THE RELATION BETWEEN THE GEOCHEMISTRY AND DEEP-SEATED FAULTS OF ACID PLUTONITES OF EGYPT

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ABSTRACT

On the basis of the present study, Egyptian granites occurring in the basement rocks are found to comprise mainly six groups, these are: Shaitian, grey, normal pink-red, strongly differentiated pink-red, anomalous pink and Aswan granites. Each of these groups has its own geochemical and structural characteristics that make it distinguishable from the others. Shaitian granites are definitely the oldest, while Aswan granites are probably the youngest.

To the first time, it is now possible to distinguish, particularly in the field, between the normal pink-red granites (pre- or syn-Hammamat) and the strongly differentiated members (post-Hammamat) previously regarded as one group of rocks. The former are found to be usually emplaced on latitudinal system of deep-seated faults (EN-WS), while the latter have generally longitudinal trends of faults (NW-SE). Chemically, these two groups of granites are related to each other by differentiation in a sense that the pre- or syn-Hammamat members represent normal granites while the post-Hammamat rocks represent their strongly fractionated members.

INTRODUCTION

The study of the geochemistry of Egyptian granites [EL SOKKARY ,1970] outcropping in the basement rocks of the eastern desert and Sinai peninsula revealed that these granites are composed of several types with distinctive chemical characters. Moreover, the so-called younger pink and red granites formerly considered as one group of rocks, were shown to comprise on chemical basis two types: a normal type beside a strongly differentiated granite type.

SCHURMANN [1966] divided the mentioned younger pink and red granites into two cycles: an older pre-Hammamat and a younger post-Hammamat cycle. Later on, EL SHAZLY, EL SOKKARY and KHALIL [1971] showed that the pink-red granites started to be developed during a later phase of sedimentation of the Hammamat group and continued after them. Thus both SCHURMANN and EL SHAZLY *et al.* agree that the pink-red granites fall into two categories: on either older or contemporaneous with Hammamat group and the other is younger than that. However, these two groups of pink-red granites could not be distinguished from each other in the field.

EL SAHZLY, EL SOKKARY and KHALIL [1972] reached to a conclusion that Wadi Shait plagioclase granite is the oldest among the earlier granites. This gives the impression that the latter granites fall into two groups: the older is the shaitian granite group, while the relatively younger are the so-called grey granites. These two types of granites were used not to be distinguished from each other and were put in one group known as grey granites [AKKAD and EL RAMLY, 1960]. However,

field relations are still wanted in order to distinguish decisively these two types of granites.

The above exposition reveals clearly that there are several types of granites that can be correlated with different stages of development of the Precambrian — Early Palaeozoic geosyncline comprising the basement rocks of Egypt. The tectonic evolution of this geosyncline was investigated recently by EL RAMLY and SALLOUM [1973]. It was thought that studying the relation between the geochemistry of acid plutonites and their geotectonic evolution might help in distinguishing clearly the different acid plutonic cycles from each other particularly in the field. This in turn will help in understanding the development of the basement rocks of Egypt in a better way.

This research possibly represents the first treatment including the relation between the geochemistry of acid plutonites and deep seated faults in the basement rocks of Sinai peninsula, eastern and south western deserts of Egypt.

TECHNIQUES

Most of the analytical data on granitic rocks are taken from EL SOKKARY [1970]. Additional data are taken from HASHAD *et al.* [1971] and unpublished work by EL SOKKARY *et al.* [1973]. Analytical data on the granite pebbles from Hammamat group and from metamorphosed geosynclinal sediments are taken from EL SHAZLY, EL EL SOKKARY and KHALIL [1971, 1972]. On the other hand, geochronological estimates are those of HASHAD *et al.* [1971] and EL RAMLY [1962].

Azimuth of deep seated faults in proximity with corresponding granitic masses are measured mainly from the geologic map of Egypt with scale 1:1000,000 recently compiled by EL RAMLY [1972].

The same map is used in measuring the total areas of basement rocks, older granites (shaitian and grey types) beside younger pink-red granites outcropping in the eastern desert only. This is done by means of a planimeter. Thus, a quantitative estimate can be obtained concering the size of all granites relative to that of basement rocks, beside a separate estimate about the sizes of the two main cycles of granites: the older and the younger granitic cycles.

PRESENTATION OF DATA

Calculations done by the planimeter revealed that the total area of outcropping basement rocks in the eastern desert is 85,600 km^2, while the respective areas of both old and younger granitoids are: 25,620 and 19,180 km^2. Thus about 29.9% of the mentioned basement rocks are represented by old granites, while 22.4% are represented by younger granites. The total area of granites represents 52,3% of the measured basement rocks. The problem of basement rocks of Egypt is therefore largely the problem of granites they contain.

Table 1 shows some important granite masses arranged in groups on geochemical-structural basis. For the individual masses, The table gives the azimuth of nearby deep seated faults, some pertinent trace elements data beside some available geochronological data. The same table includes, for comparative purposes, the analytical data on the pink granite pebbles from Hammamat conglomerates beside those data on the granite pebbles from the geosynclinal sediments. Among major and

trace elements data, EL SOKKARY [1970] showed that Ba, Sr and Rb (particularly Sr) are the most sensitive elements responding for changes in the physicochemical enviroments of granites.

Fig. 1 is a map showing the various granite masses occurring in the basement rocks of Egypt as related to corresponding deep seated faults, besides it outlines the

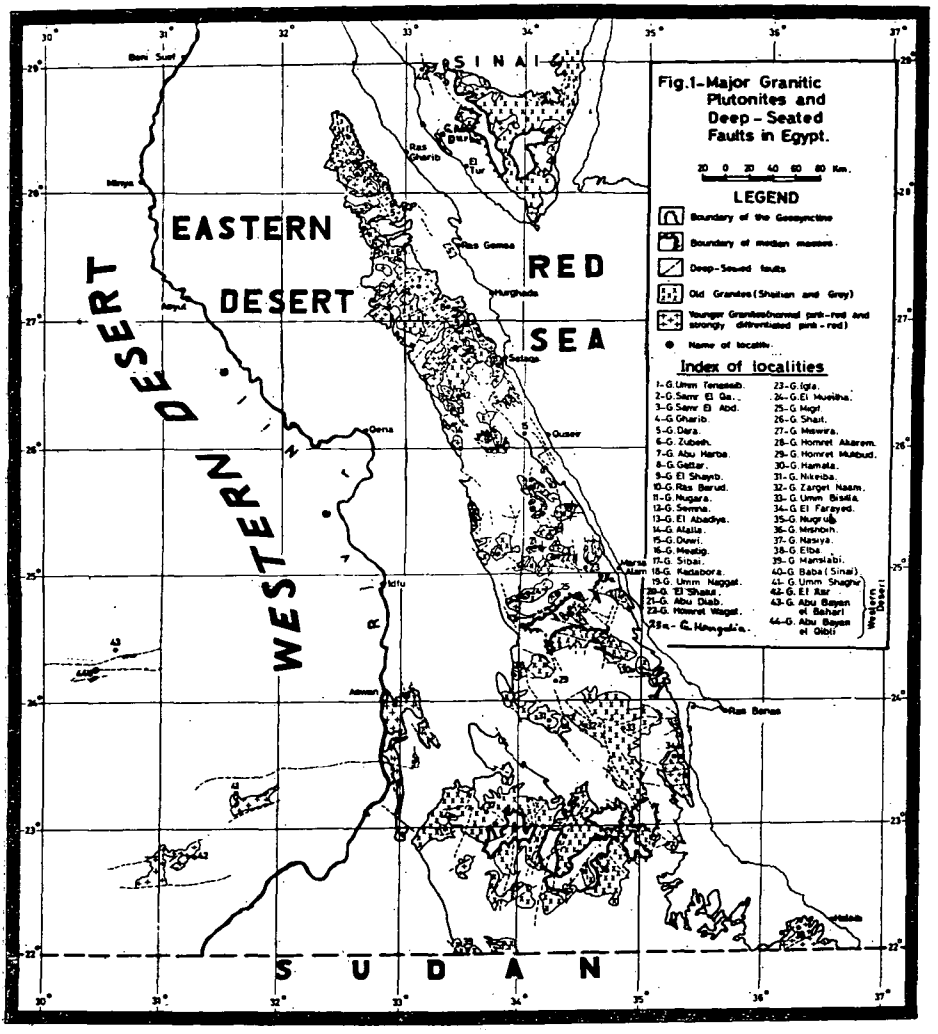

Fig. 1

terrains of median masses with which are associated the oldest granites (Shaitian) [1]. *Fig. 2* is a diagrammatic representation between the azimuth of deep seated faults of acid plutonites and their geochemistry as represented by the Sr content in ppm.

(1) It is to be noted that minor granite masses de not appear on the map.

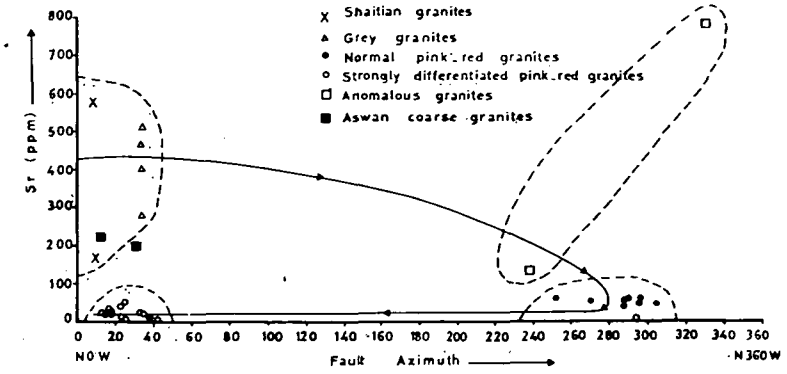

Fig.2. Relation between the azimuth of deep seated faults and Sr content (ppm) of some acid plutonites in Egypt.

TABLE 1

The azimuth of faults, trace elements data and age of some important granite masses grouped on geochemical-structural basis

Granite Type	*Locality*	*Fault Azimuth*		*Trace Elements* ppm			*Age* (m. y.)
		Measured	Converted	Ba	Sr	Rb	
Shaitian (Related to Median Masses)	G.* Shait	N8W	N8W	440	158	20	865
	W.** Baba, Sinai	N8W	N8W	635	578	76	
	Qift—Quseir (pebble)			263	216	21	
	Qift—Quseir (pebble)			1125	444	24	
Grey (Related to Geosynclinal Structure)	El Sibai Area	N33W	N33W	660	268	45	
	El Sibai Area	N33W	N33W	410	462	52	
	El Sibai Area	N33W	N33W	620	510	26	
	El Sibai Area	N33W	N33W	400	396	24	
Normal Pink—Red Pre- or Syn-Hammamat (Latitudinal)	G. Kadabora	EON	N270W	634	48	112	
		E18N	N288W	635	48	112	
	G. Elba	E26N	N296W	700	40	100	
	G. Igla	E18S	N252W	900	56	6	621
	G. Hangalia	E34N	N304W	485	44	130	
	G. Atalla	N38W	N38W	795	14	231	
	G. Abu Diab	E18N	N288W	N.D.	***35	164	533
					N. D.	26	220
	G. Siwiqat El Arsha	E20N	N290W	N. D.	51	130	515
		E35N	N305W				
		E25N	N295W				
		E34N	N304W				
	W. Kalawi (pebble)			373	58	172	
	W. Kalawi (pebble)			557	35	72	

* G. = Gebel, an Arabic Word for a mountain.
*** W. = Wadi, an Arabic Word for a valley.
*** N. D. = Not Determined.

TABLE I

Continued

Granite Type	*Locality*	*Fault Azimuth*		*Trace Elements* ppm			*Age* (m. y.)
		Measur-ed	Convert-ed	Ba	Sr	Rb	
Strongly Differentiated Pink—Red Post—Hammamat (Longitudinal)	G. El Sibai	N22W	N22W	80	13	136	
		N22W	N22W	175	36	124	
	Um Negat	N23W	N23W	49	5	228	
		N22W	N22W	62	15	226	
	G. El Muelha	N17W	N17W	57	17	154	
	G. Gattar	E24N	N294W	132	6	164	
	W. Um Dubr	N17W	N17W	N. D.	20	662	
	G. Abu Tyour	N24W	N24W	N. D.	48	90	488
	G. Homret Wagat	N14W	N14W	N.D.	7	100	
		N43W	N43W	N.D.	6	103	
	G. Homret Akarem	N17W	N17W	N.D.	20	662	
	G. El Atawi	N16W	N16W	N.D.	21	161	
		N14W	N14W				
		N35W	N35W				
		N33W	N33W				
Anomalous Pink	G. Abu Durba, Sinai	N29E	N331W	1445	776	52	
	G. Zarget El—Naam	E32S	N238W	565	125	112	
Aswan (Youngest)	Aswan Coarse	N10W	N10W	1075	223	96	470,
	Aswan Coarse	N30W	N30W	*1625*	*195*	92	*(950)*
		N27W	N26W				
		N20E	N340W				

DISCUSSION

Table 1 includes six principal granitic groups found in the basement rocks of Egypt. Each of these groups has its own geochemical and structural characteristics which make it different from the others. These characteristics are briefly discussed in the following paragraphs.

The conclusion of EL SHAZLY, EL SOKKARY and KHALÍL [1972] that Shaitian granite is the oldest among earlier granites is confirmed later by the work of EL RAMLY and SALLOUM [1973] on the tectonic regioning of the basement rocks of Egypt. The latter authors showed that only Shaitian type plagioclase granites are associated with the so-called median masses, the latter are regarded as the oldest parts of the basement geosyncline. HASHAD *et al.* [1971] assigned an age of 865 m. y. for Shaitian granites which is the oldes among the ages of other Egyptian granites.

The azimuth of the deep seated fault in G. Shait area is N8W which is strikingly the same azimuth for the granite of W. Baba (Sinai), despite of a separating distance of about 500 kms. Moreover, the two granites show together impoverishment in Rb with varying enrichment trends in Sr, i. e. undifferentiated character of granites.

It is worth to notice that trace elements data of the two pebbles from the geosynclinal sediments from Qift-Quseir area show the chemical characteristics of Shaitian

type plagioclase granites. This gives an indication that the latter granites are either older or contemporaneous with the geosynclinal sediments, a matter which again sets them as the oldest granites in Egypt.

On the other hand grey granites are related to geosynclinal structure and not to median masses like the previous group of Shaitian granites. They are typified by the granites of El Sibai area which show deep seated faults with NW—SE trends, and an azimuth of N33W. These granites till show a common geochemical feature with Shaitian granites which is the impoverishment in Rb and enrichment in Sr characteristic for undifferentiated acidic rocks.

In other words, it is possible to distinguish, particularly in the field, between the two groups of earlier granites, the first is the oldest (Shaitian) and emplaced only within the terrains of median masses, while the second group (grey) is comparatively younger and formed as a result of a later tectonic phase within the geosyncline.

To sum up, Shaitian granites are compared with grey granites from the points of view of their chemistry and azimuth of deep seated faults. On the other hand, the two groups are contrasted in a sense that only Shaitian granites are associated with median masses beside that only grey granites show some development of their potash feldspars.

To the first time, it becomes now possible to distinguish, particularly in the field, the two subgroups of younger granites formerly recognized as one group. These two subgroups are the normal pink-red granites (pre- or syn-Hammamat) and the strongly differetiated pink-red members (post-Hammamat). The former show deep seated faults usually with latitudinal trends i. e. EN—WS, while the latter are clearly emplaced on deep seated faults usually with longitudinal trends i. e. NW—SE. Geochemically the normal pink-red granites show great reduction in their Sr content with rising Rb values and almost normal distribution of Ba. On the other side, strongly differentiated granites show a sudden drop in their Ba and Sr contents with varying enrichment trends in Rb.

The trace elements data for the two pink granite pebbles from Hammamat conglomerates are conformable with those of the normal pink-red granites with latitudinal trends of deep seated faults. This assures that the latter granites are somewhat older than the strongly differentiated granites. Thus granites with latitudinal system of faults are either pre- or syn-Hammamat, while those with longitudinal faults are post-Hammamat.

On the basis of available geochronological data, the normal pink-red granites give an age ranging from 621—515 m. y., while the strongly differentiated rocks give an age for one of their varieties as 488 m. y. This difference in age (133 m. y.) between the two groups of younger granites explains the lapse of time usually reported an many works for the time of emplacement of these granites. However, it should be noted that the available geochronological data up till now are far from being stable due to a multitude of reasons. Therefore strong reliability on these data is not guaranteed.

The following granite masses are classified with normal pink-red granites that are characterized in the field and on geologic maps by latitudinal system of faults (EN—WS): G. Kadabora, G. Elba, G. Igla, G Hangalia, G. Abu Diab and G. Siwiqat El Arsha. On the other hand, the following plutonites are classified with strongly differentiated pink-red granites that are characterized by a longitudinal system of deep seated faults (NW—SE): G. El-Sibai, Um Negat, G. El Muelha, W. Um Dubr, G. Abu Tyour, G. Homret Wagat, G. Homret Akaram and G. El Atawi.

The granite masses of the south western desert, namely those occurring in the areas of G. Um Shaghir, G. El Asr, G. Abu Bayan El Bahari, G. Abu Bayan El Qibli, west of G. Abu Bayan El Qibli and Bir Tarfowi, are shown to posses a latitudinal system of deep seated faults. Unfortunately, no reliable trace elements data are available for these granites. But on the basis of the preceeding geotectonical considerations, these granites might belong to the normal pink-red group of Egyptian younger granites.

It is worth to notice that the strongly differentiated pink-red granites which are post-Hammamat are situated along deep seated faults with NW—SE direction. This fault trend is nearly the same like that of earlier granites (Shaitian and grey). Therefore strongly differentiated pink-red granites might be emplaced on rejuvenated fault system originally started by the time of emplacement of old granites. This may tentatively explain why some pink-red granites are seen cutting through or penetrating old grey granites. Admittedly, the activity of the longitudinal deep seated faults during the geotectonic development of the geosynclinal system is more pronounced than that of the latitudinal system.

Anomalous pink granites are a special division of pink-red granites which abnormal distribution of trace elements e. g. unexpected enrichment in Sr or Ba or lowering of Rb values. Their deep seated faults take a different trend from that of the previous two groups i. e. either NE—SW (contrasted with the NW—SE system for strongly differentiated granites) or ES—WN (contrasted with EN—WS for normal granites).

Aswan granites stand in a geochemical province on account of the peculiar distribution of their major and trace elements [El Sokkary, 1970]. As an illustration of this peculiar distribution, the coarse varieties show enrichment trends in Ba and Sr beside Rb. The main set of deep seated faults of Aswan plutonites take a NW—SE direction with azimuth ranging between N10W and N30W. Since this fault trend is the same like that of strongly differentiated pink-red granites, therefore, it is likely that Aswan granites can be classified as belonging to the youngest granites in Egypt. However, differences in chemistry between Aswan granites and the strongly differentiated granites are attributed to the influence of older basic country rocks on the invading Aswan acidic plutonites.

Estimates of the age of these granites are somwehat variable, but the age of 470 m. y. given by El Ramly [1962] is consistent with the present suggession that Aswan plutonites are among the youngest granites in Egypt.

CONCLUSIONS

On geochemical and geotectonical basis, six fundamental groups of granites could be identified in the basement rocks of Egypt. These groups are Shaitian, grey, normal pink-red, strongly differentiated pink-red, anomalous pink and Aswan granites. Shaitian granites are definitely the oldest granites and are associated with the median masses. Grey granites, despite of some similarities in their chemistry with Shaitian granites, are related to geosynclinal system.

It is now possible through the present study to distinguish the pre- or syn-Hammamat pink-red granites from the post-Hammamat members. The former usually show latitudinal trends (EN—WS) of their deep seated faults, while the latter show generally longitudinal trends (NW—SE). Chemically, the former group are normal granites while the latter are their strongly fractioned members.

Anomalous pink granites show unusual distribution of certain trace elements. The trends of their deep seated faults are different from those of the previous two groups of pink-red granites. These trends take the NE—SW or ES—WN direction.

Aswan coarse plutonites stand in a geochemical province. Their main system of deep faults take a NW—SE direction which is the same as that of strongly differentiated (post-Hammamat) pink-red granites. This probably makes Aswan plutonites among the youngest granites in Egypt.

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