.42	34.59	440.10	0.57	0.35	+201.74
15	50.42	9.23	6.30	34.43	513.49	0.61	0.39	+275.77
16	44.83	16.98	5.53	32.64	456.90	0.64	0.25	+226.34
17	49.87	12.65	9.58	27.88	427.43	0.51	0.19	+215.91
18	40.73	14.68	10.08	34.42	371.57	0.30	0.37	+133.89
19	41.46	17.45	7.02	34.05	287.85	0.27	0.54	+ 51.65
20	43.81	11.15	9.44	35.58	349.31	0.42	0.49	+106.99
21	39.90	15.74	14.59	29.75	317.77	0.38	0.85	+ 98.77

9. Coarse-grained hornblende granite
10. Coarse-grained muscovite granite
11. " " perthite microcline granite
12. Porphyritic biotite granite
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ملاحظات على بتروكيميائية الصخور الجرانيتية
في أم نقاط ، الصحراء الشرقية ، مصر

عادل محمد رفعت

معهد التربية للمعلمين بالكويت

محمود لطفي كابش*

المركز القومي للبحوث بالقاهرة

خلاصـــــة

يعرض هذا البحث مناقشة خلاصة نتائج واحد وعشرين تحليلا كيميائيا جديدا للصخور الجرانيتية لام نقاط ، مستخدما في ذلك حساب التركيـــب النموذجـــي للصخور ، وحساب قيمة نيجلى بالاضافة الى بعض المعاملات الاخرى ، وقد أوضحت هذه الدراسة أن الصخور الجرانيتية لام نقاط لها صفات بوتاسية مميزة ، مع بعض الميول الصودية ، وقد اتضح أيضا أن هذه الصخور تعتبر كلسية الى كلسية قلوية .

ان المتغيرات الكيميائية للصخور الجرانيتية لام نقاط توضح ان هذه الصخور ذات أصل صهيري ، وانها تكونت بفعل عمليات التفارق الصهيري . وقد أمكن تقسيم هذه الصخور الجرانيتية باستخدام معادن الفلدسبار الناتجة من حســـــاب التكوين النموذجي ، ونتيجة لهذا التقسيم اتضح ان صخور المنطقة المدروسة تشمل اســاسا الجرانيت والكوارتز مونزونيــت .

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