CHAPTER VII

SUMMARY AND CONCLUSION

The tectonic evolution of the Neoproterozoic Pan-Afraican basement rocks in the Eastern Desert of Egypt is equivocal and a matter of much debate. It is uncertain wheather they were formed by plate toctonic processes (ensimatic) or they are ensialic and unrelated to subduction of oceanic crust or collision of continental plates.

Several models of formation of the Arabian-Nubian Shield, which in turn a part of the Pan-African belt, were proposed:

(a) The formation and accretion of ensimatic island arcs with marginal basins (Al Shanti and Mitchell, 1976; Al Shanti and Gass, 1983; Bakor et al., 1976; Greenwood et al., 1976; Frisch and Al Shanti, 1977; Gass, 1977, 1981; Schmidt et al., 1979; Kroner, 1983, 1983, 1985; Vail, 1983; Camp, 1984; Stoeser et al., 1984; Stoeser and Comp, 1985).

(b) Rifting of an older sialic basement (Garson and Shalaby, 1976; Hepworth, 1979; Engel et al., 1980; Delfour, 1981; Stern, 1981; Kemp et al., 1982).

Church (1980) suggested also an ensimatic model, but he raised some douts about the idea that all metaultramatic masses of the Eastern Desert of Egypt represent the suture zones of closure of their respective ocean basins. He stated that the ophiolites of the Eastern Desert are exogeosynclinal cycle, rather than by arc-arc collision at the end of the cratonization cycle.

Shackleton et al. (1980) and Ries et al. (1983) considered that the metaultramafic, metagabbros and pillow lavas represent pieces of Precambrian oceanic crust and is overlain by island arc volcanics, and the . sequence is structural rather than a stratigraphic one.

Bentor (1985) proposed four major evolutionary phases for the Arabian-Nubian Shield; a) an oceanic phase (1100-900 Ma), including emplacement of oceanic mafic and ultramafic rocks (ophiolites); b) an island arc phase (950-650 Ma), dominated by andesitic volcanism and dioritic intrusions; c) a calc-alkaline batholithic phase (640-590 Ma), characterized by talc-alkaline and silica-rich magma, as well as the cratonization of the shield; d) a per-alkaline phase (590-540 Ma), produced alkaline granites and rhyolites.

El Gab)/ et al. (1988) classified the shield rocks of the Eastern Desert of 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 sedimentary rocks.
4- Foreland assemblage of Wadi Allaqi.

They (op. cit.) suggested that the second unit was thrust from the east over the pre-Pan-African rocks that were largely mylonitized at shallow depths, or remobilized at greeter depths.

Unrug (1997) stated that the Pan-African orogenic cycle was a period of major crustal accretion, where continental, island arc and oceanic terrains were brought together to form crystalline basement of African continent as part of late Neoproterozoic supercontinent.

Recently, Blasband et al. (2000) proposed accretionary islan arc model for the Arabian-Nubian Shield. Their model envolves three • tectonic phases: Ophiolites and island arc remnants are relicts of an oceanic phase. This phase was followed by arc-accretion. The metamorphic core complexes, late orogenic extensional basins and large strike slip zones were formed during this phase as a result of the gravitional instability at the final stage of arc-accretion phase caused the collapse, which resulted in extension at the latest stages of the Pan-African Orogeny in the Arabian-Nubian Shield.

The present thesis shed much light on the relation between plutonism, faulting and mineralization at the Northern Cabal Qattar peripheral zone, in the Northern Eastern Desert of Egypt. This area shows most of the geological aspects of the basement rocks that exposed to the north of the prominent Qena-Safaga shear zone, which separtaes remobilized older continental rocks and infolded locally metamorphosed Dokhan volcanics and mollase type Hammamat sedimentary rocks to the north from ophiolites, arc metavolcanics and metavolcaniclastics to the south (El Gaby et al., 1988; Hamimi, 1999). The exposed rocks at the area are arranged chronologically starting with the oldest as follows:

Hammamat sedimentary rocks

Acidic and intermediate dykes

Qattar younger granites

Basic dykeS

Quaternary deposites

The Dokhan-Hammamat relationship is nicely observed just to the north of the mapped area. Of important to denote here that the leading work of Akaad and Noweir (1980) indicates that the Hammamat sedimentary rocks recorded eleswhere in the Central and Northern Eastern Desert are formed at, the base of an alternation of predominantely "Igla Formation" which passes upward into sub-greywackes and volcanic arenites frequently enclosing thick conglomerates bands. The derivation of the Igla Formation from the underlying Dokhan volcanics and the varied participation of the latter in the upper Hammamat has led some workers to visualize an unreal contemporaneity between the Hammamat and Dokhan Groups (Akaad, 1996). On the other hand, (El Gaby et al., 1988) assumed that the calc-alkaline granites, the Doldian volcanics and the Hammamat clastics are penecontemporanious and that the granites and volcanics became more acidic and richer in modal K-feldspars. However, El Gaby's opinion has caused bewilderment as regards to the contemporaneity of the Hammamat sedimentary basins themselves.

The Hammamat sedimentary rocks of G. Um Tawat are bordering the northern peripheries of G. Qattar pluton. They are composed mainly of alternating beds of conglomerates, greywakes and siltstones. These sediments are dissected by acidic, intermediate and basic dykes as well as quartz veins. They are distinctly bedded, slightly metamorphosed, probably related to the magmatic activity in the area during the late Precambrian intrusion of the younger granitic pluton.

These rocks comprise two cycles of deposition separated by tectonic processes of folding as indicated by angular unconfonnity between two series.

Cabal Qattar represents the type locality of the Younger Granites in Egypt. It occupies a large part of the mapped area and acquired its importance due to hosting the molybdenum and uranium mineralization. The granites of G. Qattar are characterized by their relief and elevated peaks. They are rosy to reddish in color, medium to coarse grained hard and compact with few or without mafic minerals.

The Qattar granites are produced by magmatic activity marking the end of Pan African orogeny in the Eastern Desert of Egypt. They are post-orogenic, unfoliated, leucocratic, epizonal and display intrusive contact relationship towards the oldest country rocks.

Petrographically, the granites are essentially composed of K-fekdspar, quartz and plagioclase together with minor amount of biotite and opaque minerals. They can be classified as perthitic leucocratic granite and subsolvus granites due to the presence of light minerals and two kinds of feldspars. Zircon, fluorite and iron oxides are the accessory. minerals.

The most common alteration features of the Gabal Qattar granites are mainly represented hematitization, silicification, kaolinitization, fluoritization, episyenitization and dendrites of manganese oxide. The granite of Cabal Qattar cut by basic dykes and quartz veins, while the acidic and intermediate dykes are older than the intrusion of the granite.

The area is fractured and tectonized, pointing that it had been affected by successive tectonic events. These tectonic events created various structural features in the exposed rocks represented by ductile and brittle deformations. The ductile deformation comprises a major abroad

NE-SW anticlinal fold before the intrusion of the granite, which well developed in the oldest series of the Hammamat sedimentary rocks. While the youngest series of Hammamat sedimentary rocks were affected by the intrusion and emplacement of Qattar pluton that forceful the bedding upward. These caused E-W major and minor overturned folds at the southern part of the Gabal Um Tawat at the contact with the granites

Brittle deformation is represented in the study area by joints, fractures and faults. These structures acquired their importance as being the passways for the uranium mineralizing solution.

The statistical treatments and stereographic projection of joints in the Hammamat sedimentary rocks indicate that the most predominant sets strike NE-SW, ENE-WSW, NNW-SSE and NW-SE. For the granite, the most predominant sets strike NE-SW, NW-SE, and NNW-SSE.

Both minor and major faults in the Hammamat sedimentary rocks and Qattar granites were measured and statistically treated. They revealed that the NNE-SSW, NW-SE, NNW-SSE and NE-SW are the most predominant fault trends in the area of investigation.

Based on the field observation, the fault trends could be arranged chronologically from oldest to youngest as follow NE-SW, NNW-SSE, NNE-SSW, NW-SE, and NE-SW.

Field radiometric investigation all over the area of study revealed the presence of various relationship between radioactivity, lithology and structure for the outcropping rocks. The fresh granite of G. Qattar is characterized by high background gamma radioactivity, ranging from 80 to 185 cps, with average 150 cps. The average uranium and thorium contents about 15 ppm and 25 ppm, respectively and the ratio Th/U is around 1.8. This indicates that G. Qatar granite could be considered as uraniferous granite.

The concentration of uranium and thorium in the altered granite ranges from 33 to 10000 ppm, and from 15 to 180 ppm, respectively, with a very small Th/U ratio reached 0.01. This proves a strong secondary enrichment in uranium relative to the thorium.

Many uramium mineralized occurrences were discovered in G. Qattar area, among them the most importance occurrences namely GI, GII, GV and GVI. A brief description of these occurrences will be discussed in the following:

GI occurrence shows that secondary uranium mineralization recorded along NNE-SSW faulted zone. The uranium mineralization is found as a form of discontinuous lenses locating along N10°-20°E trend. Quartz veins and fluorite are visible along this fault zone. The most predominant alteration features met within this occurrence are hematitization silicification, lcaolinitization, fluoritization and epidotization, in addition to small amount of manganese oxide, chloritization and carbonitization.

GII occurrence occurs along the southern tributary of Wadi Balih north of GI occurrence. It is bounded by three major faults, striking N10°E, N65°W and N50°E. The uranium mineralization at this occurrence is found as lenses varying in size and shape. These lenses are structurally controlled. The NNE-SSW, NE-SW and WNW-ESE are the most common trends that control the mineralized lenses. Uranium mineralization is also recorded in subsurface excavated vertical shaft at 40-meter depth. It is associated with jasperoid and silicified vein nearby an altered basic dyke.

GV uranium occurrence is located at the contact between the Hammamat sedimentary rocks and Qattar granites, along the southern bank of Wadi Balih. The uranium mineralization is mainly confined to the fractures and fissures of Hammamat sedimentary rocks with a little amount in the altered granite along the contact zone. The mineralization usually associated with the strongly altered Hammamat and granite. The most predominant alterations are hematitization, bleached Hammamat, kaolinitization, fluoritization, episyenitization of the granite.

GVI uranium occurrence runs subparallel to GI fault trend. It is extends for about 2 km. in length and varies in width from 1 to 10 m in. The secondary uranium mineralization is associated with hematitization, silicification, koalinitization and fluoritization. The mineralizations are found in two parts; along major fracture zone striking NNE-SSW and in the flat topped area. The uranium mineralization at flat topped area is structurally controlled by N-S quartz vein, NW-SE hematitized fracture and E-W master low dipping joint. The high concentration of uranium is encountered along the intersection of these trends.

The relationship of the Qattar pluton against the enveloping Hammamat sedimentary rocks highlighted how pluton is emplaced. The bedding or laminations of the Hammamat sedimentary rocks seem to be forceful and are deformed to become parallel or essentially parallel to the intruding surface of Qattar plutons during its ase.oi Lal depth, the Hammamat sedimentary rocks exhibit a ductile or plastic behavior due to the effect of the invaded granite. This is proved in the field by folding and fracturing of the Hammamat strata near the granitic intrusion.

The obtained results could be explained within the frame of the recently accepted Unger's model, which shows the relation and similarity between the emplacement of granitic plutons and salt intrusion. Where the strain environment along the sides of salt emplacement is matched with what this study describe for the folds, fracture and faults associated with the emplacement of Qattar pluton.