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GRANITIC ROCKS NORTH OF W. GEMAL, EASTERN DESERT, EGYPT

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Abstract. The granitic rocks north of Wadi Gemal in the south Eastern Desert of Egypt consist of gneissose adamellites intruded by pink granites and granodiorite porphyries and belong as a whole to the Younger Granitoids of the basement complex. The petrographical and petrochemical characteristics of the granitic rocks are described. The granitic groups are shown to have distinct differences in both texture and chemistry. The pink granites are assumed to have been derived from a residual melt formed by fractional crystallization of the parent adamellite magma, while the granodiorite porphyries were most probably generated independently from a separate magma.

INTRODUCTION

The granitic rocks north of Wadi Gemal form an elongate outcrop along the eastern border of the basement complex of the Eastern Desert of Egypt. In both the 1967 edition of the geological map of the Eastern Desert between latitudes 22° and 25° N, 1 : 500,000 (Hunting Geology and Geophysics 1967) and the 1972 edition of the new geological map for the basement rocks in the Eastern and South-western deserts of Egypt, 1: 1000,000 (EL-Ramly 1972), the present granitic rocks were considered as pertaining to the younger granites. The term younger granite was first introduced by EL-Ramly and Akaad (1960) to include granites and some granodiorites and adamellites being younger than the main tectonism that affected the basement rocks of Egypt.

As far as the writer is aware, the present paper represents the first study of the petrographical and petrochemical characteristics of the granitic rocks north of Wadi Gemal. The area examined for this purpose (Fig. 1) shows that the granites under consideration have intrusive relations with all the surrounding basement rocks which consist of metasediments, metavolcanics, serpentinites, metagabbro-diorite complex and syntectonic to late tectonic granite. The contacts between the granite and the enveloping

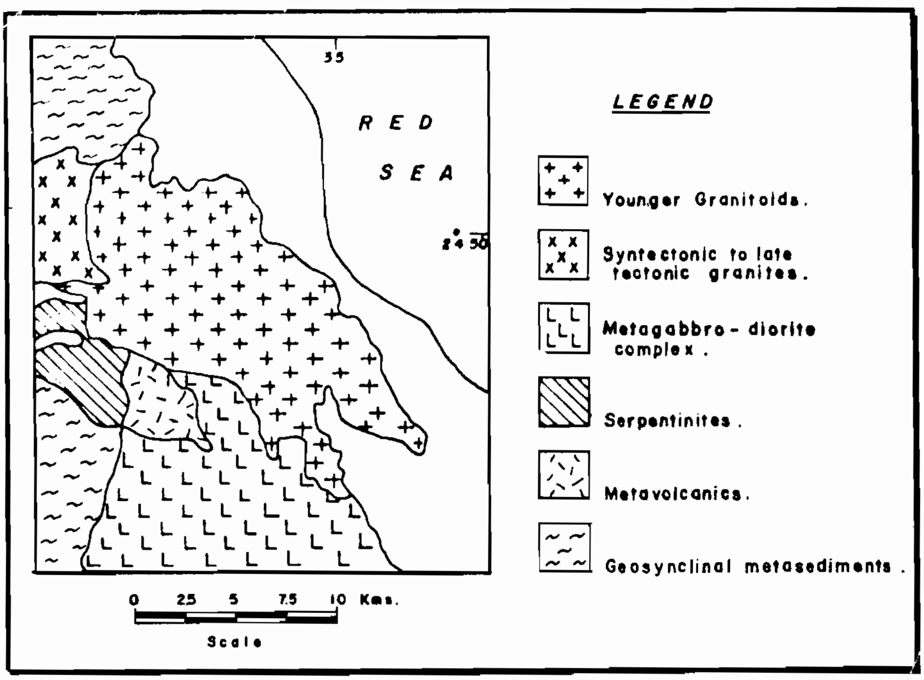

FIG. 1. Geological map of the area north of Wadi Gemal, Egypt

basement rocks are almost always sharp. Apart from a few dykes and veins that cut across the granite, the latter represents the last event in the history of the basement complex of the area mapped.

The three main granitic types recognized in the field were pink granite, gneissose adamellite and granodiorite porphyry. The field relationships indicate that both the pink granite and granodiorite porphyry intrude the gneissose adamellite. No relation has, however, been observed between the pink granite and the granodiorite porphyry.

Description of the Rock Types

The Pink Granites

The pink granites represent the dominant variety. They cover large outcrops forming high mountains with rugged peaks. The rocks are pinkish in colour and coarse to medium in grain size, although in places fine grained granular types occur. Under the microscope the rocks show hypidiomorphic textures and consist largely of quartz, microcline and plagioclase with rare mica. Zircon, epidote, iron oxide and apatite are minor accessories. Quartz forms variably strained interstitial grains, 0.4 - 3.8 mm in diameter. Microcline is commonly microperthitic and occurs as subhedral crystals up to 3.1 mm across. Plagioclase has the composition of oligoclase (An_{12}) and forms laths and stumpy crystals ($0.9 \times 3.4 - 0.2 \times 1$ mm). Albite twinning is well developed in most grains. Carlsbad twinning as well as polysenthetic twinning on another law, probably pericline, occur in some sections. Mica, including both biotite and muscovite, occurs as slightly bent flakes 1.2 mm long.

The granitic mass is crossed at its central part by a major shear zone trending almost NW – SE, along which the pink granites are highly sheared and altered. Granite samples collected from the vicinity of this shear zone show a marked cataclastic fabric. In these rocks, quartz shows sutured granulated boundaries as well as strong undulose extinction. Plagioclase and mica are severely bent, and epidote and sphene are abundant accessories.

The Gneissose Adamellites

The gneissose adamellites are relatively subordinate and are best exposed in the southern sector of the granitic mass where they are intruded by the pink granites and granodiorite porphyries. The rocks are coarse to medium grained and consist mainly of quartz, microcline, plagioclase and biotite with accessory zircon, apatite, iron oxide and epidote. Texturally the rocks show a gneissose deformed fabric most obviously represented by the subparallel arrangements and bending of biotite, mosaics of deformed quartz as well as bent twin lamellae in microcline and plagioclase. Intergrowth of quartz and feldspar in micrographic texture is clearly observed in most rocks. Quartz (up to 2.7 mm) is anhedral and often interstitial. It is usually strained and sometimes exhibits granulated intergrain boundaries. Microcline microperthite (2.5 mm) forms a few subhedral crystals but is mostly anhedral and interstitial. Plagioclase occurs in well formed, often rather stumpy laths (1 x 3.1 mm). The crystals are always oligoclase in composition (An_{16}). Biotite is strongly pleochroic from straw yellow to dark brown, and occurs in bundles with a strong preferred orientation.

The Granodiorite Porphyries

The granodiorite porphyries represent the least common rock type. These rocks outcrop as scattered masses invading the cataclastic adamellites in some parts of the southern part of the mass area. The grain size varies from fine to medium grained and the texture is always inequigranular. The rocks contain phenocrysts of feldspar, quartz and biotite (average grain size 2.5 mm) embedded in a groundmass having the same minerals as the phenocrysts but with an average grain size of 0.17 mm. The accessory minerals include zircon, apatite, iron oxide, epidote and sphene. Oligoclase phenocrysts (An_{20}) commonly form stumpy crystals. There is always some zoning and in some specimens it may be quite common. Potash feldspar phenocrysts are represented mostly by microcline. Quartz phenocrysts are slightly embayed with the groundmass and are commonly strained. Corroded biotite phenocrysts are distinctly pleochroic from straw yellow to dark brown.

The average modal composition of four pink granites, three gneissose adamellites and three granodiorite porphyries are given in Table 1.

TABLE 1. Average modal analysis (volume per cent) of the granitic rocks north of Wadi Gemal

Volume %	Pink granite	Gneissose adamellite	Granodiorite porphyry
Quartz	28.9	25.5	24.8
Potash feldspar	34.7	29.4	25.6
Plagioclase	30.3	32.8	39.6
Mica	3.9	9.2	7.2
Accessories	2.0	3.1	2.8

Petrochemistry

Chemical analyses for four pink granites, three gneissose adamellites and three granodiorite porphyries were carried out. The results, expressed as weight per cent oxides, as well as calculated alkalinity ratios are listed in Table 2. Niggli values and CIPW norms for the analysed samples are also given.

Alkalinity Ratios

Wright (1969) has proposed

$$\frac{Al_2O_3 + CaO + \text{total alkalies}}{Al_2O_3 + CaO - \text{total alkalies}}$$

(all in weight percent) as a parameter for the alkalinity ratio. If SiO_2 exceeds 50% and K_2O: Na_2O is $> 1 < 2.5$, 2 Na_2O is used in place of total alkalies). The ratio has been tested on some well documented igneous suites in the form of variation diagram by plotting it against SiO_2 on a log linear scale.

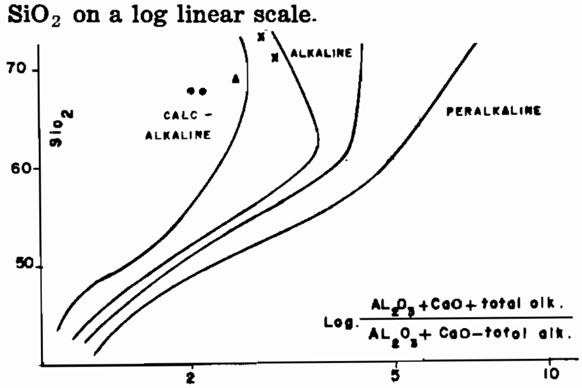

FIG. 2. Plots of calculated alkalinity ratios of the granitic rocks on the alkalinity ratio variation diagram of Wright (1969). Symbols : (X) pink granite, (▲) gneissose adamellite, (●) granodiorite porphyry.

The alkalinity ratios of the analysed granitic rocks were accordingly calculated and plotted as abcissa against SiO_2 as ordinate on the alkalinity ratio variation diagram (Fig. 2). The diagram indicates that the pink granites show transitional affinities between alkaline and calc-alkaline (alkalinity ratio average 2.9), whereas the gneissose adamellites and granodiorite porphyries are characteristically calc-alkaline (alkalinity ratios average 2.5 and 2 respectively). The granodiorite porphyries are the least alkaline of the three groups recognised.

Niggli Values

The plot of the Niggli values of the analysed

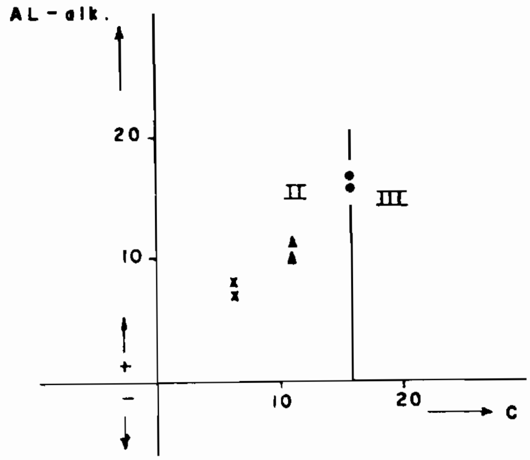

FIG. 3. Plots of granitic rocks on Niggli's plannar representation. Symbols : (X) pink granite, (▲) gneissose adamellite, (●) granodiorite porphyry.

rock varieties is shown in Fig. 3. The diagram represents a section through the double tetrahedron al-fm-c-alk, as has been outlined by Niggli (1954). From this figure, it is evident that the pink granites and the gneissose adamellites pertain to the alkali aluminosilicate magma type (type II in Niggli's classification), whereas the granodiorite porphyries are transitional between alkali aluminosilicate and alkali-calc aluminosilicate rocks (type III).

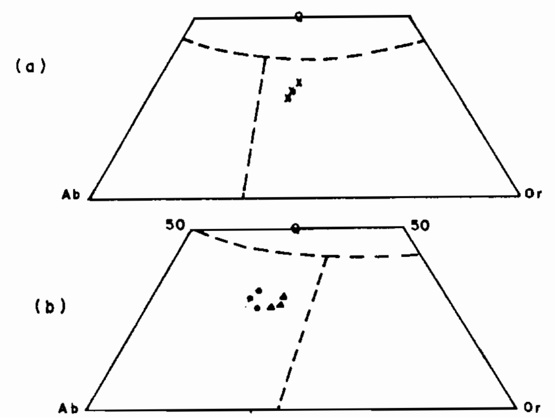

FIG. 4. Plots of normative Ab - Or - Qz of the granitic rocks in relation to cotectic lines and eutectic points valid for Obsidian - anorthite - H_2O having (a) an Ab / An ratio of 7.8 for pink granite and (b) an Ab / An ratio of 3.8 for gneissose adamellite and granodiorite porphyry. Symbols : (X) pink granite, (▲) gneissose adamellite, (●) granodiorite porphyry.

TABLE 2. Chemical analysis (weight per cent), Niggli Values and Norms of the granitic rocks north of Wadi Gemal

Chemical analysis

%	Pink granite				Gneissose adamellite			Granodiorite porphyry		
	1	2	3	4	5	6	7	8	9	10
SiO_2	72.71	71.60	73.30	72.90	69.30	69.27	69.35	67.80	68.01	67.91
Al_2O_3	13.88	13.96	13.66	13.82	14.53	14.45	14.51	15.34	15.35	15.36
Fe_2O_3	0.85	1.04	0.79	0.85	1.46	1.49	1.42	1.24	1.25	1.25
FeO	1.29	1.72	1.25	1.27	2.69	2.71	2.70	2.38	2.40	2.42
MnO	0.05	0.06	0.05	0.05	0.06	0.06	0.06	0.08	0.09	0.09
MgO	0.36	0.45	0.26	0.34	0.75	0.72	0.80	1.42	1.41	1.41
CaO	0.97	1.11	0.74	0.92	2.21	2.25	2.19	3.51	3.54	3.56
Na_2O	3.62	3.75	3.47	3.59	3.56	3.60	3.59	3.76	3.73	3.75
K_2O	5.09	5.12	5.36	5.13	4.21	4.18	4.22	2.86	2.79	2.81
H_2O	0.52	0.56	0.48	0.51	0.62	0.64	0.62	0.67	0.65	0.65
TiO_2	0.36	0.39	0.24	0.34	0.35	0.37	0.34	0.51	0.52	0.53
P_2O_5	0.15	0.17	0.13	0.15	0.16	0.16	0.15	0.20	0.22	0.21
Total	99.85	99.93	99.73	99.87	99.90	99.90	99.95	99.77	99.96	99.95
Calculated alkalinity ratio	2.85	3	2.85	2.9	2.5	2.5	2.5	2.1	2	2

Niggli Values.

	1	2	3	4	5	6	7	8	9	10
Si	400	372	415	450	322	322	322	290	292	291
al	45	43	46	45	40	39	39	39	39	40
fm	12	6	12	12	21	21	21	22	22	21
c	6	6	4	6	11	11	11	16	16	16
alk	37	36	38	37	28	29	29	23	23	23
k	0.48	0.47	0.50	0.48	0.44	0.43	0.44	0.33	0.33	0.33
mg	0.24	0.22	0.19	0.23	0.25	0.24	0.26	0.41	0.41	0.41
qz	+152	+128	+163	+202	+110	+106	+106	+ 98	+100	+ 99

CIPW Norms

	1	2	3	4	5	6	7	8	9	10
Qz	28.1	25.5	28.1	28.1	24.5	24.1	23.8	20.4	24.2	23.7
Or	30	30.5	32	31	25	25	25.5	17	16.5	17
Ab	33	34	33	32.5	32.5	33	33	34	34	34
An	4.15	4.65	2.85	3.56	10.15	10.65	10.15	16.3	16.35	16.30
en	1.0	1.2	0.68	1.0	2.2	2.0	2.20	4	4	4
fs	1.0	1.5	0.96	1.0	2.80	2.60	2.80	2.4	2.4	2.1
Mt	0.9	1.0	0.84	0.9	1.50	1.50	1.50	1.2	1.2	1.35
Cor	1.14	0.86	0.96	1.14	0.64	1.34	0.34	0.28	0.36	0.28
IL	0.4	0.60	0.40	0.40	0.40	0.60	0.40	0.60	0.60	0.80
Ap	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.54	0.54	0.54

CIPW Norm Values

The major normative difference between the three granitic groups is the normative An, which averages 3.8 in the pink granite, compared with 10.3 and 16.3 in the gneissose adamellite and granodiorite porphyry respectively. Any consideration of experimentally studied systems must therefore take into account the distinct difference in anorthite content. In this regard the normative Ab, Or, Qz proportions of the samples are plotted and the results compared with the experimental data of Von Platten (1965) for the system Obsidian - Anorthite - H_2O having (a) an Ab / An ratio of 7.8 for pink granites with an average Ab/An ratio of 8.6 and (b) an Ab/An ratio of 3.8 for gneissose adamellites and granodiorite porphyries which have average Ab / An ratios of 3.2 and 2 respectively (Fig. 4). In each diagram there are three regions of crystallization (first for quartz, second for plagioclase and third for alkali feldspar) separated by three cotectic lines which meet in the eutectic point. The pink granites are shown to lie in the alkali feldspar region. The gneissose adamellites and the granodiorite porphyries lie, on the other hand, in the plagioclase region. The diagrams reveal, however, that the granitic rocks could not have been produced by the fusion of a single pre-existing rock type or by fractional crystallization of a single magma.

CONCLUSION

The crosscutting relationships indicate that the gneissose adamellite is older than the pink granite and the granodiorite porphyry. The intrusive sequence of the younger granites began therefore with an emplacement of adamellite and continued with granite and granodiorite.

Considering the diversity of texture represented by the granitic groups, the deformed gneissose fabric exhibited by the adamellites is ascribed to either intrusion under dynamic stresses or to post-crystallization deformation prior to the intrusion of the granites and granodiorites. The marked porphyritic texture of the granodiorites with a sharp break in grain size between the phenocrysts (2.5 mm) and the groundmass (0.17 mm) points, however, to a high level intrusion of the granodiorite magma.

From the petrochemical point of view, the three granitic groups show relative abundances in SiO_2, Al_2O_3, MgO, CaO and K_2O. The pink granites and the gneissose adamellites pertain to the alkali aluminosilicate magma type of Niggli (type II) whereas the granodiorite porphyries are transitional between alkali aluminosilicate and alkali-calc aluminosilicate rocks (type III). On the basis of experimentally studied systems the granitic liquids which resulted in this variable groups of rocks clearly could not have been produced by the fusion of a single pre-existing rock type or by fractional crystallization of a single magma. The increasing alkalinity ratio from the oldest gneissose adamellite (average 2.5) to the youngest pink granite (average 2.9) is suggestive, however, of a fractionated series. In this regard the parent adamellite magma, present at depth, could have suffered some type of fractional crystallization resulting in the relative enrichment of the silica and alkalies approaching granite in composition. The granodiorite porphyries, on the other hand, which show an average alkalinity ratio of about 2, presumably represent a separate parent magma that was generated independently.

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صخور الجرانيت بشمال وادي الجمال بالصحراء الشرقية المصرية

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قسم الجيولوجيا بجامعة الكويت

خلاصـــــة

يمثل هذا البحث دراسة بترولوجية وجيوكيميائية على صخور الجرانيت الواقعة شمال وادي الجمال بالجزء الجنوبي من الصحراء الشرقية المصرية .

وتتكون هذه الصخور الجرانيتية من ثلاثة أنواع هي الجـــرانيت الاحمـــر ، والاداميللايت النيسوزي ، والجرانودايورايت البورفيري ، وتنتمي جميعهـــا الى مجموعة الجرانيت الحديث المعروفة بصخور القاعدة المصريـة . وتختلف الانـواع الجرانيتية الثلاثة عن بعضها في القوام والتركيب الكيميائي . وقد ثبت من العلاقات الحقلية أن صخور الاداميللايت قد تداخلت أولا ثم أعقبتها صخـــور الجـــرانيت والجرانودايورايت . وتشير الدراسة الجيوكيميائية الى احتمال تكون الجـــرانيت الاحمر من الصهير الاداميلليتي نتيجة لتأثره بتبلور تجـــزيئي ، أمـــا صخـــور الجرانودايورايت البورفيري فمن المعتقد انها قد نتجت من صهير آخر مستقل .