CHAPTER I

INTRODUCTION

I. INTRODUCTION

The Precambrian rocks of Sinai occupy the southern triangular part of the Peninsula. These rocks include schists, gneisses, migmatities, mafic-ultramafic rocks, granitoids and volcanics.

The present study is carried out on the area south of Taba city, As far as the author is aware, no detailed studies were carried out before on that area, except scarce studies by Amit and Eyal (1976) and Eyal (1980), in which the present work has showed many defects. The present Thesis includes detailed geological, structural, petrochemical and geochemical studies for the different types of metamorphic and igneous rocks as well as their relation to the Egyptian rock units. Special emphasis is given to the migmatization processes and the associated mineralogical and chemical changes of each migmatized rock type.

These studies will generally throw light on the geological history of the area as a part of the Egyptian Precambrian especially in Sinai.

1.1 LOCATION AND ACCESSIBILTY OF THE STUDY AREA

It is a strip-like area extending parallel to the Gulf of Aqaba, between Taba and Nuweibi (Fig. 1.1). The area is limited by Latitudes 29^{o} 05` and $29^{o}$ 26` N and around Longitude 34^{o} 45 E, dissected by a number of Wadis running nearly in NW direction. These wadis, from north southward, include Wadi (W.) Tweiba, W. Um Zariq, W. Qreyia, W. Morakh, W. Minarish, W. El-Himeira, W. Muqabila, W. Mahash, W. Abu Samra

W. Um Yehia, W. El-Quseiyib, W. Abu Khamsa, W. Ras El-Burqa, W. Mahash El-Asfal and the two tributaries of W. El-Malha. All these eadis drain into the Gulf of Aqaba. The study area could be reached from Nuweibi or from Taba throught an asphaltic road running parallel to the Gulf of Aqaba mostly along the NE fault planes. There is another road crossing W. Morakh from Ras El-Naqb.

1.2 SAMPLING

The different metamorphic and intrusive rock varieties were sampled (more than 200 samples). Sampling took place along the wadi courses dissecting the area in nearly regular traverses as well as along the asphaltic roads. Most of these wadis are traversed on foot for the impossible path of the cars due to the present boulders and rock dumps.

1.3 METHODOLOGY

Petrographical and mineralogical studies as well as major chemical analyses were done by the author in the laboratories of Banha Faculty of Science. X-ray diffraction analyses were carried out using philips 1730 X-ray diffraction apparatus housed at the Geology Department, Faculty of Science, Canal University. Trace and rare earth elements (REE) were analyzed using ICP spectrometry of the Nuclear material corporation. The analytical system used in this study was philips Pv 8210 1.5 m air path spectrometer equipped for the measurment of 30 elements simultaneously and the Pv 8490

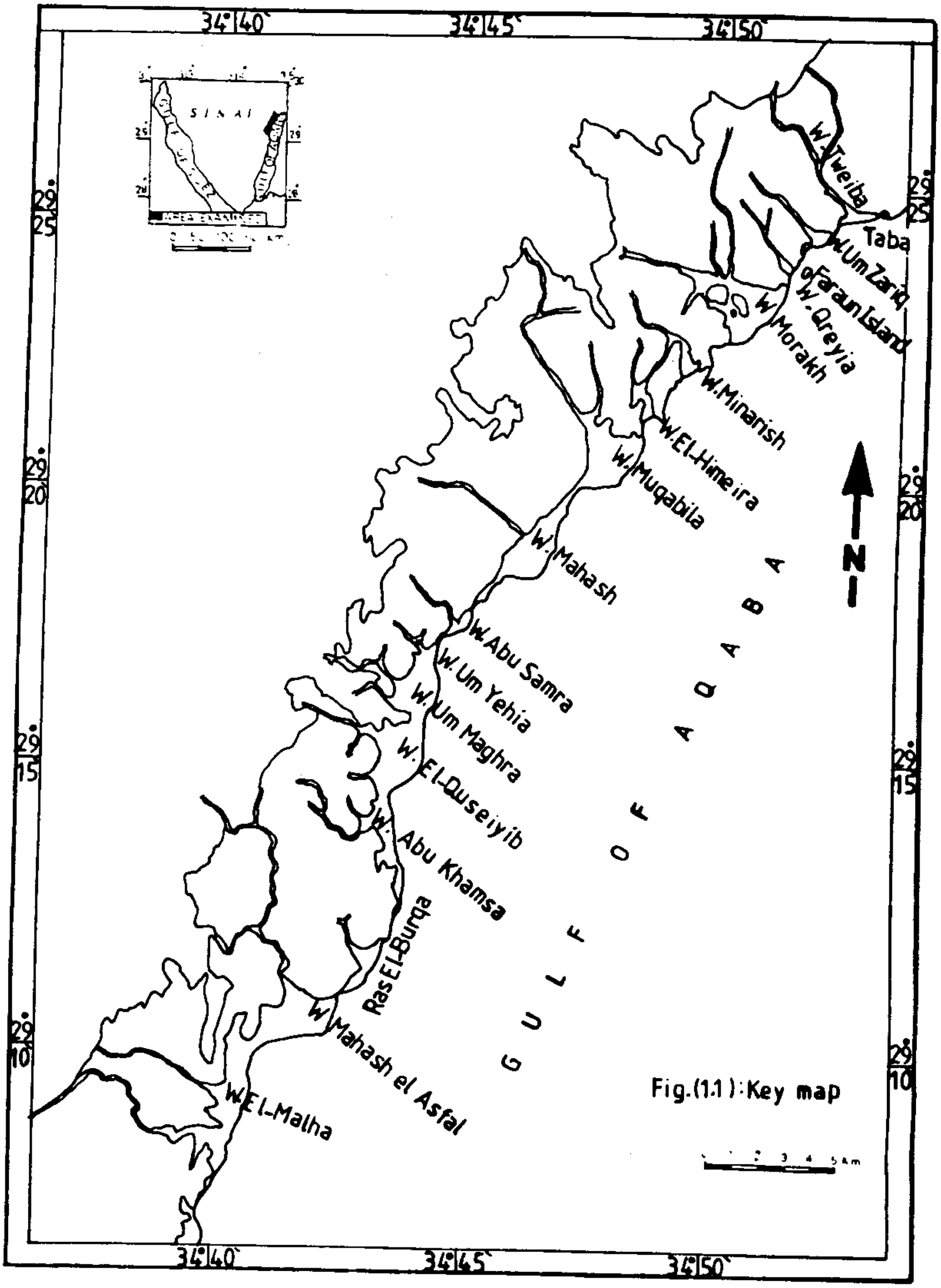

Fig.(1.1): Key map

source unit, a high frequency (50 MHZ) free-runing generator. This was linked to the philips 852 Computer which is used to store the prepared calibration lines and the out put results directly as ppm on the teletype point out. The instrumental conditions used are summarized in the followings: (Brockaert et al., 1979 and Mc Loren et al., 1981):

Plasma gas flow	17 L. min^{-1}
Carrier gas flow	1.2 L.min^{-1}
Observation zone above coil	15-19 mm
Power (forward power)	1.2 Km (50 MHz)
Sample uptake	2.3 ml min^{-1}

1.4 SCOPE AND AIM OF WORK

Aiming to identify and study in detail the different metamorphic and igneous rock types present in the study area as well as establishing a relation with the other Precambrian rocks in Egypt, the following points are achieved.

1. The preparation of a field photogeological map (scale 1:40.000).

2. The preparation of a structural map to show and analyse the different structural elements met within the study area.

3. Collection of representative samples (more than 200 samples) from the different Precambrian rock types.

4. Petrographic study for all samples, together with the ore-microscopic investigations for 50 samples are carried out.

5. Major elements chemical analyses for 75 representative samples using Shapiro's methods (1975).

6. X-ray diffraction analyses of 5 samples of schists and amphibolites are carried out.
7. Minor, trace and rare earth elements analyses for 21 samples.

1.5 PREVIOUS WORK

The previous work gives spot lights on four main divisions: the main classifications of the Egyptian Basement Complex, the Migif-Hafafit gneisses and migmatites, some intrusive rocks related to those of the study area and the basement rocks of Sinai in general with special emphasis on the study area.

1.5.1 Classification of the Egyptian Basement:

Since 1907, many detailed studies and classifications were carried out on the basement rocks of Egypt. Those of Akaad and El-Ramly (1960), El-Shazly (1964), Sabet (1972) and Akaad and Noweir (1969) & (1980) may be the most sound among those considering the geosynclinal ideas in the Eastern Desert of Egypt. As examples, the classification of Akaad and El-Ramly (1960) and that of Akaad and Noweir (1980,Table 1.1) are cited here. The classification of Akaad and El-Ramly, (1960).

Youngest 11- Alkaline volcanic suite.
10- Post-granite dykes.
9 - The younger granites.
8 - The Igla Formation.
7 - Volcanics (Dokhan type).

Table (1.1): Akaad and Noweir classification (1980).

Age	Stages of evolution	Supergroup and group	Formation
Lower Cretaceous	Post-Geosynclinal phase		Kab Absi Essexite Gabbro
			Khors Volcanic
			Nubia Sandstone
			Regional unconformity
450-590 m.y.			Younger Granites
			Post-Hammamat Felsites
	Epirogenic phase		Qash Volcanics
		Hammamat Group	2- Shihimiya Formation
			1- Igla Formation
			Regional unconformity
660-700 m.y.			Dokhan Volcanics (unmetamorphosed)
			Older Granites
900-1000 m.y.	Orogenic phase	Rubshi Group	2- Sid Metagabbros
			1- Barramia Serpentinites
	Geosynclinal phase	Abu Ziran Group	8- Abu Diwan Formation
			7- Eraddia Formation
			6- Sukkari Metabasalts
			5- Um Seleimat Formation
			4- Atalla Formation
			3- Atud Formation
			2- Muweilih
			1- Hammuda Formation
1300 ?? m.y.			Abu Fannani Schists
		Meatiq Group	

6- The grey granites.

5- Epidiorite-diorite.

4- Serpentinites and related rocks.

3- Metavolcanic series.

2- Schist-mudstone-graywocke series.

(Oldest) 1- The Migif-Hafafit gneisses.

Recently a new phase in studying of the Precambrian rocks of Egypt was introduced dealing with such rocks as representatives of ophiolites, El-Sharkawy and El-Bayoumi (1979), Schackelton et al.(1980), Takla et al.(1982), Abd El-Kader et al.(1983), Sturchio et al.(1983), El-Gaby et al. (1988) and others.

1.5.2 Migif-Hafafit gneisses and Migmatites (Meatiq Group):

The Migif-Hafafit gneisses (Akaad and El-Ramly, 1960) which also termed the Meatiq Group (Akaad and Noweir, 1980) are located in Egypt in the Eastern Desert, Western Desert and Sinai. In the Eastern Desert, they are found in Wadi Bietan (Abd El-Khalek, 1967), Meatiq dome (El-Nady, 1982), Sturchio et al 1982, Reis et al 1983 and El-Gaby et al (1984) Migif-hafafit area (Akaad and El-Ramly 1960; El-Ramly and Roufaiel, 1974 and Abd El-Wahed et al 1984) and Wadi Ghadir (Takla et al, 1987 a,b). In the Western Desert, they are exposed at Gabal Oweinat (Schandelmeier and Darbyshire, 1984). In Sinai, the gneisses and migmatites are found in Wadi Feiran (Akaad et al, 1967, El-Gaby and Ahmed, 1980 and Stern and Manton, 1987); Wadi Abu Zeneima, Wadi Baba and Wadi Dafari, (El-Sharkawy et al, 1988 and El- Aref et al, 1988).

The origin of these gneisses has been subjected to many discussions with respect to the ortho-or para-origin. Many authors (Akaad and El-Ramly, 1960; Abd El-Khalek, 1962; El-Ramly and Roufaiel, 1974; and Reiss, 1983) has assigned para-origin for these gneisses. Others (Akaad and Noweir, 1980; Habib et al, 1982; El-Nady, 1982, Sturchio et al, 1982; El-Gaby et al, 1984; Schandelmeier and Darbyshire, 1984, and Takla et al, 1987 a,b) has assigned ortho-origin.

Dating of the gneisses gave two ages, the first is more than 1200 m.y. (Schurmann, 1974, Klerix and Deutsch, 1977, Abd El-Monem and Hurly, 1980, Shimron, 1980, Gillespie and Dixon, 1983, Cahen et al, 1983 and Schandelmeier and Darbyshire, 1984) and the second is the age less than 760 m.y. (Geith, 1961, Hashad, 1980, Sturchio et al, 1983 and Stern and Monton, 1987).

Stacey and Hedge (1984) gave an age of 1630 m.y. for the Precambrian granodiorite of Saudi Arabia. Vail and Hughes (1984) considered the migmatitic gneisses in Saudan (Selak Formation) of Middle Proterozoic or older in age. Ekweume (1984) considered the Kibaran orogeny not restricted to Africa south of the equator.

Caen Vachette and Ekwueme (1988) made geochronological studies on staurolite-and cordierite- garnet schists in southeast Lokoja, Central Nigeria (Rb/Sr whole rock age). These metasediments gave ages of 1315 ± 72 Ma, 1005 ± 35 Ma and 687 ± 13 Ma respectively. The first two ages show the same Sr^{87}/Sr^{86}(0.702) while the third one shows higher Sr^{87}/Sr^{86}

(0.7066). They interpret the first two ages as the times of deformation and metamorphism and the third one as the time of reworking of these rocks by the Pan-African tectono-thermal episode. They gave the ortho-amphibolites (work in progress) an age of 1313 ± 7 Ma. These rocks are more or less comparable to the Migif-Hafafit gneisses.

Zalata et al.(1984) made detailed petrographic and petrochemical studies on the migmatites and the associated metamorphic rocks at Hyfan and Shebam Assalw areas, Yamen Arab Republic. They assigned medium grade metamorphism (medium amphibolite facies) followed by anatexis and injection processes as a mode of origin of these migmatites and the associated metamorphic rocks.

Abd El-Wahed et al.(1984) in their study on the gneisses of the northern Migif-Hafafit area, south E.D. has differentiated three deformation phases F_1, F_2 and F_3. These phases associated with three metamorphic events M_1, M_2 and M_3, respectively affecting the gneisses and migmatites in the area. They reported the following conclusions:

1) F_1 is represented by tight isoclinal and recumbent minor folds, axial planes trending NW-SE, plunging SE and NW. M_1 multistage metamorphism of amphibolite-granulite facies.

2) F_2 tight overturned minor folds with SW plunge. M_2 regional metamorphism of lower amphibolite Facies.

3) Thrust tectonics after F_1 led to ophiolitic metlange.

4) F_3 open and tight Folds with vertical axial planes trending NW-SE.

This is responsible for updoming of the gneisses. M_3 regional metamorphism of greenschist facies.

They showed that the migmatites are best developed in the hornblende and biotite gneisses with which they form gradational contacts. M_1 gave migmatites and nucleation of sillimanite, as well as growth of almandine both syntectonically and post-tectonically to the transposed M_1 foliation

Takla et al.(1987) in their study of Wadi Ghadir area, South Eastern Desert, noted the presence of amphibolites, gneisses and migmatites representing the oldest rock unit in the area. They assigned from ore-microscopic study, ortho-origin for these amphibolites with gabbroic parent for the coarse variety and basic volcanic parent for the fine one. Ore-microscopy is also used in determining the parent gneisses of the migmatites.

Takla et al.(1989a) assigned the trace elements characteristics of the gneisses, migmatites and granitoids exposed at W. Ghadir area, south of Mersa Alam. They reported that the granite mobilizate is a leucocratic secretion product of the area include diorites and granodiorites (older granitoids) and biotite granite, perthitic leucogranite and graphic granite (younger granites).

1.5.3 Intrusive Rocks:

1.5.3.1 Gabbros:

The gabbroic rocks are subjected to many studies in the Eastern Desert (E.D.) of Egypt. (e.g. Amin et al., 1953, Akaad and El-Ramly, 1960, Sabet, 1961, Sabet, 1974, El-Ramly, 1972 and Bishady et al, (1983).

Takla (1971) and Basta and Takla (1974 a,b) studied the geology, petrography, opaque mineralogy and geochemistry of numerous gabbroic occurrences of Egypt. They classified the gabbros into: a) older metagabbros and b) younger gabbros. The latter group is further subdivided into some phases of variable opaque mineralogy.

Takla and Noweir (1977) used the opaque mineralogy in determination of the petrogenesis of the gabbroic rocks of the E.D. The main ore-mineralogical differences between the fresh-gabbro and metagabbro as deduced from their study are:the fresh-gabbros show high (magnetite/magnetite+ilmenite) ratio (0.2-0.5), rare or no alteration of the opaque minerals and dominance of the different types of exsolution intergrowths; the metagabbros show low (magnetite/magnetite+ilmenite) ratio (0.0-0.2) with densely altered ore minerals and rare or absence of exsolution intergrowths.

Takla et al.(1981) assigned the geological, petrographical, opaque mineralogical and geochemical characteristics of the older and younger gabbros of Egypt (the gabbroic rocks in many localities in the E.D. of Egypt). They reported that the older gabbros is subsequent to the Alpine serpentinites and the younger gabbros are post-tectonic intrusions just older than the post-tectonic granitoids and are younger than the Hammamat. Later on, the older metagabbros were considerd as the ophiolitic gabbros (Takla et al, 1982 and Dosuky et al, 1987).

The gabbroic rocks of Wadi Watir, Sinai (South to the study area) are considered to be related to the younger gabbros (Takla et al, 1989b).

Wiebe (1974) studied differentiation in the layered gabbro-diorite intrusions, Inconish, Scotia. The main rock units in the area include hornblende gabbro and biotite-hornblende diorite. He clarified a composition gab between the gabbro and diorite although both are calc-alkaline and deduced that they are not related by fractional crystallization. He also deduced the presence of three types of gabbros: 1) high alumina basaltic composition (Kuno, 1968) characterized by relatively high total Fe, 2) high alumina basaltic andesitic composition characterized by high SiO_2 and low total Fe, 3) tholeiitic composition characterized by relatively low Al_2O_3 and total Fe.

1.5.3.2. Granitioids:

The Egyptian granitoids are subjected to many detailed studies, mainly in the E.D. Akaad and El-Ramly (1960) divided them into grey and pink granites. El-Shazly (1964) divided them into syn-orogenic and post-orogenic granitoids. El-Gaby (1975) suggested that the Egyptian granites represent one continuous granitic series with the early members of tonalite composition and the latter members are of granite composition with the last phases acquired alkaline or peralkaline affinities. El-Gaby and Habib (1982) has differentiated the granitic rocks of the area southwest of Port Safaga, E.D., Egypt according to the field relations, into syn-orogenic, late-orogenic and post-orogenic granitoids. The syn-orogenic granitoids are of tonalite to adamellite composition and occur as autochthonous, parautochthonous and intrusive bodies. The late-and post-orogenic granites of El-Gaby and Habib (op. cit.) are of intrusive nature and are of calc-alkalic and alkali granite composition, respectively. Akaad and Nowier (1969 & 1980) divided the Egyptian granitoids into older and younger ones.

Dixon (1980) studied the age and chemical characteristics of some Pre-Pan-African rocks in the Egyptian Shield. He considered the quartz diorites (tonalites) of Wadi Shût, South E.D. to be emplaced just prior to the main peak of Pan-African igneous activity and concluded an age of 711±7 Ma (U-Pb ages on zircon) which is characterized by very low intial Sr ratio (Sr^{87}/Sr^{86} = 0.7026) and very low abundances of K_2O and related large-ion lithophile trace elements. REE-contents are low (less than 20 X chondritic abundances). Abundance patterns show only moderate light REE enrichment (La/Yb=4.5). These characteristics are inconsistent with any models requiring fractional fusion of pre-existing continental crustal material.

Hussein et al.(1982) has classified the Egyptian granitoids, depending on their tectonic setting into G-I-, and G-II-G-III granites.

1. G-I- granites: Subduction related granites, formed above the old Benioff zones including the syn-orogenic (old, Shaitian or grey) granites and the porphyritic Aswan granites.
2. G-II granites: Formed as a result of suturing formed by partial melting of the lower crust and some addition from the mantle including the post-orogenic (red) granites.
3. G-III granites: These are intera-plate anorogenic granites formed within the plate subsequent to cratonization, including the alkali or peralkaline granites and partly the "younger granites" of Akaad and El-Ramly (1960) and El-Gaby (1975).

Greenberg (1981) made detailed study of the Egyptian younger granites. He classified them into (I-, II- and III-groups) depending on geological, mineralogical, textural and geochemical studies.

Ali (1968) studied the distribution of trace elements in the Egyptian granites. Kabesh and Lotfi (1970) assigned calc-alkaline petrochemical characters (colour index of about 39) of Wadi el Mallaha granitic rocks, Eastern Desert of Egypt. Sayyah et al.(1973) has studied the distribution of K, Ca, Rb, Sr, Y and Zr of some pink granites of Egypt and grouped them into: A) Less differentiated group and B) Higher differentiated group. Kabesh et al.(1980) studied the petrochemistry and petrogenesis of Abu Dob granitic stock, Eatern Desert of Egypt and assigned calc-alkaline nature and magmatic origin of them.

Awadallah and Kamel (1981) gave petrographical and geochemial studies of the granitic mass of Gabal Kadabora-Gabal Abu Dob, Central Eastern Desert of Egypt and concluded that this mass is leucocratic biotite granite grading to syenogranite.

El-Ramly et al.(1982) gave petrological and petochemical characteristics of the younger granites of Hamret Mukbud, Homr Akarim and El-Ghorabat in South Eastern Desert of Egypt. They found that these granites are mainly biotite-muscovite or muscovite perthite granite.

Awadallah et al.(1985) studied the geology, pertography and petrochemistry of the gneisses, granites and syenites of Wadi Arab, southeast Aswan. They concluded that the rocks of the area had undergone a long history of successive events. The oldest feature is represented by the mafic and biotite gneisses of probable Archean age, which were affected by a whole-sale extensive granitization to form felsic gneisses in a Pre-Pan-African episode. The latest event is exhibited by the biotite-and muscovite-granites as well as the syenites as a result of the mobilization of the older crustal rocks in a Pan-African episode.

Awadallah (1986) studied the petrological and geochemical characteristics of the metamorphic-granite massif of Gabal

El-Abyad area, Southeastern Desert. He concluded a granitization process has been started since the Pre-Pan-African (Proterozoic?), then by the mobilization of the metamorphic rocks during the Pan-African, the biotite and muscovite granites were produced.

Ragab (1989) in his study on Aswan and Ras Gharib granitoids suggests crustal anatexis for their magma source (in contrast to the subduction related magmas, dominated by diorites and tonalites). He proposed a post-collision granitoids by crustal anatexis in the arc-terranes and suture zones as a plate tectonic model for their generation.

The Egyptian granitoids are all of Pan-African age (876-410 Ma). El-Ramly (1962) reported an age of 640-410 M.a for Egyptian younger granites. Hashad _et al_.(1972) assigned an age of 876 M.a for granodiorite with relatively higher initial Sr^{87}/Sr^{86} (0.7081). Dixon (1980) reported on age of 711±7 Ma (U- Pb on zircon). Stern _et al_.(1984) proposed an age of 670-550 M.a for the granitic magmatism in Egypt. Stern _et al_ (op. cit) gave four principal magmatic events at 615-570 m.y (older granitoids), 620-615 m.y (granodiorites), 600-575 m.y (younger granites) and at 550 m.y (minor alkaline granites and dykes). Kamel and Abdel Aal (1987) gave an age range 588-538 m.y for the older granitoids and 593-513 m.y for the younger granites. They reported that the first age is unreliable for the older granites and seem to be affected by the intrusion of the younger granites.

1.5.4 The Basement of Sinai and Study Area:

The basement rocks of sinai has subjected to numerous studies in the last twenty years. The following pages summarize most of these studies.

Akaad et al (1967) studied the Feiran gneisses and migmatites and revealed that the migmatites has suffered a high-grade metamorphism before they were subjected to anatexis and metasomatism. They also indicated that the end product of the granitization processes of the para-gneisses are the formation of coarse-grained homogeneized gneisses or rather migmatitic granite of tonalitic to trondhjemitic composition.

Shimron and Zwart (1970) indicated that transgression has been clearly demonstrated both in Elat and Sinai since the lower Cambrain and no orogenic movements followed this transgression. Hence, in their openion, the youngest age of the basement rocks in Sinai is older than 550 Ma (Middle Cambrian). Shimron and Brookings (1974) reported that there are no regional unconformities between Shadli rocks, Dokhan rocks and the youngest Hammamat rocks in Sinai in contrast to Schürmman (1966). They considered them as contemporaneous polyphase deformation and progressive metamorphism and gave them an age of 934±80 Ma (Rb-Sr).

Bielski et al (1979) made geochronological studies on Iqna granite of Wadi,Kid, Sinai (younger granite) and gave an age of 580±23 Ma (Pan-African) for these granites. Shimron

(1980), in his study of volcanism and sedimentation in Sinai (Mainly Wadi Kid), has plotted two volcanic occurrunces in the studied South Taba area. He considered the calc-alkaline and alkaline granites of Pan-African age of about 600 ±50 Ma and gave Feiran gneisses an age of 1035 Ma.

Bogoch (1977) studied the quartz-plagioclase-diopside-garnet ± hornblende rocks in the intermediate to acid biotite gneisses in Wadi Feiran. He assigned a para-origin for them under regional metamorphism at the amphibolite facies.

El-Gaby and Ahmed (1980) studied the Feiran-Solaf gneiss belt. They assigned two major anticlines with their axes as well as the thrust faults trending nearly NW-SE. They indicated a para-origin for these gneisses and migmatites from semipelitic and calc-pelitic parent rocks. They concluded that these rocks were subjected to two stages belonging to one cycle of metamorphism and gave the following progressive series depending on field relations and petrographic investigation. The calcareous pelites were metamorphosed into fine-grained biotite-hornblende gneisses which were transformed in situ by anatexis and potash metasomatism into medium-grained banded and/or homogenized biotite-hornblende gneisses and then into medium-grained gneissic granites. Successive mobilization of the highly anatectic medium-granites. Successive mobilization of the highly anatectic medium-grained gneisses and gneissic granite gave rise to tonalitic and granodioritic migma granites, respectively.

Soliman et al (1986) studied the area south of Latitude 28^{o} 45̀ N, Sinai. They found that metamorphism in the mapped area belong to three phases; two progressive and one retrogressive, grading from the greenschist facies to the amphibolite facies. Three phases of deformation D_1, D_2, D_3, are recognized, two of them during the prograde metamorphism, and the last during the retrograde metamorphism and cataclasis.

Stern and Manton (1987) made geochronological studies for the basement rocks of Fieran using Rb-Sr whole-rock and U-Pb zircon dating methods. They gave an age of 610 Ma (Rb-Sr) and 632±3 Ma (U-Pb zircon) for the paragneisses which is interpreted as either the time of formation of these gneisses or the age of the crust samples by protolith sediments. Granodiorites gave an age of 782±Ma (U-Pb zircon).

Abd El-Khalek et al.(1988a), in their study of the geology of Saint Catherine area, reported the following basement rocks: old continental gneissose metasediments, greenstone belt including subduction related volcanics (moderately metamorphosed) intercalated with metasediments, calc-alkaline granites (G-II-granites), rifting related volcanics, and anorogenic within plate granites (G-III-granites). Abdel-Kalek et al.(1988b) on geochemical bases, found that the G-II-granites are richer in TiO_2, Ca (An), iron, and magnesium in relation to G-III-granites. The former are calc-alkaline while the G-III-granites are alkaline with slight peralkaline affiliation. The G-III-granites are formed from isofalic to salic magma at high to intermediate vapour pressure, while the G-III-granites are formed at intermediate to low vapour pressure from salic magma. Chemical classification revealed that the G-II-granites are emplaced in orogenic belt and are related to compressional environment while the G-III-granites are emplaced in anorogenic belt and are related to extensional environment.

El-Shorkawy et al (1988) made geological studies on the basement rocks of Abu Zeneima, West Central Sinai and indicated that the area is occupied by igneous and metamorphic rocks, represented by biotite, sillimanite-cordierite-biotite schists and gneisses with subordinate garnet porphyroblasts, migmatites, diorites and granodiorites. These rocks are intruded by younger pink granites and traversed by sets of dykes of different compositions and trends. They assigned three phases of deformation affecting schists and gneisses depending on field study of minor structural elements (foliation, different types of lineations and minor folds). They found that the granodiorites (granodioritic to tonalitic compostion) are mainly gneissose and xenolithic and enclose large bodies of migmatites and diorites.

A very restricted number of studies including those of Amit and Eyal (1976), Eyal (1980) and Eyal et al.(1981) were done on the area under consideration.

Amit and Eyal (1976) studied the migmatites of Wadi Magrish (Wadi Muqabila) with respect to their composition, genesis and their relation to the country rocks. They differentiated the migmatites into two sharply contacted units: a) leucosome composed of quartz and plagioclase and, b) melanosome composed of quartz, plagioclase and biotite and sometimes garnet and sillimanite. They supposed a metamorphic differentiation of the schist rocks reported in the north as a suitable mode of origin of these migmatites giving the following reasons:

a) Chemical similarity of the migmatites, schist and Fiord gniess (gneiss of Wadi Muqabila). They stated that Fiord gneiss results from the schist through an isochemical processes.

b) The absence of orthoclase in the leucosome and the lake of eutectic composition, rejects the origin by eutectic processes.

c) They supposed separation of the leucosome and melanosome in a closed system.

d) Similarity of plagioclase composition in both types of migmatites.

e) Biotite concentration around-, and its absence from the leucosome, leads to their conclusion that quartz and plagioclase have migrated and crystallized in a new place while biotite was left as restite by metamorphic differentiation.

Eyal (1980) studied the geological history of the metamorphic rocks in the area between Wadi Tweiba and Wadi Um Maghra. He gave an account on the geology and petrography of schists, gneisses and migmatites and indicated that these rocks were formed during an orogenic cycle which began with geosynclinal sedimentation, followed by low-medium pressure metamorphism and deformation, and terminated with an intrusive magmatic activity (Syn-and Post-Kinematic). He identified four deformation phases in the schists on the basis of foliation, growth of minerals and the mutual relationships between them. Some minerals such as staurolite, garnet and biotite were formed during three distinct generations. Extensive areas of migmatites have been shown to be the product of metamorphic differentiation of original paraschist. Eyal (op. cit.) stated also that the various types of gneisses are interpreted as being ortho-gneisses (depending on field and petrographic evidences) formed by two metamorphic events from at least three separate events of magmatic intrusion and metamorphic interfinger with four phases of deformation.

Eyal *et al*.(1981) studied the tectonic development of the western margin of the Gulf of Aqaba rift. They assigned NW-trending prominant faults as well as E-W-trending El-Quseiyib graben. These faults are post-Early Miocene (20-22 Ma) showing 4-5 Km sinistral displacement.

Takla *et al*.(1989b) in their geological and petrological studies of W. Watir area, Sinai (just south of the study area), reported that the old metamorphic rocks are represented by ortho-gneisses of diorite and granite composition with minor amphibolite enclaves. These rocks reflect high-grade regional metamorphism and wholesale K-metasomatism that led to the formation of porphyroblastic granitoids and their mobilizate. This unit was later intruded by different phases of granitoids and younger gabbro.