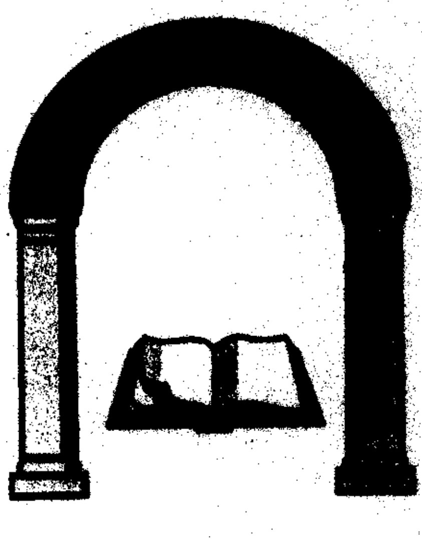
CHAPTER I

INTRODUCTION



CHAPTER I
INTRODUCTION

The present thesis deals with the geology, petrography, geochemistry and radioactivity of Wadi (W.) Abu Maamal area, North Eastern Desert, Egypt.

1.1 Location, Topography and Physiography

The studied area represents a part of the North Eastern Desert of Egypt; it covers about 179 km^2 of crystalline basement rocks. It is bounded by latitudes 27° 09` and 27° 19` N and longitudes 33° 15` and 33° 22` E (Fig. 1.1). The Dokhan volcanic masses represent the highest elevation points in the area (1661 m above sea level), while the other rocks are relatively lower.

The area is dissected by numerous wadis namely; W. Umm Sidrah (drain to Red Sea), W. El-Muallaq, W. Umm Lihag, W. Bili, W.Umm Adalah and W.Abu Maamal which leads to ancient quarries of the Imperial porphery and Roman temple (Fig. 1.2a). The water sources of the area are scanty except one water well (Bir) named Bir Badia (potable water), (Fig. 1.2b). Also, several dry water pits and dry rock basins are found. The area is characterized by arid climatic conditions. The vegetation is scarce except some grasses and few scattered trees.

1.2 Accessibility

Wadi Abu Maamal area can be reached through Cairo – Hurghada asphlaltic road along the Red Sea coast, about 415 km from Cairo, then to

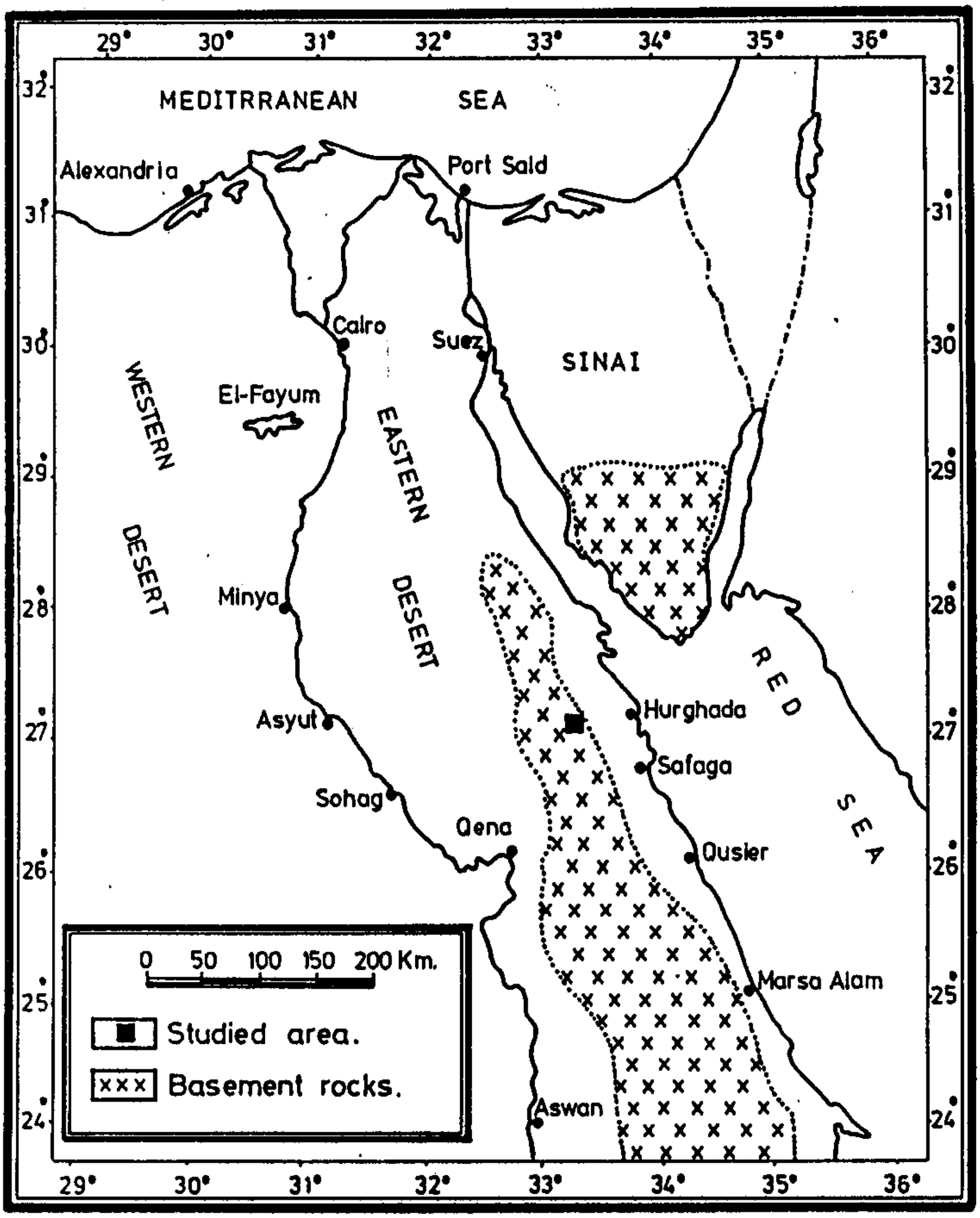


FIG.(1.1):LOCATION MAP OF WADI ABU MAAMAL AREA.

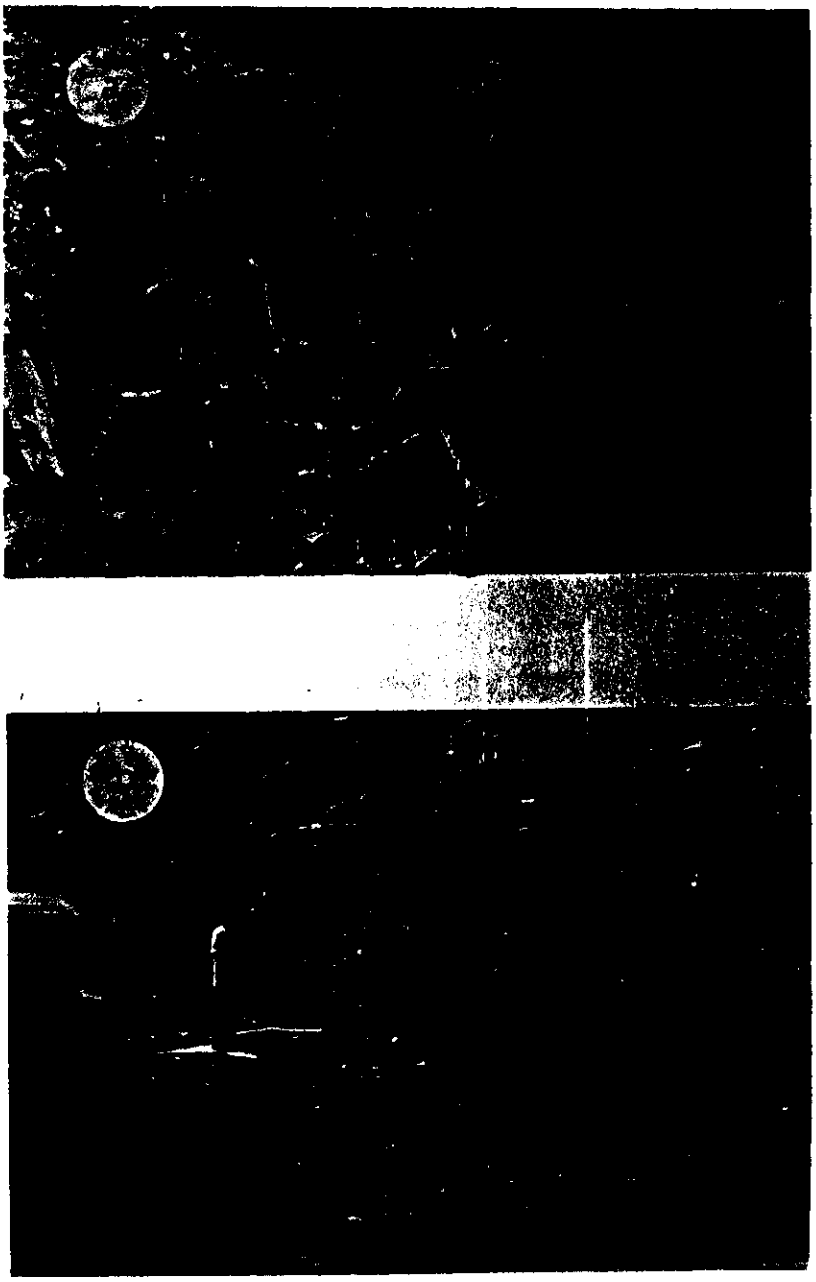


Fig. (1.2)

a): General view of Roman temple runes, W. Abu Maamal area. Looking southeast.

b): General view of Bir Badia (potable water), W. Abu Maamal area. Looking northwest.

the west within vast sand plane through the desert track about 30 km to the study area.

1.3 Aim and Scope of the Work

The present thesis aims to study of the geology, petrography, geochemistry and radioactivity of the basement rocks of W. Abu Maamal area.

For achieving these purposes, the following plan was carried out:

1- Collecting of the previous work.
2- Construction of a geologic map at scale 1:50000 for the study area.
3- Study of the structural features.
4- Radiometric study for the exposed rock units.
5- Petrographic study for the various rock types.
6- Geochemical study for the various rock types.
7- Interpretation of the obtained results and evaluation of the area from the radioactivity point of view.

1.4 Methodology

In order to achieve the previous aims, an extensive and detailed field work was carried out through several field trips. Detailed geological map (scale 1:50,000) was prepared using vertical aerial photographs as a base map.

More than 450 rock specimens representing the Dokhan volcanics, Hammamat sediments and younger granites were collected; from which 75 thin sections were prepared. The petrographic studies were carried out using Nikon (Optiphot-Pol) polarizing microscope equipped with an automatic photomicrographic attachment (Microflex AFX-II).

The chemical analyses for the major, minor and trace elements were done in the Analyses Department of the Nuclear Materials Authority (N.M.A). Forty one samples (representing all previously mentioned rocks) were selected for chemical analyses. The major element oxides were determined using wet chemical analysis technique (Shapiro and Brannock, 1962). The trace elements were analysed using Inductively Coupled Plasma technique (ICP).

The U and Th contents (in ppm) were chemically measured using U-laser analyzer and spectrophotometric techniques, respectively. All these analyses were carried out in the laboratories of the Nuclear Materials Authority, Cairo.

1.5 Synopsis on the basement rocks of Egypt

The basement rocks of Egypt cover about 100,000 km^2 (about 10 % of the total area of Egypt). These rocks crop out, mainly, in the Eastern Desert and south Sinai as well as a limited area in the southwestern corner of the Western Desert (Oweinat area). In the Eastern Desert, the Precambrian rocks extend as a belt parallel to the Red Sea coast for a distance of about 800 km between latitudes 22° 00' and 28° 40'N. These rocks are unconformably overlain on their western and eastern margins by Nubian sandstones and younger sediments.

Since the beginning of last century, extensive geological studies on the basement rocks of the Red Sea hills and south Sinai were carried out in order to classify them in a stratigraphical, chronological sequence. The cartographic units of the Basement of Egypt comprise the following, beginning with the oldest: *(1) Gneisses and Migmatites, (2) Geosynclinal Metasediments, (3) Geosynclinal Metavolcanics, (4) Serpentinites, (5) Metagabbro-Diorite complex, (6) Older Granitoids, (7) Dokhan Volcanics, (8) Hammamat Group, (9) Post-Hammamat Felsites, (10) Gabbros, (11) Younger Granitoids and (12) Ring complex.*

Gneisses and migmatites are exposed in a large domal structure (250 km^2) at the Meatiq area and are considered to form the base of the succession of the Arabian Desert Super-Group (Akaad and Noweir, 1980). Sturchio et al. (1983) gave an age for Meatiq gneisses of 626 ± 2 m.y. with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7030 ± 0.0001. The low initial ratio does not favor derivation from an ancient sialic (high Rb/Sr) source. El-Gaby et al.(1984) considered the Meatiq gneisses as reactivated pre-Pan-African old basement, representing the eastern continuation of the Nile Craton cropping out at Oweinat area in the southwestern corner of Egypt. Ragab (1987a) considered that they are related to suturing during arc-arc collision and immediately before the intrusion of younger granites.

Geosynclinal metasediments display the alternation of sediments (immature flysch-type sediments) and volcanics, which represent the typical eugeosynclinal filling of the Arabian Desert Geosyncline (Akaad and Noweir, 1980). Ries et al. (1983) and Shackleton (1986) considered the metasediments in the central Eastern Desert as "ophiolitic mélange" enclosing huge fragments of oceanic crust and solid upper mantle. Ragab

(1987a) considered that some of these metasediments are related to back-arc basins and resulted from the weathering of immature island arcs.

Geosynclinal metavolcanics are represented by metabasalts, metadolerites, meta-andesitic basalts and their related tuffs and agglomerates as well as acid-intermediate varieties (Ghanem et al., 1973). Wetait (2001) characterized a low K- tholeiitic and basic meta-volcanic of ophiolitic oceanic ridge basalt to back-arc basalts and medium K- calc-alkaline arc metavolcanics dominated by meta-andesites.

Serpentinites are considered as the base of obducted ophiolitic sequence or as intercalations with the flysch-type metasediments forming ophiolitic mélange in trenches or outer arcs. Most of the ultramafic rocks of Egypt are belonging to the "Alpine-type" orogenic belts (Takla and Noweir, 1980). El-Amawy et al. (2000) and Wetait (2001) assign back-arc tectonic setting for the serpentinites and the ophiolitic sequence in south Eastern Desert.

Takla et al. (1992) identified, for the first time, rodingites in the serpentinized ultramafic bodies of Sikait-Abu Rusheid area and advocated the presence of low temperature-high pressure metamorphic assemblages in the southern region of the Eastern Desert. Takla et al. (1996) studied the setting of some Egyptian ophiolitic ultramafics based on evidences from the enclosed metadiabases, which are rodingitized in Sikait-Abu Rusheid and Hafafit area. They concluded that, the rodingitization is always contemporaneous with the upward adiabatic movement of the mafic-ultramafic association at increasing pressure component and descrease in temperature.

Metagabbro-Diorite complex includes a group of gabbroic and doleritic masses which were tectonized, uralitized and affected by the next group of older granitoids (El Ramly, 1972).

Older granitoids range in composition from quartz diorites, tonalites, adamellites and granodiorites (Ghanem et al., 1973). They form batholiths, which may range up to several hundred square kilometers in extent (El Ramly, 1972). They send dykes and veins into the metavolcanics (Sabet et al., 1972) and invade the metagabbro-diorite complex (Francis, 1972). They are named as "Grey Granites" (Hume, 1935), "Older Grey Granites" (El Ramly and Akaad, 1960), "Synorogenic plutonites" (El Shazly, 1964) and recently as "G I- granites" (Hussein et al., 1982). The latter publication described this granitic type as subduction related granites formed by partial fusion of the mantle wedge with little or no crustal melt contribution.

Dokhan volcanics are mainly composed of andesites, dacites, tuffs and minor occurrences of felsites, rhyolites and quartz-feldspar porphyries (Ghanem et al., 1973). Ragab (1987 b) plotted the K_2O-content of average andesites with SiO_2 on a regional scale. It is concluded from this plots that the direction of subduction is generally northwards or probably NE normal to the NW-SE trend of the serpentinite thrust sheets in the suture zone west of Quseir. Abu Zeid (1991) stated that the Dokhan volcanics evolved in a subducted-related volcanic arc environment on crustal thickness intermediate between island arc and active continental margin setting during the final stages of the Late Precambrian Pan-African orogeny in Egypt. El-Sharkawy et al. (1991) studied the volcanic rocks of G. El-Dokhan and stated that these volcanics are currently regarded as a type locality for one volcanic succession "Dokhan volcanics" but based on their recent detailed mapping, two contrasting volcanic rock sequences could be distinguished: (1) an old slightly metamorphosed "Dokhan volcanics" (lower green schist facies) subduction related sequence and (2) a younger unmetamorphosed volcanic sequence which is tied to an extensional tectonic regime.

Hammamat Group has the most complete succession, about 4000 m thickness, at Wadi Hammamat. Francis (1972) recorded the interbedded nature of the Dokhan volcanics with the basal part of the Hammamat sediments in the north Eastern Desert. Hammamat Group is intruded by the post-Hammamat felsites and the Um Had (younger granites) pluton; it rests unconformably on the Dokhan volcanics and older rocks (Akaad and Noweir, 1980). The Hammamat Group includes a thick succession of slightly metamorphosed, wholly clastic, immature to semi-mature sediments of distinct molasse facies (Wetait, 1997). The clastic fragments of Igla Formation (basal part of the Hammamat Group) red beds were mainly derived from the Dokhan volcanics and mainly transported by rivers nearby foreland basins.

Post-Hammamat Felsites are usually exposed as elongated masses. They intrude the Hammamat sediments and are invaded by the younger granite bodies. They may be either the volcanic equivalent of the younger granites or the end stage of the Dokhan volcanics.(Akaad and Noweir, 1980).

The gabbroic rocks of Egypt were classified by Takla (1971) for the first time into older and younger gabbros based on geological, mineralogical and geochemical investigations. Takla et al. (1981) considered the older gabbros as being related to the ophiolitic rocks, while the younger gabbros were considered to be post-orogenic (post-Hammamat).

Younger granites form relatively small masses in comparison with the older granitoids, usually with rounded or oval outline. They were classified as "Gattarian" (Hume, 1935), "Younger Red and Pink Granites" (El-Ramly and Akaad, 1960), "Late- and post-orogenic plutonites" (El-Shazly, 1964) and "G II- and G III-granites" (Hussein et al., 1982). The GII-granites were proposed to be formed by the partial melting of the lower crust probably with some addition from the mantle by collision (suturing) at plate boundaries while the GIII-granites are suggested to be intra-plate anorogenic granites formed by melting of pre-existing crustal rocks (Hussein et al., 1982). Ghanem et al. (1973) stated that the younger granites are red and pink in colour and range in composition between adamellites to normal granites and perthite granites. Some of the younger granites are peralkaline containing riebeckite, e.g. G. Gharib and G.El Zeit. Wetait (1997) considered that the younger granites represent the intrusive equivalents of the Dokhan volcanics. He assigned active continental margin tectonic setting for the Dokhan volcanics and their intrusive equivalents.

Generally, granitoids constitute an important rock group that covers vast areas of the Arabian-Nubian shield. In Egypt, granitoids (cover about 35,000 km^2) constitute about 35% of the basement rocks. Table (1.1) summarizes the different classifications of the Egyptian granitoids (older granitoids and younger granites).

Table (1.1): Classification of the Egyptian granitoids (modified after Dardier, 1997 and Moharem, 1999).

Hume (1935)	Grey granites (Older phase)	Gattarian granites (Younger suite)	
Schürmann (1953)	Shaitian granites preceding the grey granites		
El Ramly and Akaad (1960)	Older grey granites	Younger pink and red granites	
El-Shazly (1964)	Syn-orogenic plutonites	Late- and post- orogenic plutonites	
Sabet (1972)		Pink granites Red biotite -poor pegmatitic granites Muscovite-garnet granites	
Sayyah et al. (1973)		Less differentiated group Higher differentiated group	
El Gaby (1975)	Syn-orogenic granitoids	Post- orogenic granitoids	
Sabet et al. (1976)	Late Proterozoic intrusions	Late Proterozoic – early Paleozoic intrusions	Cretaceous Paleogene intrusions
Greenberg (1981)		group III group II Group I	
Hussein et al. (1982)	GI Subduction related granite	GII Suture related granites	GIII Intraplate granites
El-Gaby and Habib (1982)	Older, syn- to late- orogenic calc alkaline granite series		Younger, post-tectonic alkaline to peralkaline granite series.
El-Shatoury et al. (1984)	Group (A) granitoids		Group (B) Granitoids
El Gaby et al. (1990)	(g_α) calc-alkaline tonalites to granodiorites	(g_β) calc-alkaline ideal two feldspar granites	(g_γ) anorogenic subalkaline to peralkaline granites
Takla and Hussein (1995)	Older granitoids "GI" diorite-tonalite-granodiorite association	Younger granites "G II" Continental margins and within plate granites.	
Meneisy (1972) El-Manharawy (1977) Dixon (1979) Hashad (1980)	Their ages range from 930 to 850 m.y., possibly extend to 711 m.y.	Their ages range from 622 to 430 m.y. which are contemporaneous with the Pan-African tectonic thermal events	

The ring complex of Wadi Dib is only the ring complex recorded in the Eastern Desert north of latitude 25° 00' N. It occurs at latitude 27° 34' N and longitude 32° 56' E. This ring complex is about 2 km in diameter, and is formed of an outer alkali syenite ring enclosing a quartz bearing syenite core carrying alkali trachytic agglomerates (Ghanem et al., 1973). Screncsits et al. (1979) gave an age of 544 m.y. for this ring complex.

The application of the plate tectonic theory threw more light on the evolutionary history of Egyptian basement complex. Ragab et al. (1993), classified the basement rocks of Egypt into:

- Pre-Pan- African rocks.
- Pan-African rock assemblages.
- Post-Pan-African magmatism.

1.5.1 Pre-Pan-African rocks

They are mainly represented by the basement rocks of Oweinat area (Schandelmier and Darbyshire, 1984). The pre-Pan-African rocks comprise the higher grade metamorphic rocks (medium to high –grade schist, gneiss, and granite gneiss, together with their mylonitized products). They represent the lower structural level that reworked by the Pan – African orogeny; the effects of the orogeny varied according to the prevailing temperatures. At low temperature and shallow levels, the rocks of the old continental crust were subjected to plastic deformation of quartzo-feldspathic mylonites and blastomylonites. At higher temperatures and deeper levels, the older rocks were remobilized and mostly transformed into migmatites and granitic gneisses (El-Gaby et al., 1990).

1.5.2 Pan-African rock assemblages

The term Pan-African was originally proposed by Kennedy (1964) to denote a specific tectono-thermal event nearly at the close of the Precambrian, 400-600 Ma ago, which caused deformation and remobilization of Archaean and Proterozoic rocks, metamorphism to higher grades as well as migmatization, anatexis and wide scale intrusions of granites.

The Pan-African rock assemblages are represented by a late Proterozoic orogenic belt, which resulted from the formation of immature and mature intraoceanic island arcs, dominated by low-K tholeiitic and low-K calc-alkaline magmatism respectively (Ragab et al., 1989), and by the eventual closure of the Pan-African (950-550 Ma) ocean by arc-arc suturing (Gass, 1982; Stoeser and Camp, 1985 and Ragab, 1987a). The emplacement of the late- collision granites and the sedimentation of the late-collision molasse-type sediments mark the culmination of the Pan-African orogeny and eventually the stabilization or cratonization of this mobile belt (Ragab and El-Kaliouby, 1992).

El-Gaby (1994) stated that the Pan-African belt in Egypt is classified into three segments of contrusting geologic features by two megashears, namely the dextral NE-SW Qena-Safaga megashear; and the sinistral NW-SE Kom-Ombo megashear ; they represent the first order conjugated shear system along which large scale displacement occurred. Takla and Hussein (1995) proposed a simplified tectonostratigraphic classification of the shield rocks of Egypt (Table 1.2).

Table (1.2): Classification of the Egyptian shield rocks (Takla and Hussein, 1995).

IV- Continental margins-within plate magmatism and sedimentation
-Younger" G II" granites
-Younger gabbros
-Hammamat sediments" Clastic molasse facies"
-Younger volcanics" Basaltic andesite-andesite-rhyolite* association"
III- Older "G I" granitoids
Diorite-tonalite-granodiorite association
II- Ophiolitic mélange and island arc association
-Metasediments
-Intermediate to felsic metavolcanics and metapyroclastics
-Ophiolitic mafic volcanics
-Ophiolitic metagabbros
-Metaultramafites
~~~~~~~~~~~~~~Thrust contact~~~~~~~~~~~~~~~~~~~~~~~~~~
I- Gneisses, migmatites, amphibolites and high grade schists

N.B. Pre-Pan-African (association I)
Pan-African (associations II, III and IV)
* Rhyolite is post Hammamat

1.5.3 Post-Pan-African magmatism

A plate tectonic model (Ragab et al., 1993) is suggested to follow the mantle lithosphere interaction, step by step, and the consequences of the geodynamics of the lithosphere from the culmination of the Pan-African orogeny to the Quaternary in the Gulf of Suez-Red Sea region.

1.6 Previous Work on the Studied Area

The area of study was previously studied by many authors, the previous works on the studied area could be summarized in the following :-

Barron and Hume (1902) explained the bedding of the different rock types in G. El-Dokhan as volcanic sequences comprising different lava flows and sheets comprising tuffs and agglomerates with volcaniclastic agglomerates of different composition. Barthoux (1922) identified the Imperial porphyry as porphyrite of dacitic composition occurring in rocks, which had traversed G. El-Dokhan breccia of andesitic composition. He related the rosy color of the Imperial porphyries to the presence of hematite impregnations and withamite as a secondary alteration of feldspar. He stated that the Dokhan volcanics were deposited over the Shadli metavolcanic series with an insignificant unconformity in the form of veins and necks.

Andrew (1932) confirmed the idea of Barron and Hume (1902) that the rocks of the volcanic sequences are lavas, tuffs and agglomerates. He also concluded that the Dokhan volcanics enclose several offshoots of porphyritic granites. Hume (1935) assigned an Eparchean age to the Dokhan series, while Schurmann (1953) reported the same age for both the Dokhan volcanics and their overlying rocks of the Hammamat series. Andrew (1939) discussed the stratigraphic position of the Dokhan volcanics in the sequences of the basement rocks in the Eastern Desert. He concluded that the volcanic rocks of Barron and Hume are younger than the volcanic breccia.

Akaad and El-Ramly (1960) proposed that the Dokhan volcanics were mostly extruded at the end of the Eo -Cambrian. El – Ramly (1963) reported an age of 465 m.y. for the Imperial porphyry. This age is contemporaneous to the intrusion of the younger or pink granites.

Schurmann (1966) described the Dokhan series as particularly unfolded, but often tilted, broken and crushed. He also concluded that these volcanic rocks (1200 m in thickness) unconformably overlie the Shadli metavolcanic series.

Ghobrial and Lotfi (1967) studied the geology and petrography of G. El-Dokhan and G. Gattar area. They stated that the Dokhan volcanics are the products of repeated volcanic eruptions and flows. The rock varieties are andesite porphyry, dacite porphyry, vesicular porphyritic andesite, volcanic tuffs and Imperial porphyry. The same authors related the crushing of these volcanics and their thermal metamorphism to the effect of major intrusions of younger Gattarian Granites. Awadallah (1972) concluded that the Dokhan volcanics originated by the differentiation of normal tholeiitic basaltic magma.

Dardir and Abu Zeid (1972) concluded that the Dokhan volcanics are older than the gabbros and younger granites in the sequence of rock units in the Dokhan area. They noticed that the Umm Tawat sediments unconformably overlie the Dokhan volcanics and thus could be correlated stratigraphically with the Hammamat series. They also stated that the Umm Tawat sediments are green to greyish – green in colour and are distinctly bedded. The rocks strike in an ENE – WSW direction and dip to the south.

El-Ramly (1972) discribed the Dokhan volcanics as post tectonic, unmetamorphosed volcanics represented mainly by andesites, porphyrites, pyroclastics and Imperial porphyry. According to El - Ramly, this rock unit is of a limited distribution, mainly developed north of latitude 26° N. Sabet (1972) considered the Dokhan volcanics equivalent to the granodiorite group formed at depth in the syntectonic phase of orogeny.

Zalata (1972) assigned all of the late-orogenic, non- metamorphosed, intermediate, subvolcanics and acid associations to the Dokhan volcanics. Initial magmatic activity was of andesitic composition. It progressively differentiated to alkaline rhyolites.

Dardir (1973) related both the Dokhan volcanics and the Hammamat sediments to the consolidation stage of orogeny. The rocks were described as being essentially unmetamorphosed and belonging to an epeirogenic phase with an age of 600-700 m. y. (Akaad and Noweir, 1978). Later, several authors gave ages for the Dokhan volcanics ranging between 639 m.y. and 581 m.y. (Dixon, 1981; Bentor, 1985 and Stern and Hedge, 1985).

Garson and Shalaby (1976) concluded that the Dokhan volcanics and possible mineralization were emplaced on the continental margin (Andean type) above the steeply dipping Quseir – Baranice Benioff zone.

Basta et al. (1979) studied the Dokhan volcanics at its type locality (G. El-Dokhan) and classified them petrographically into andesite, quartz andesite (including the Imperial porphyry), dacite, rhyodacite, quartz trachyte and pyroclastics. The former three rock types are the most dominant. According to them, the Imperial porphyry contains appreciable amounts of piedmontite (withamite) and basaltic hornblende that are responsible for the characteristic purple colour. These andesitic Dokhan volcanics occasionally suffered some propylitization that can be considered as a post – magmatic regional metasomatic process. Basta et al. (1980) studied the petrochemical and geochemical characteristics of Dokhan volcanics and suggested that these volcanics have a non-iron concentration trend and are calc – alkaline with mild tholeiitic tendency.

Greenberg (1981) mentioned that the younger granites, in the Red Sea hills, are interpreted as three petrographical and geochemical groups charactrized by their homogeneity, absence of tectonic foliation, presence of pegmatites and typically low sr^{87}/sr^{86} ratio.

Dardir et al. (1982) believed that the extrusion of the Dokhan volcanics took place in successive phases over long lapse of time. The Imperial porphyry represents most probably the latest phase of this volcanicity. They considered that the Dokhan volcanics represent a well developed island arc with a thick continental crust or an active continental margin which are possibly characterized by a medium rate of convergence.

Ressetar and Monrad (1983) concluded that the Dokhan volcanics record a period of transition between compressional tectonics and crustal stability. They also stated that the Dokhan volcanics were subjected to low grade alteration during the waning stage of the Pan African event.

Stern et al. (1984) believed that the common bimodality of andesite in the Dokhan volcanics indicates that the crust was actively extending and undergoing rifting at the time of their extrusion.

Stern and Gottfried (1986) reinterpreted the Dokhan volcanics and pink granites as extrusive and intrusive components of a bimodal suite and these rock associations occurred in a strongly extensional environment during the interval 575 – 600 m.y. Willis et al (1988) gave ages of 585 $\pm$ 15 m.y. using Rb-Sr method and 588-567 m.y. using K-Ar method for the Hammamat sediments of the north Eastern Desert of Egypt.

El– Sharkawy et al. (1991) distinguished two contrasting volcanic sequences of Gabal Dokhan volcanics. The old sequence includes low greenschist facies of andesitic flows and their pyroclastics as well as Imperial porphyries. The young volcanic activity (basaltic and rhyolitic dykes) is related to an extensional tectonic regime affecting the Dokhan volcanics and the Hammamat sediments.

Khalaf (1994) stated that the Dokhan volcanic sequence is of clac-alkaline nature and is formed in Andean type subduction related volcanic arc suites. He also stated that the Dokhan volcanics are overlain unconformably by Hammamat sediments, especially in the southern side along Gabal Umm Tawat. Khalaf (1996) concluded that the late Proterozoic volcanics at G. El-Dokhan area display a clear evolutionary cycle ranging from basaltic andesites through andesites to more evolved rhyolites, in which the andesites represent the dominant rock type. He also recognized six alteration facies for the two types of andesites:

1) biotitization – silicification
2) sericitization – silicification
3) albitization – silicification
4) epidotization – silicification
5) chloritization
6) desilicification.

Abdel Magid et al. (1997) suggested that the alkali feldspar granites in the southern part of wadi Umm Sidrah cropout at wadi Abu Maamal area. They are medium to coarse-grained with frequently porphyritic texture. They also stated that the Hammamat sediments overlie unconformably the Dokhan volcanics. They consist of bedded series of conglomerates, greywackes and siltstones.

Masoud et al. (1997) stated that the thick successive sequences of Dokhan volcanics are represented by minor amount of basalt, andesite, trachy – andesite, dacite, rhyodacite porphyry and their pyroclastics. The pyroclastics are formed of ash, crystal lapilli tuffs, agglomerates and ignimbrites. Dokhan volcanics are unconformably followed by thick sequences of Hammamat molasse sediments that represent the erosion of the uppermost part of the previous rocks. These rocks are intruded by several phases of granites that range from quartz monzonite- quartz monzodiorite, monzogranite, alkali feldspar granite and granophyric microgranite.

El- Kholy (1999) mentioned that the Dokhan volcanics are mainly composed of andesites, dacites, rhyodacites and rhyolites. He also stated that Gabal Umm Tawat Hammamat sedimentary rocks are composed of conglomerates, greywackes and siltstones.

Nossair and El- Galy (1999) classified the granitic rocks intruding Gabal Dokhan volcanics into three types; granodiorite, monzogranite and syenogranite. They also stated that the most secondary products are related to the hydrothermal processes that cause silicification, chloritization and albitization.