CHAPTER I
INTRODUCTION

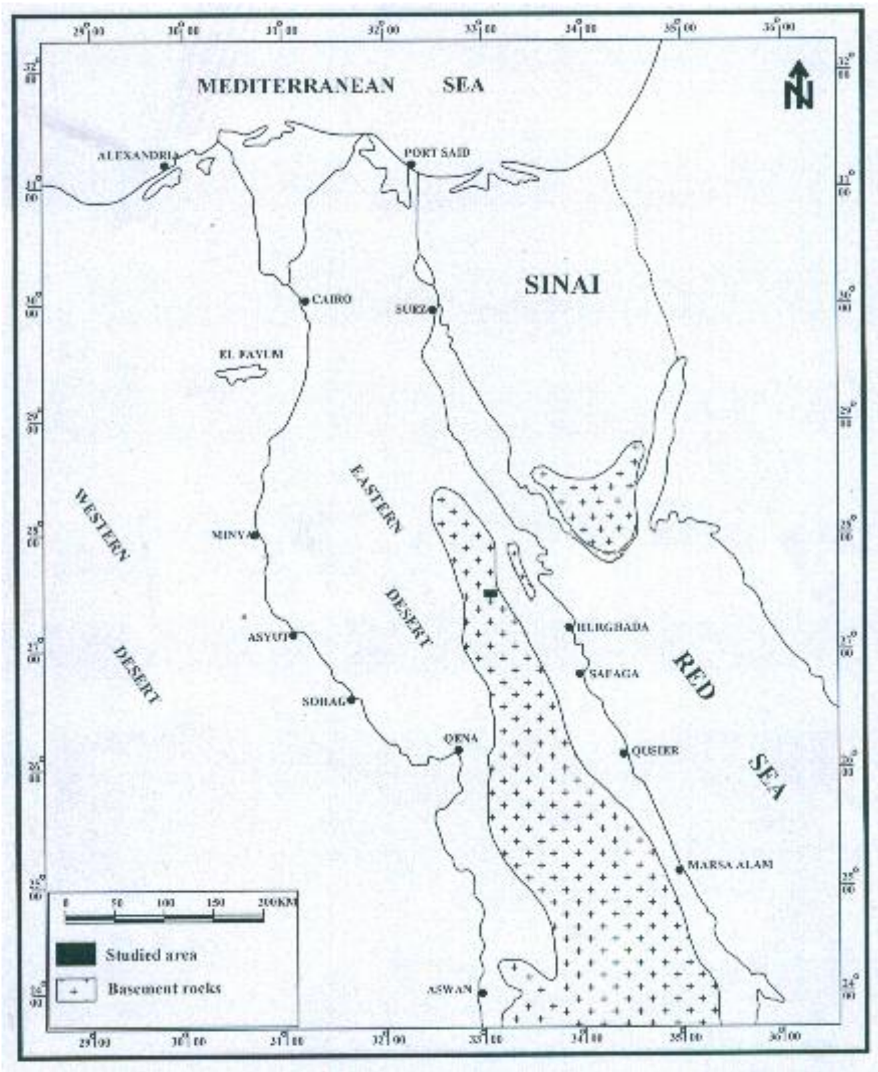
The present thesis deals with the geology, petrography, geochemistry and radioactivity of Gabal (G.) Milaha area, North Eastern Desert, Egypt.

1.1 Location, Topography and Physiography

The studied area represents the north extension of the western part of the Arabo-Nubian Shield. This shield was affected by tectono-thermal events of the Pan African orogeny (Kennedy, 1964) in a period of the New Proterozoic from 950 to 450 Ma (Kroner, 1984 and Shackleton, 1986).

The studied area covers about 620 km^2 of crystalline basement rocks. It is bounded by latitudes 27° 27` and 27° 39` N and longitudes 32° 55` and 33° 12` E (Fig. 1.1). It is of rough topography with low to high relief. The most conspicuous peaks in the area are comprising: G. Sabir (1398 m), G. Milaha (1119 m), G. Ladid al-Ji'dan (1113 m), G. Madrab al-Nigm (931 m), G. Utayyiqah (874 m), G. Markhat al Afa'i (539 m) and G. Manzal al-Seil (495 m) above sea level.

The area is dissected by numerous wadis (W), some of them drain to the Red Sea, namely W. Milaha, W. al-Murayr, W. Salman, W. ath-Thimilah and W. Ladid al-Ji'dan while the other wadis drain to W. Milaha and linked to the Red Sea, namely W. Milaha ath-Thimilah, W. Umm Sitw, W. al-Hunkan and W. Tal'at Zarqa. W. Sabir is the only wadi which drains to Wadi Qena and linked to the River Nile.



(Fig. 1.1): Location map of Gabal Milaha area

The water sources of the area are scanty except one water well (Bir) named Bir al-Murayr that yield low quantity of saline water and not suitable for drinking (Fig. 1.2). Also, some magals that store the rainwater are found. The area is characterized by desert climatic conditions since the winter is cold and rainy and the summer is very hot and rainless. The vegetation is scarce except some grasses and few scattered trees such as Sanamaka, Syal Acasia and palm trees (Fig. 1.2).

1.2 Accessibility

Gabal Milaha area can be reached through Gharib – Hurghada asphlaltic road till the road mark 75, then turn to the west through the old asphaltic road about 10 km to the study area.

1.3 Aim and Scope of the Work

The present thesis aims to study the geology, petrography, geochemistry and radioactivity of the basement rocks of G. Milaha area. For achieving these purposes, the following plan was carried out:

1- Collection of the previous work.

2- Construction of a geologic map at scale 1:50,000 for the study area.

3- Study of the structural features.

4- Radiometric study for the exposed rock varieties.

5- Petrographic study for the various rock types.

6- Geochemical study for the various rock types.

7- Interpretation of the obtained results and elucidate the favorability of the area from the radioactivity point of view.

(Fig. 1.2): General view of Bir al-Murayr and the surrounding palm trees, G. Milaha area, looking SW.

In order to achieve the previous aims, an extensive and detailed field work was carried out through several field trips. Base map was prepared using vertical aerial photographs (mosaic) at scale 1:50000, then detailed geological map of the same scale was constructed during the field work.

More than hundred and fifty rock samples, representing the metavolcanics, metagabbros, older granitoids, Dokhan volcanics, Hammamat sedimentary rocks, younger granites and ring complex were collected. Seventy thin sections were prepared; fourteen of which represent the metavolcanics, seven represent the metagabbros, seven represent the older granitoids, sixteen represent the Dokhan volcanics, ten represent the Hammamat sedimentary rocks, ten represent the younger granites and six represent the ring complex for the identification of the different minerals occurring in these rocks as well as the different analytical purposes. The petrography was studied using a Nikon (Optiphot-Pol) polarizing microscope equipped with an automatic photomicrographic attachment (Microflex AFX-II).

1.4 Analytical Techniques

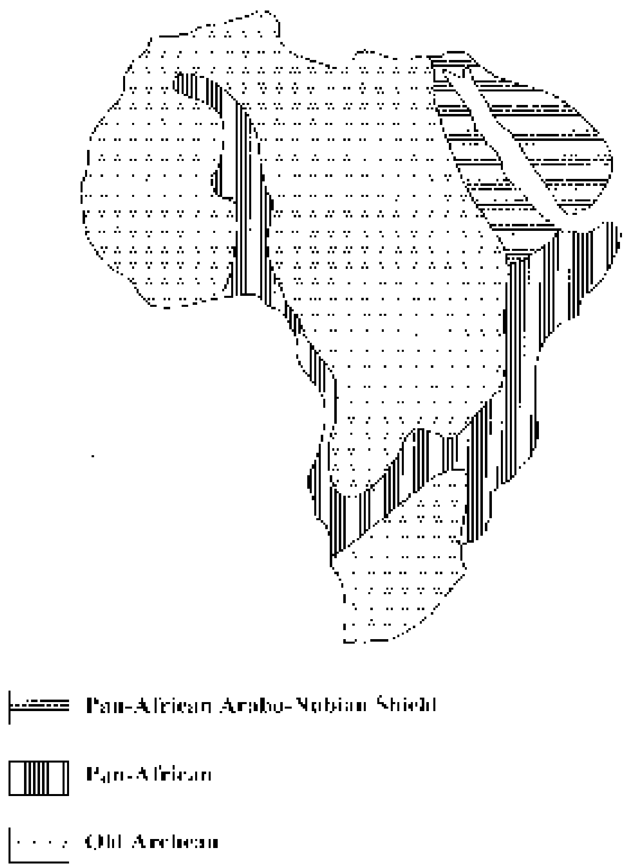
Seventy representative samples were crushed and ground for geochemical analyses. Whole rock geochemical analyses were carried out for major oxides and trace elements. The major oxides were analyzed using wet chemical analysis techniques (Shapiro and Brannock, 1962), while the trace elements were analyzed using X-ray fluorescence (XRF) technique. Uranium was chemically measured by using U-laser analyzer technique. Thorium was measured colourimetrically by using spectro-photometric analysis. Also, radiometric analyses (using quantitative gamma-ray spectrometry techniques) were carried out to measure equivalent uranium (eU) and equivalent thorium (eTh) in the field.

The mineralogic identifications were done by using x-ray diffraction technique (XRD) and scanning electron microscope technique (SEM). All chemical analyses were carried out in the laboratories of the Nuclear Materials Authority (N.M.A.), Egypt.

1.5 Synopsis on the Basement Rocks of the Eastern Desert

The basement rocks of Egypt cover an area of about 93,000 km^2 (about 10 % of the total area of Egypt). They crop out at the Eastern Desert (constituting the Red Sea hills), southern part of Sinai and minor exposures at the extreme southwestern corner of the Western Desert of Egypt (Oweinat area), (Fig. 1.1). They 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 Nubia Sandstones, Miocene and younger sediments. Generally, the Arabian Nubian Shield covers the northeastern sector of the U-shaped Pan African orogenic belt (Engel et al., 1980; Fig. 1.3).

In the last three decades, the plate tectonic theory was applied and a great number of studies had been published on the recognition of ophiolitic assemblages among the Precambrian rocks in the Eastern Desert (e.g. Garson and Shalaby, 1976; El-Sharkawy and El-Bayoumi, 1979; Gass, 1980; Dixon, 1981; Stern, 1981; Takla et al., 1982; Basta, 1983; Ries et al., 1983; Abdel Khalek et al., 1984; El-Gaby et al., 1984; Habib, 1987; Abdel Khalek et al., 1992 a and b; El-Gaby, 1994; Hamimi



(Fig. 1.3): Distribution of the Pan-African rocks (Engel et al., 1980)

et al., 1994 a and b, El-Mansi,1996; Hamimi, 1996; Takla et al.,1996; El-Metwally et al.,1997; Ahmed, 1999 and Abdel Kader et al., 2000).

The majority of the recorded ophiolitic successions occur as dismembered sequence. However, El-Sharkawy and El-Bayoumi (1979) identified a complete ophiolitic succession within a mélange body in Wadi Ghadir area. Many authors believed that, the ophiolitic rocks are formed in situ and delineated suture zone (Gass, 1977), others believed that they were formed elsewhere and occupied the present positions as a result of sea floor spreading (Shackleton et al., 1980; Basta, 1983; El-Gaby, 1983; Takla et al., 1987; Church, 1988; Ragab et al., 1993 and Hamimi, 1996). The direction of dip of the suggested subduction zone was believed to be due east (Gass, 1977; Nasseef and Gass, 1980; Schmidt and Brown, 1982; Ries et al., 1983; Basta, 1983; Ragab et al., 1993; Greiling et al., 1993 and Hamimi, 1996). Other authors believed that the subduction is from east to west, i.e. westerly dipping (Garson and Shalaby, 1976; Kroner, 1979; El-Sharkawy and El-Bayoumi, 1979 and Schmidt et al., 1979).

The term "Pan African", first introduced by Kennedy (1964), defines an important widespread tectono-thermal event, which took place throughout the African continent during the periods of 1100 to about 450 Ma ago (Shackleton, 1976; Gass, 1977; Kroner, 1980 and others). Kennedy (1964) believed that the Pan-African episode had led to the structural differentiation of the entire continent into cratons and orogenic area.

Greenwood et al. (1976) and Gass (1977, 1979 and 1981) believed that the shield had evolved on oceanic crust from the welding together of a series of island arcs.

Engel et al. (1980) proposed an ensimatic model and considered that the oldest units in the basement complex of the Eastern Desert are mafic and ultramafic sequences representing an oceanic substrate, while the andesitic rocks are similar to those in medium Circum Pacific island arcs.

Church (1982 and 1983) envisaged the evolution of the Pan-African in the Eastern Desert of Egypt through a complex sequence of events involving the development of one or several rift zones propagated within a more intracontinental crustal evolution resembling the Appalachian and Hercynian systems of Northern America and Western Europe respectively.

El-Gaby et al. (1984) criticized the ensimatic island arc model and considered that the Pan-African orogeny is identical to Phanerozoic continental margin orogenic belts, such as the Cordilleran-Andean belts of Western America. They stated that the orogeny is the result of the coeval swelling of infrastructure and thrust movements of suprastructure, and that both processes are independant and were directly or indirectly initiated by subduction. The subduction is situated in the eastern part of the Arabian Shield and dips to the southwest.

Bentor (1985) proposed four main evolutionary phases for the development of the shield:

1- An oceanic phase (1100-900 Ma) represented by emplacement of oceanic tholeiites, mainly pillow basalts and their plutonic equivalents.

2- An island arc phase (950-650 Ma) represented by andesitic volcanism and dioritic intrusions.

3- Calc-alkaline and silica-rich magmas, as well as the cratonization of the shield.

4- A per-alkaline batholithic phase (590 - 550 Ma) producing per-alkaline high level granites and rhyolites.

El-Gaby et al. (1988) classified the Precambrian rocks in Egypt into four main groups, starting with the oldest:

1- Pre-Pan-African granites, gneisses and schists and their mylonitized and remobilized equivalents.

2- Pan-African ophiolites and island arc assemblage.

3- Dokhan Volcanics and molasse-type Hammamat sediments.

4- Foreland assemblage of Wadi Allaqi.

Greiling et al. (1988) described a tectonostratigraphic succession in the Pan-African rocks of the Eastern Desert, composed of high grade gneisses, low grade metavolcanics, metasediments and ophiolitic melange.

Most of the ultramafic rocks of Egypt belong to the "Alpine-type" which characterise the orogenic belts (Takla and Noweir, 1980). The gabbroic rocks of Egypt were classified based on geological, ore mineralogical and geochemical characteristics by Takla (1971) for the first time into older and younger gabbros. 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 continental intrusions (post-Hammamat).

Abdel Kader and Hafez (1986) studied the petrogenesis of the zoned mafic-ultramafic complex of Abu Hamamid. The characterization of both types of ultramafic and mafic rocks was given in detail by Takla (1971) and Hafez and Shalaby (1983).

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 Gabal 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.

Khudeir and Ahmed (1992) studied the Hammamat sediments at Wadi Abu Shiqili , Central Eastern Desert and stated that, they were deposited as alluvial fans in two separated faulted-bounded basins.

Renno et al. (1992) studied the petrogenesis and origin of the A-type granites “Apogranites” of Nuweiba, Abu Dabbab and Igla, and stated that there are various kinds of metasomatic processes, which affected these rocks. The strongest one was the microclinitization of the perthitic K-feldspars.

Ragab et al. (1993) studied the crustal evolution and suturing of Gabal Meatiq-Wadi Atalla area, Central Eastern Desert and found that this area comprises a gneiss-dome situated at the concave side of an arcuate ophiolitic mélange belt as well as molasse-type sediments fringing and overlying the ophiolitic mélange zone.These three rock assemblages are bounded from both sides by island arc metavolcanics.

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; which represent the first order conjugated shear system along which large scale displacement occurred.

Hamimi et al. (1994 a) studied the geology and structure evolution of El-Shalul Dome and environs, Central Eastern Desert, and concluded that the area of study is covered by two main lithotectonic units, viz. granitic gneisses (infrastructure) and ophiolitic mélange (suprastructure); these rocks are intruded by various intrusives, including younger gabbros, leucogranites and muscovite granites, and the granitic gneisses were thrusted by the ophiolitic mélange rocks.

Takla and Hussein (1995) proposed a simplified tectonostratigraphic classification of the shield rocks of Egypt (Table. 1.1).

Messner (1996) studied the dynamic of sedimentation in the Hammamat-type molasse basins in different tectonic settings in the Eastern Desert (Wadi Hammamat, Wadi El-Myah and Wadi Kareim basins) and concluded that the first basin is a foreland basin,

Table (1.1): 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 (associatons II, III and IV)

* Rhyolite is post Hammamat

Wadi El-Myah is a strike-slip basin and finally Wadi Kareim is an intermountaine-orthogonal extension basin.
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Neumayr et al. (1996) studied the Meatiq basement dome, Central Eastern Desert, and proposed a polymetamorphic Pre-Pan-African basement which has been reworked during the Pan-African orogeny. Also, they presented the first quantitative data on the P-T-t evolution of the Meatiq Dome suggesting two high T-metamorphic events that indicate a phase of crustal consolidation consistent with the evolution of the Meatiq terrain during multiple orogenic events.

Akaad et al. (1996) studied the Pan-African basement of Wadi Abu Ghusun-Wadi Khashir district in the South Eastern Desert. They stated that, the Pan-African history of this region began with the arc volcanics (Ranga metavolcanics) passing through arc-continent collision accompanied by the disruption of the oceanic lithospheric floor. The volcanic arc and overthrusting oceanic slice (Atshan ophiolitic Metabasalts) were followed by the emplacement of the Mahara and Abu Ghalaga metagabbro-diorite complexes. This was followed by the intrusion of five plutons of older granitoids and the peneplanation of these granites, and the extrusion of the Dokhan volcanics which overly unconformably all the older rocks; finally the deposition of the Igla Formation at wadi Ranga which was intruded by the Mastura post-Hammamat felsite. The intrusion of the two feldspar Dau Hamata younger granite terminates the Pan-African history of the region.

Takla et al. (1996) studied the petrology and geochemistry of Precambrian rocks of Wadi Dib area, North Eastern Desert and concluded that, the area of study is devoided of any ophiolitic rocks that predominate in the Central and South Eastern Desert.

The Egyptian granitoids attracted the attention of many workers who classified them according to several ways as: 1) Type localities

(Shaitian and Gattarian granites), 2) Relative age (older and younger granites), 3) Dominant colour (grey, red and pink granites) or 4) Their relation to orogeny (syn-, late- and post-orogenic granites) and so on. Table (1.2) summarizes the different classifications of the Egyptian granitoids (modified after Dardier, 1997 and Moharem 1999).

Sabet (1972) considered the younger granites as members of late orogenic stage and further suggested that these granites were not intruded in a single upsurge of the magma; the pink granites seem to have been introduced as first, followed by the red, biotite - poor pegmatitic varieties and at last by the muscovite - garnet variety.

Sayyah et al. (1973) classified the younger granites, based on K/Rb ratios, into less and higher differentiated groups. The higher differentiated group is characterized by lower K/Rb ratio (125-260), higher Rb/Sr ratios as well as lower average Zr content (117 ppm), relative to those of the other group.

El Gaby (1975) classified the granitoids into: a) syn-orogenic granitoids comprising the Shaitian and grey granites as well as a slightly later phase representing the Aswan Granite, and b) post-orogenic granites comprising the younger pink-red granites.

Table (1.2): 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_τ) 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	

El-Sokkary et al. (1976) grouped the Egyptian granitoids into: granodiorites, anomalous granites, normal pink-red granites and strongly differentiated pink-red granites. They concluded that, these groups may form a granite series and that the various granite groups of Precambrian age of Egypt vary from grey autochtonous members to the normal and strongly fractionated pink-red granites.

Sabet et al. (1976) suggested the following sequence of intrusive magmatism in the Eastern Desert:- a) the late Proterozoic intrusions, b) the late Proterozoic-early Paleozoic intrusions and c) the Cretaceous-Paleogene intrusions.

El Manharawy (1977) stated that, the isotopic analyses of the younger granites show wide variation in their $^{87}Sr/^{86}Sr$ ratios as they range from 0.7041 to 0.7164. This may suggest a localized origin for the magma rather than the production of a regional magma body.

Greenberg (1978) concluded that the Egyptian younger granitic plutons were produced from partial melting at the base of rather primitive and thin sialic crust.

Akaad and Noweir (1980) stated that, the granites of the Eastern Desert could be assigned to three different cycles:

1- An old cycle that provided the synorogenic granites (Grey Granites and Shaitian type).
2- A younger cycle that provided the later orogenic granites (gneissose granites, pink-red granites and associated pegmatites and aplites).
3- A post-orogenic cycle that provided the alkaline granites.

Greenberg (1981) classified the Egyptian younger granites into three groups: 1) Plutons near the SiO_2-rich end point are classified as "group I" (mainly hypersolvus), 2)Intermediate plutons are classified as "group II" (mainly transsolvus) and 3) Plutons near the mafic end point (65-70 % SiO_2) are classified as "group III" (mainly subsolvus).

Hussein et al. (1982) proposed a new classification of the Egyptian granitoids as the following:

1- GI granitoids; subduction-related calc-alkaline granitoids,formed above Benioff zone (Shaitian granites).

2- G II granitoids; suture related granites, formed in a thickened crust due to folding and thrusting (younger granites).

3- GIII granites; intraplate, anorogenic granites, related to hot spots and incipient rifting (alkaline to peralkaline granites).

El Gaby and Habib (1982) classified the Egyptian granitoids into the following:

1- An older, syn- to late-orogenic, calc-alkaline granite series comprising the "old Grey Granites", the porphyritic granites of Aswan and two feldspar "Younger Granites". These series correspond to group A-granitoids of El-Shatoury et al. (1984) and encompass both G I and G II granites of Hussein et al. (1982).
2- A younger, post-tectonic alkaline to peralkaline granitic series comprising quartz syenite, alaskite and aegirine- or riebeckite- bearing leucocratic granites. These series correspond to group B-granitoids of El-Shatoury et al. (1984) and G III granites of Hussein et al. (1982).

Rogers and Greenberg (1983) concluded that the younger granites of the Eastern Desert of Egypt form a series of post-orogenic, discordant, commonly massive plutons, characterized by very low contents of Ca, Mg and related elements.

Kabesh et al. (1987) studied 36 younger granite plutons in the Eastern Desert. They concluded that, the examined granites were most probably formed by suturing at plate boundaries in compressional environments. They also suggested that the examined younger granitoids share both S- and I-type granites with the majority leaning to the S-type side.

Ragab et al. (1989) described the older granitoids as I-type, plutonic equivalent of the Dokhan volcanics (mature island arcs), of low-K calc-alkaline magmatism. The authors also described the younger granites as products of extensive crustal anatexis as a result of thrust imbrication at the culmination of the Pan-African orogeny when arc-arc suturing is compatible. They are of calc-alkaline character with low Nb-contents. Their low Nb-contents (40 ppm) preclude within-plate hot-spot related magmatism in comparison with:

1- The Oslo Rift within-plate granites with Nb-content of 226 ppm (Pearce et al., 1984).
2- The NE Sudan, within-continental plate granites with Nb-content of about 50-300 ppm (Gass, 1979).

El-Gaby et al., (1990) suggested that, the granitoids of Egypt are considered as Pan-African rocks. They also revealed that, granitoids are subdivided on the new geological map (of scale 1: 50,000) into calc-alkaline tonalites to granodiorites (g_α), calc-alkaline two feldspar ideal granites (g_β) and anorogenic subalkaline to peralkaline granites (g_τ).

Hassan and Hashad (1990) gave ages of older granitoids ranging between a minimum of 614 Ma and maximum of 850 Ma. They also concluded that the younger granites lie between 530 and 620 Ma range.

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:

Francis (1971) reported that the Dokhan volcanics of the studied area are ranging from intermediate to acidic composition. These volcanics comprise welded tuffs, flow tuffs, porphyritic and nonporphyritic varieties of andesite and dacite, but the dominant are the pyroclastics of acidic to intermediate composition. He also believed that by the end of the geosynclinal stage when mountain chains were undergoing intensive weathering, the sediments of molasse character were deposited in intramountain basin. These sediments represent the latest stage of sedimentation in the Precambrian of Egypt.

Francis (1972) mapped the studied area as metavolcanics, diorite-epidiorite rocks, granodiorite, Dukhan volcanics, Hammamat sediments, Gattarian granites and ring complex. He mentioned that the W. Dib ring complex is formed of a complete outer ring of white very coarse alkaline syenite enclosing central and relatively younger inner core of pink coarse oversaturated syenite. He further added that this core block carries dark patches of volcanic breccia.

El Ramly et al. (1976) described the sequence of the formation of the complex and they related the complex to an orogenic intraplate magmatic activity. They also stated that Wadi Dib ring complex is the only complex in Egypt, which contain quartz-bearing syenites.

Garson and Krs (1976) concluded that Wadi Dib ring complex lies at the intersection of a N60E lineament and NW transcurrent fault. Sabet et al. (1977) investigated the mode of emplacement of Wadi Dib ring complex. They believed that plutonic rocks of alkali granite followed by syenites and explosive volcanic breccia forming the ring complex of Wadi Dib.

Serencsits et al. (1979) determined the age of Wadi Dib ring complex by using K/Ar analyses as 553 Ma (Cambrian age). They concluded that Wadi Dib ring complex represents the oldest ring complex in the Eastern Desert of Egypt.

Akaad and Noweir (1980) considered the Hammamat sedimentary rocks a group composed of two formations: Igla Formation which is composed of sandstones, siltstones and silty mudstones with a basal conglomerates and El Shihimiya Formation which is composed of conglomerates, greywackes and sandstones. Each formation was subdivided into members.

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.

Ries et al. (1983) stated that the age of the Hammamat sedimentary rocks is bracketed between 616 ± 9 and 590 ±11 Ma. Stern and Hedge (1985) reported that the Hammamat sedimentary rocks in the North Eastern Desert were deposited in time span between the Dokhan volcanics (592 ± 13 Ma) and the Gattarian granites (565 Ma).

Ragab (1987) stated that the Dokhan volcanics of the northern Eastern Desert belong to the low – K subseries of the calc-alkaline series that matches with the Cascade Range. Their geotectonic environment is characterized by ensimatic nature island arcs in which the low-K calc-alkaline magmatic arcs were recorded by immature island arcs. K_2O % regularly increases northwards indicating the direction of subduction and migration of the magmatic arcs. Willis et al. (1988) defined the age of the Hammamat sedimentary rocks as 585 ±15 Ma. using Rb-Sr whole rock analyses.

Rabie et al. (1994) studied the magnetic and radiometric trends associations and their relation to uranium remobilization in G. Ladid El Gedan area. A two dimensional trend analysis for the magnetic and gamma-ray spectrometric data is conducted through the application of autocovariance function technique, to define the relation between the trends of surface and subsurface structures, as well any significant relation reflecting radioelement mineralization control. Furthermore, the degree of remobilization of uranium in each rock unit is shown as reflected from the trend variations of uranium and thorium with their ratio.

El Sheshtawi et al. (1995) described the gabbroic rocks of Wadi Dib as older hornblende gabbro which have tholeiitic affinity and related to Mid Oceanic Ridge Basalt (MORB).

Rabie et al. (1996) mentioned that the interpretation of the gamma-ray spectrometric data of W. Dib was directed towards the identification and outlining of the probable boundaries of any potential province. The potential of uraniferous provinces can be fully evaluated through an integrated program in three ways. The first is a statistical treatment of data searching for areas showing high uranium content within each unit. The second route is by examining the stacked profiles for regions of high eU, eU/eTh and eU/K. the third option is by calculating the average uranium, thorium and potassium for each rock unit and comparing these with the published crustal average values. The resulting of this study indicates that all types of rocks have radioelement average abundance values either below or within the crustal average.

Hassanen et al. (1997) mentioned that the rocks of the W. Dib ring complex have field relationships and chemical signatures such as high total alkalis and HFS elements (Nb, Zr, Y, Rb, La and Ce) indicative to within-plate source region related to lithospheric stretching. The latter onset after the subduction magmatism ceased as a terminal of Pan-African orogeny.

Masoud et al. (1998) concluded that the studied area is moderate to high relief comprising intensively folded and regionally metamorphosed volcanics and volcaniclastics. These rocks are intruded by a prolonged highly fractionated plutonics started with the intrusion of gabbro and followed by the intrusion of granodiorites. The metamorphic suite rocks were affected by magmatic activity resulted in the emplacement of the Dokhan volcanics followed by the intrusion of younger granites. During this stage the Hammamat sedimentary rocks were deposited either contemporaneous with or immediately younger than the Dokhan volcanics. They also stated that the ring complex of W. Dib represent the last magmatic activity in the studied area .

Ghoneim et al. (1999) concluded that W. Dib ring complex was formed in a within-plate suite shifted towards a post-orogenic environment due to extensional and compressional tectonic suites. Consequently, it exhibit similarities with both within-plate and post-orogenic types.

Ayoub (2003) identified the younger granites cropping out along W. Sabir as granophyres. He stated that these rocks are rich in plagioclase and mafic contents and poor in quartz and potash feldspars. They are heterogeneous in their colour, the whitish colour is due to their high content of plagioclase, they gradually change to pink or reddish colour by the increasing of potash feldspars or when they are stained by secondary hematite. These rocks are invaded by knife-shaped black and red ridge of basic and acidic dykes.