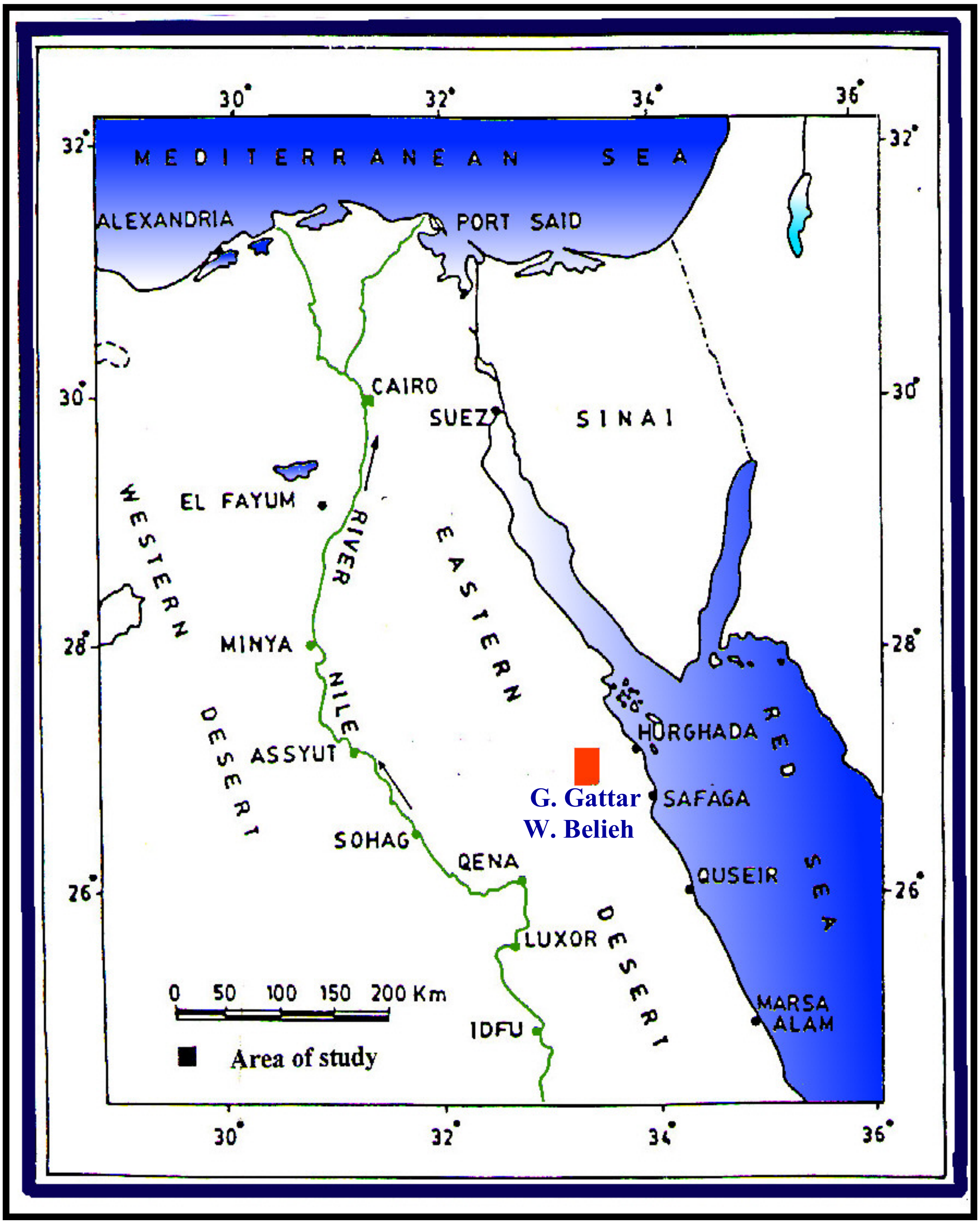
CHAPTER I

INTRODUCTION

I.1. General Statement

The geologic field group of the Northen Eastern Desert Deveplement Department (NEDDD) of the Nuclear Materials Authority (NMA) started an intensive radioactive exploration work carried out at Gabal (G.) Gattar granitic pluton has led to the discovery of nine significant uranium mineralized occurrences along its extreme northern peripheries (Fig. 1). These occurrences are namely from G-I to G-IX, they collectively constitute what is known as G. Gattar Uranium prospect. All the previously mentioned occurrences are of intragranitic nature. The uranium mineralization at G-V occurrence is mainly restricted to the contact zone between the younger granite of G. Gattar and the older Hammamat sedimentry rocks of G. Umm Tawat, along the southern bank of Wadi Belieh (Fig. 2).

Annual Seminar of the Nuclear Materials site during 17/9/1989-21/9/1989. Gabal Gattar Research Project (GGRP) aimed to demonstrate the beginning of 1990, NMA started a program of underground exploratory mining works at G-I occurrence, in addition, two open pits of 15X5X5 m. at two selected mineralized parts G-II and G-V, besides detailed surface studies and excavation of an exploratory mine at G-V occurrence to study the relation between the surface mineralization and its behavior at the subsurface.



(Fig.1): Location map of Gattar Uranium prospect area, Gabal Gattar, W. Belieh, Northern Eastern Desert, Egypt.

I.2. Location and topography

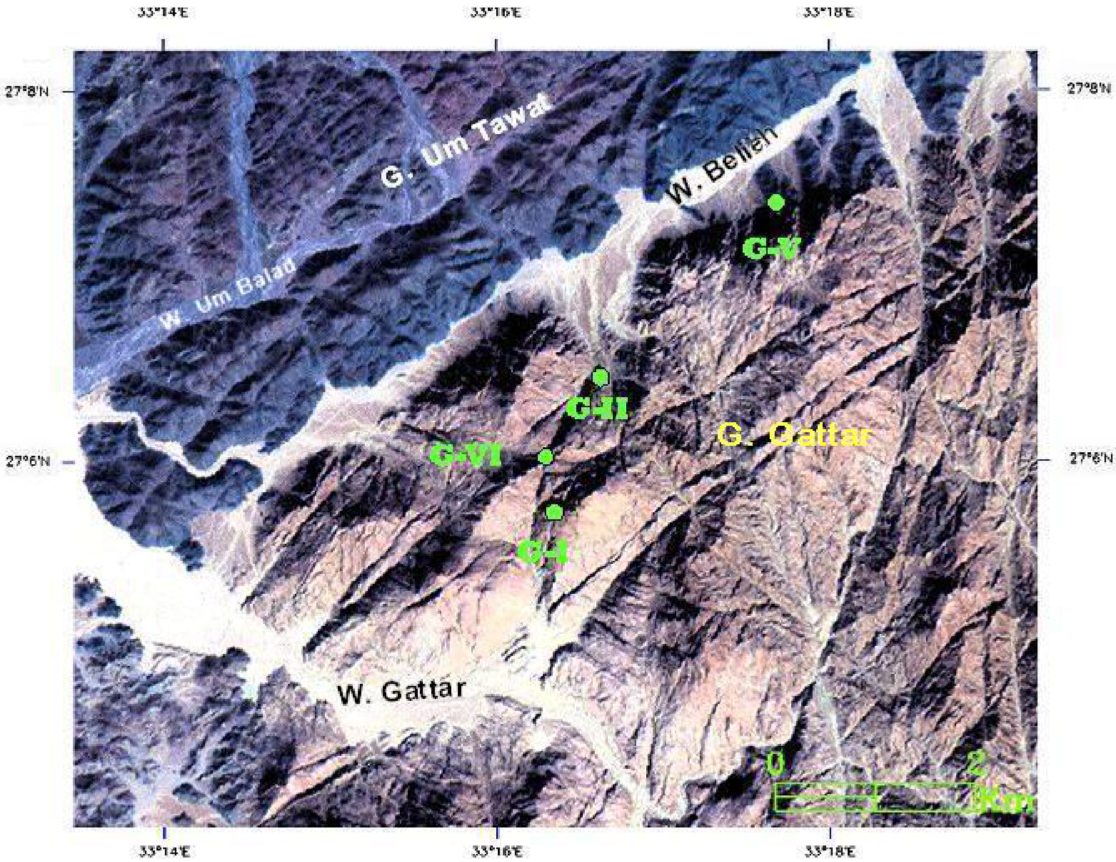
Gabal Gattar area is located at the northern Eastern Desert of Egypt at about 35 km west of Hurghada City. This prospect is located at the intersection of Latitude 27° 7' 30" N and Longitude 33° 17' 5" E covering an area of about 2km^2 (Fig. 2).

This prospect is bounded from the north by the southern part of Gabal Um Tawat. The highest elevation of the mapped part (the southern part) is 800 m above sea level (a.s.l.) and the lowest point is 540 m northward in Wadi Belieh. The mining works were carried out at the contact zone between the Hammamat and the younger granite of Gabal Gattar at heights of 582 m (a.s.l.).

1.3. Previous work

Barthoux (1922) divided the Gattarian granite into pink granites and red granites which are posterior to the gray granites. He noticed that the presence of red granite is in gradational contact with the pink granite. The intermediate zone between them at Gabal Gattar could reach in width as much as five hundred meters. According to the field observation of **Haridy (1995)** these red granites represent the strongly tectonized and hematitized pink granite along shear zones and don't represent a separate granitic phase.

Akaad and El Ramly (1960) studied the age of the basement rocks of the Eastern Desert of Egypt using the K-Ar method. They mentioned that they range in age from 600 to 400 m.y. and extends from Late Precambrian to Tertiary. They added that the Gattarian granite is of Precambrian age between 600 and 590 m.y.



(Fig.2): Location map of Gattar-V (G-V) prospect area Gabal Gattar, Northern Eastern Desert, Egypt

Ghobrial and Lotfi (1967) studied the geology and petrography of Gabal Gattar and Gabal El- Dokhan area including the different rock types starting from the oldest as follows: metasediments, diorite rocks, and volcanic rocks of Gabal El- Dokhan series, Hammamat sediments, Gattarian granites and dyke systems. They stated that Gabal Gattar granites are pink, perthitic leucocratic younger granites composed of quartz, orthoclase, microcline, plagioclase and biotite. The main accessories are zircon, apatite and iron oxides. The mineral resources present in these areas are molybdenum, wolframite, lead, malachite and imperial porphyry.

Rasmy (1969) carried out some petrographical and mineralogical investigations on 20 samples collected from Gabal Gattar pluton. She stated that these granites are leucogranites, alaskitic in composition and added that some samples are rich in quartz as normal granite and may be due to latter enrichment.

El Shazly (1970) referred Gabal Gattar granitic batholith to the orogenic plutonites which have been emplaced along the major weak structural zones trending NNW- SSE to N-S.

Dardir and Abu Zeid (1972) published a geological map of the basement rocks of the northern part of the Eastern Desert of Egypt between latitude 27˚and 27˚30'N. The field relations and petrographic characteristics for the different rock types are studied in detail including the regional structural trends, mineral resources and ornamental stones of these areas.

Dardir *et al.*, (1983) studied the molybdenite deposits associated with quartz veins in Gabal Gattar granites. They stated that the mineralization may be related to late magmatic phases subsequent to the intrusion of Gattar granites and classified the molybdenum ore into four types as follows: coarse crystalline ore, wall rock ore, thin quartz veinlets ore and disseminated ore.

Stern and Hedge (1985) assigned an age for 24 rock samples provided from different rock types of the Eastern Desert of Egypt using Rb-Sr, U-Pb and zircon techniques. This study revealed that the granitic rocks are predominant in the northern and southern parts of the Red Sea hills rather than the central parts. They added that Gabal Gattar granites have (238 ppm) Rb and (6.1 ppm) Sr and its age was estimated 575 Ma by Rb- Sr model, but when using the zircon technique the age was 579 Ma.

Field radiometric survey started in the area, around G. Gattar in 1984, as many of the younger granites of Egypt are reported to host uranium mineralization. This work ended with the discovery of seven uranium mineralized occurrences in G. Gattar area; namely GI, GII, GIII, GIV, GV GVI and GVII (**Salman et al., 1986**).

El Sirafe and Rabie (1989) in their interpretation of the aeromagnetic data with the geological information on G. Gattar area stated that G. Gattar has been affected by five significant tectonic trends namely NE- SW, NNE- SSW, N-S, NW- SE, and ENE- WSW.

Attawiya (1990) determined the uranium and thorium contents of some samples provided from G. Gattar by using X- ray fluorescence, the statistical treatment of the data obtained from these analyses showed that U-content ranges from 20 to 64 ppm and 10 ppm with Th/U ratio varying from 0.078 to 0.45 reflecting that G. Gattar could be classified as uraniferous granites.

The uraniferous Hammamat rocks located at the northern contact with G. Gattar granite were studied by **Mahdy *et al.*, (1990)**. They concluded that the secondary uranium mineralization is mainly presented in the altered siltstones occupying the surfaces of joints and minute fractures.

The northern peripheries of G. Gattar granite are in contact with the Hammamat sedimentary rocks along a local reverse fault running ENE-WSW and dips 45° to 65° to SSE direction. Along the local reverse fault delineating the granites- Hammamat contact some parts of the granite were subjected to episyenitization effects resulted from the hydrothermal leaching of quartz. The episyenitized granitic rocks are spongy in shape due to the disappearance of quartz content, highly hematitized and kaolinitized **(Shalaby, 1990)**. It is noticed that the pink granite becomes reddish to reddish brown in colour due to strong hematitization. The sediments are separated from G. Um Tawat, which is also compose from Hammamat sedimentary rocks by one of the major ENE- WSW faults running along W. Belieh.

According to **El Rakaiby and Shalaby (1992)** G. Gattar represents the northern part of a big pink granite batholith formed of G. Gattar (1963 m), G. Um Dissi (1620 m.), G. Kehla (1882 m.), G. Thelma (1733 m.), G. Abu El Hassan (1550 m.), G. Abu El Hassan El Ahmar (1234 m), and G. Abu El Samyuk (1750 m.). It is worth to mention that G. Gattar intrudes a country rock mainly composed of Hammamat molasse sediments type.

El- Terb (1994) carried out ground magnetic and ground gamma-ray spectrometric studies at G-V prospect. The ground magnetic studies indicated that the shear zones of ENE- WSW direction and their intersection with the fault and fractures NNW- SSE trend reflect the highest radioactive concentrations in the prospected area.

Moussa (1994) studied the field relationships, petrography and geochemistry of four younger granitic masses located at the northern Eastern Desert among which was G. Gattar. He analyzed Rb, Sr, Ba, U, Th, Zr, Nb, Y, and REEs to interpret the magma type of Gattar granite as well as its tectonic setting. He concluded that the K/Rb ratio indicated that the source region from which the granitic magma originated were Rb- enriched and this may indicate that these younger granites could originate from recycled crustal materials.

Salman et al., (1994) mentioned the following uranium minerals in GI and GII, using X-ray diffraction analysis: - 1) In GI occurrence:- Uraninite, becquerelite, umohite, carnotite, uranophane and soddyite., and 2) In GII occurrence:- Clarkeite, zippeite, uranophane, soddyite and kasolite.

The Hammamat sedimentary rocks, bordering the northern peripheries of the granite along W. Belieh, are essentially composed of siltstones of dark green to greenish black colors, foliated and well jointed. Their bedding attitudes are dipping $45^{\circ} - 50^{\circ}$ to the SSE direction. Near the contact with G. Gattar granite, their bedding is obliterated and they were affected by local metamorphism due to their intrusion by the huge mass of the pink granite batholith **(Roz, 1994)**.

Abu Zeid (1995) studied the relation between surface and subsurface uranium mineralization and structural features of G.Gattar, the studied area was bounded by Latitude 27^0 02' 20" N and Longitudes 33^0 14' 11", 33^0 20' 26" E, covering about 148 km^2. The area is covered by Hammamat Sedimentary rocks and G.Gattar granites. Uranium deposit and the presence of uranium minerals at different levels confirm the role of ascending hypogene solutions in the granites and their adjacent Hammamat sedimentary rocks.

Haridy (1995) studied the physical and mechanical properties of G.Gattar granites pluton and the relation to the joint type uranium mineralization. In this study field measurements, of the structural elements affecting both the younger granites and Hammamat sedimentary rocks, were statistically treated and stress analyses were carried oud to delineate the paleostresses which affected the area.

Khalaf (1995) studied the mineralogy of G. Gattar granites, using X- ray diffraction and indicated the presence of uranophane, beta-uranophane as secondary uranium minerals. She added that fluorite and iron oxide are always associated with uranium mineralization.

Khazback *et al.*, (1995) stated that the secondary uranium minerals in G-II occurrence are mainly uranophane, beta- uranophane, Kasolite and iron – uraniferous granites.

Mahmoud (1995) studied the distribution and recovery of uranium and molybdenum from their minerals at G.Gattar area. He identified the uranium minerals as uranophane, beta – uranophane. Masuyite has been also recorded for the first time in the study area. Besides, molybdenite, as a representative mineral for molybdenum ore. A technical flow-sheet for the extraction of both uranium and molybdenum was proposed at the end of the leaching study.

Shalaby (1995) mentioned that the presence of potential uranium mineralization in G.Gattar granites is greatly affected by the presence of internal tectonic events, which offered good ground preparation of the sites for mineralization. He also added that, G.Gattar granite is characterized by high magmatic uranium background, which ranges from 12 ppm to 25 ppm, hence it is considered as uraniferous granite.

Detailed field structural measurements were carried out by **Shalaby (1996)**, at the various uranium occurrences of Gabal Gattar uranium prospect, in order to determine their structural relationships and the influence of stress and mechanical properties of the host rocks on the opening of fractures and joints for mineralization. Gattar–V occurrence was involved in this study. This study revealed that the various uranium occurrences are mostly controlled by sinistral faults dipping from 65° to 85° to the ESE direction and NW-SE dextral faults dipping between 70° and 80° to the SW direction. The study also revealed that uranium mineralization took place along the AC and BC tension planes and their intersections.
He mentioned that the model of compressive stress at G.Gattar area indicated that the area was affected by a main compressive force mostly directed NNW and plunging to the NNW with an angle of 30^{o}.

Youssief (1996) in his correlation among some uraniferous granitic rocks from the Egyptain Eastern Desert, concluded that Gabal Gattar granites are subsolvus, peraluminous, S-type granites of collision tectonic setting. These granites were derived from the remelting of materials and emplacement during the late-collision stage, He also added that the autoradiographic technique indicated the probability of the presence of primary uranium minerals in these granites. He also mentioned that the radiometric investigations suggested that G.Gattar granites are uraniferous granites. The pre-exising primary uranium minerals are the source of the present secondary uranium mineralization with a contribution from the hydrothermal source.

According to **Moharem (1997)** G. Gattar granite is considered as strongly differentiated, low calcium granite and originated from peraluminous calc-alkaline magma with some alkaline affinity. It is considered as post orogenic granite intruded in crust of thickness greater than 10 km at water pressure between 1 and 2 kb. They have been crystallized at temperature ranging from 800 C to850 ºC. He also added that the area was affected by various cycles of different types of hydrothermal solutions having various compositions which caused the different alteration types of the granite. The measurements of radioactivity revealed that the altered granites possess higher uranium content than the fresh one. The ferruginated granite is the highest mineralized one followed by the silicified granite, kaolinitized granite and finally the desilicified granite. Uranium and thorium are concentrated mainly in the accessory minerals; more than 80% of U is contained in accessory minerals while only a maximum of 20% U is associated with essential minerals. The secondary minerals (as hematite, fluorite, and clay minerals), which were formed during post magmatic processes, concentrating much more U than Th indicating that U enrichment is controlled to a great extent by post magmatic processes.

Shalaby and Moharem (2001) suggested that the geochemical behavior of U and the genesis of U deposits in G-V occurrence could have proceeded through the following successive stages:

(1) Uranium was mainly first trapped in the crystal lattice of accessory minerals of the granites.

(2) The area was affected by tectonic events producing faults and shear zones which acted as good channels for the hydrothermal ascending fluids and the percolating meteoric water to mix with the trapped residual magmatic fluids rich in U and Th and generating a low temperature hydrothermal system. This releases U from the essential and accessory minerals of the hosting granites are redeposited as uranium minerals in the shear zones.

(3) The supergene meteoric water and super heated solutions could pass through the structural network. They leached some of the magmatic U from the younger granites and reprecipitated their loads, in the shear and weak zones of the Hammamat sediments, by the effect of evaporation and adsorption on the surface of Fe oxides and clay minerals.

Abu Steet (2003) noticed that the acidic Dokhan volcanic has a relatively high radioactivity (4.7-10.5 ppm). Also, syanogranite and monzogranite rich in magmatic uranium 21.7 and 11 ppm, respectively. This high uranium content in both acidic Dokhan volcanic and younger granites could be considered as source rock for uranium.

Salem *et al*., (2003) studied the geological and fluid inclusion constraints on the genesis of hydrothermal uranium deposits. They mentioned that the homogenization temperatures from the pre-ore stage (Na – metasomatism) on quartz range from 220 ˚C to 320 ˚C, with salinities of 9.8 to 22 wt% NaCl equivalent. Homogenization temperatures from the ore-stage on fluorite range from 122 ^{0}C to 263 ^{0}C with salinities of 12 to 5.6 wt % NaCl equivalent. The temperature from the post – ore stage on calcite ranges from 110 ^{0}C to 140 ^{0}C, with salinities of 1.2 to 3.2 wt% NaCl equivalent and boiling was detected in the ore-stage. She (op. cit) mentioned that the precipitation of pitchblende from hydrothermal fluids in fractures, vein filling and dissemination in brecciated zones occurred by leaching pink granites and Hammamat sediments through exchange reactions initially at temperatures of 320 ^{o}C falling to 110 ^{o}C at a depth of about 430 m (water pressure 52 bars and density equivalent to 0.92 g/cm3) which indicates epithermal origin for uranium mineralization at Gattar area.

Hammoda (2003) carried out comparative mineralogical and geochemical studies of some surface and subsurface granite samples 610 m

Gattar- I uranium occurrence. He noticed that the presence of quartz veinlets and deep violet fluorite in the mineralized granites is a supporting evidence for the role of hydrothermal solution that accumulated uranium mineralization in their present position.

El-Dabe (2004) in his studies on the geology and radioelements distribution in Gabal Salaat El-Bali and G.El-Reddah environs recorded two radioactive anomalies during the geological and radiometric survey. He mentioned that the first one is encountered associated with a fluorite vein striking NW-SE and cutting the Gattar granite. The second one is associated with quartz vein intruding the quartz diorite in a NW-SE direction. He (op. cit) mentioned that the radioactive anomalies are mainly associated with crushed and shear zones which are characterized by extensive alteration features such as hematitization, kaolinitization, silicification and manganese oxide staining.

Mahfouz, (2004) studied the contact zones between Hammamat sediments and younger granite in the areas of G.Umm Had and G. Gattar. At Umm Had area, although the geological situation is the intrusion of granitic rocks into Hammamat sediments and presence of high uranium contents in the Um Had granite as well as the presence of fracture system affecting it, there is no visible secondary uranium mineralization in these fractures or along the contact with Hammamat sedimentary rocks. The possible reason for this observation is the absence of uranium source and suitable conditions for the formation of secondary uranium mineralization.

Abdel-Hamid (2006) discussed the geologic factors controlling the radon emanation that used as guide for locating subsurface mineralization zone.

1. 4. Scope and aims of the present study

Intensive uranium exploration and prospecting programs, conducted at the Eastern Desert of Egypt, by the Nuclear Materials Authority, showed that most of the discovered uranium mineralization are hosted by the younger (Gattarian) granite and few of them were recorded at the Granite-Hammamat contact where some sporadic mineralization are recorded at surface. This unique situation attracted the author's attention and at the same time raised a lot of important specific questions which strongly favored the choice of the subject of the present work. Collectively these questions are mainly concerned with surface and subsurface structural features controlling uranium mineralization at the Granite – Hammamat contact. Answering of these questions necessitated the accomplishment of the following integrated studies and investigations:

1- Constructing a regional geological - structural map of the study area Scale 1: 10.000.
2- Constructing a detailed geological - structural map of the target area Scale 1: 200.
3- Constructing a detailed radiometric contour map for the uranium mineralized zones 1: 200.
4- Constructing a detailed geological - structural map of the drilled trenches and mining works along Hammamat - Granite contact.
5- Treatment of the surface structural elements data and their relation with the uranium mineralization.
6- Correlation between the surface and the subsurface structural elements controlling uranium mineralization.
7- Field spectrometric and lab. radiometric studies for the distribution of uranium and thorium at the study area.

CHAPTER II

Geological Setting

II.1. Introduction

A semi-detailed geological map scaled 1:10,000 was performed for the northern part of G. Gattar. The study area includes the exposures of the Hammamat sedimentary rocks along W. Belieh and W. Umm Balad and the area between Wadi (W.) Belieh and W. Gattar (Fig. 3). It is about 80 Km^2 mainly exhibiting very rough mountainous terrains of northern Gattar granite batholith. Survey work was carried out using 1:10,000 topographic maps as a base over which all the mapped geological information was projected. Geological stations were taken at nearly constant interval (100 m) or profiles to overcome the roughness of the topography.

II.2. Geology

The study area is occupied by Late Proterozoic basement rocks comprising Hammamat sedimentary rocks and Younger granites in the northern part of G. Gattar north of the Eastern Desert. According to the geological map of Egypt (1985) and the classification of El Ramly (1972), the chronological sequence of the rock types exposed in the mapped area (Fig. 3) is as follows:

Quaternary Alluvium Sediments (Q) ---- (Younger)

Basic Dykes (B2)

Gattarian Granites (medium grained biotite granites)

Basic Dykes (B1)

Acidic Dykes (Felsite f1)

Hammamat Sedimentary rocks