CHAPTER IV: SUMMARY AND CONCLUSIONS

Chapter (4)
Summary and conclusions

The Mediterranean basin consists of different domains formed during the Mesozoic to Present intercalations between Eurasia and Africa. The Mediterranean lithosphere is made up of i) the remnants of the Mesozoic Tethys subducted from the Cretaceous to the Present as a result of the Africa-Eurasia convergence and collision system (Central eastern Mediterranean), ii) Cenozoic lithosphere formed in the back arc regions of some of the numerous Eurasia-Africa subduction systems developed in the last 60Ma at least.

The most important factor in shaping the East Mediterranean area during the Late Cretaceous-Early Tertiary is the subduction of African plate underneath the Crete and Cyprus trenches. Moreover this observation is ascertained by hot spot reference frame **(Gripp and Gordon 2002)**, the Hellenic slap which was attached to the African plate is moving westward relative to the mantle **(Doglinoi et al. 2007)**. The westward movement is opposite to the subduction direction, a model that requires a progressive steepening of the subducted African slap through the upper mantle to the mesopher **(Wortel and Spakman 2000, Piromallo and Morelli 2003)**.

The horizontal velocities of the plates measured in the East Mediterranean area evidence the occurrence of a counterclockwise rotation of a broad region relative to Eurasia from the Arabian plate at rates ranging from 20-30mm/year **(Reilinger et al. 2006)**. In general, all the plates around Eastern Mediterranean, i.e. Eurasia, Arabia and Africa, are moving northeastward with respect to the hypothetic centre of the Earth. In hot spot reference frame relative to the mantle, all these plates rather move in opposite direction (westward or southwestward, **Gripp and Gordon 2002**).

The East Mediterranean is basically a relic of the Neotethys **(Garfunkel 2004)** whose original passive margins are still preserved in the east and to the south in the Levantine and Herodotus basins. To the north, the Eastern Mediterranean is characterized by the NE directed subduction of the African plate under Crete and Cyprus trenches, whereas further south of the Herodotus basin rising back arc distinguishes the African plate margin. This back arc included the many folds previously known as the Syrian Arc system.

The back arc system started probably during the Triassic associated with the opening of the Neotethys and the build up and migration of the Cimmerian continent. The build up of these features went gradually through time, with many negative jolts identified by the many unconformities in the Mesozoic-Cenozoic section along the African passive margin.

The general northward subsidence of the African plate and the gradual migration of the Cimmirean continent northward led among other fracture systems to the important E-W faults in Shabrawet area. Further north and along these fault planes basins were developed in embryonic stages and gradually by pull-apart movement helped by the subduction mentioned above, the basins become wide and because of the many movements they were arranged in parallel lines in north Egypt.

The E-W fault system extended in north Egypt since the Triassic through the Jurassic and the Cretaceous leading to the development of the many thick basins in north Egypt including a wide range of sediments dated mostly Jurassic and Cretaceous; only one basin i.e. Arief El Naga is characterized by a Triassic section with both Jurassic and Cretaceous deposits.

The deposition regime through the Phanerozoic and the change in facies through time in the Egyptian rocks, the thick versus thin formations, the unconformities, the rise and fall of sea level, all these and many others are generally ruled by the structure pattern of the study area.

The Archean crust is exposed in West Africa Shield, in the Congo Shield and in Uweinat block in SW Egypt **(Pasyanos and Nyblade, 2007)**. In general the Archean-Proterozoic basement rocks in east Egypt were shaped as a crescent opening to the west and north. The concave side of the crescent was gradually filled by sediments throughout the Phanerozoic, some cascaded over the crescent ridge cropping in its other east side. Sedimentation started humbly mainly with coarse clastics, increasing in thickness northward, with time by fine clastics and carbonates. The sediments unconformably overlie the very uneven and irregular surface of the underlying basement rocks. This basal surface had high ridges or arches running in a NE-SW direction. Most important and extensive well developed arch is the Uweinat-Bahariya-Port Said arch running in between Gabal Uweinat in the southwest corner of Egypt, through Bahariya Oasis and extends further to the NE to reach the Mediterranean to the east of Port Said. Next to the east another arch was well developed, Bir Tarfawi-Qena-South Sinai. More to the southeast, the Chepheren Quarries-Kom Ombo arch is located, the continuation of the arch to the NE is lost in the many swarms and basement dykes of Central Eastern Desert.

Other arches were mapped and described by **Issawi et al. (2009)** covering many lines in north Eastern Desert and Sinai. Of importance to the present study is the Trans North Egypt Fracture Zone which stretches in between Taba in the east at the head of the Aqaba Gulf through Ras El Naqb-El Temed, Suez-Cairo where it bends to the NW to reach Daba'a on the Mediterranean shore. In most if not all along these arches, the basement is near to the surface since the arches are constantly uplifted, whereas on both sides the areas are gradually sinking

and full by the addition of new sediments with time. Drilling at Arief El Naga, in NE Sinai, reached the basement rocks from below the basal Triassic sediments.

From this general picture it seems that in the many domal areas in north Sinai or in the north Eastern Desert the basement is found at shallow depths below the sediments. The intense structures on the surface along these lines especially what has been known as the Syrian Arc system plus the Shabrawet area, Gabal Ataqa, Northern and Southern Galalas, are expressions of the subsurface structures. In other words what we see on the surface is a reflection of what is found in the subsurface. Contrary to that in between arches the thick sedimentary cover nullifies the stresses in the basement or the deep sediments and major changes in between the surface and subsurface were well noticed and described by geophysical studies.

The general structure of the area is represented by a huge major dome covering an area of 15km^2. Along the axis of this dome, two closures (anticlines) mark the center of this dome namely Shabrawet east and Shabrawet west. Along the southern flank of the major, dome a crescent strike-slip fault was mapped trending nearly E-W displacing the Wadi Hof Formation against the Shabrawet Group. A major thrust trending ENE-WSW was observed along the axis of the two Shabrawet anticlines. The major dome is covered by Miocene sediments represented by Sadat Formation at base, Hommath Formation at Middle, and Hagul Formation at top. Along the axis of this major dome, the two Shabrawet closures; the eastern closure, Shabrawet east, is covered by Lower Cretaceous Malha Formation at base overlain by Cenomanian Halal Formation followed by Turonian Maghra El Hadida Formation and capped by 50m Pliocene conglomerates.

At Shabrawet west closure, the core is covered by Cenomanian Halal Formation overlain by Turonian Maghra El Hadida Formation and topped by Upper Eocene Wadi Hof Formation. The E-W thrust fault dissecting the two Shabrawet anticlines most probably cut through the area post Turonian, Maghra El Hadida Formation. South of this fault, within the two Shabrawet anticlines, the area there is covered by a thick ca. 300m conglomerate succession including paleosol thin beds, deposited through a long span of time, post Turonian up to the Priabonian. It seems that the northern part of the two Shabrawets was episodically submerged during the Early Cretaceous, the Cenomanian, the Turonian followed unconformablly by Priabonian Wadi Hof Formation. However, even through this Lower Cretaceous section intraformational conglomerates depict other diastems within the Cretaceous and the Upper Eocene sediments. An important N-S fault displaced Shabrawet east up against Shabrawet west, the Lower Cretaceous Malha Formation is at Shabrawet east against the Cenomanian Halal Formation in Shabrawet west.

The continuity of Shabrawet Group are lost to the east and southeast of Shabrawet east against a major NNW-SSE fault, which build the Geneifa scarp. It seems that the fault was active since the Bartonian when the area to the east of this fault and west of the Great Bitter Lake was thrown down against the Shabrawet Group to the west of the fault. The section to the east includes thin marl, shale, paleosol, and conglomerate, indicating fluvial environment with shallow marine incursions. The section is 15m thick, the base is not exposed. The correlatability of this section to the top Eocene section in Gabal El Goza El Hamra to the south substantiate its Middle/Late Eocene age.

The different in thickness of the Eocene and Oligocene sediments north of the two Shabrawetes (50m) and south of the crescent fault (ca. 300m) indicates a down faulted block south of the two Shabrawets against north of the fault. The thick conglomerate section south of the two Shabrawets reaching a thickness of ca. 300m is unique succession in the stratigraphy of north Egypt. The section is hereby named Shabrawet Group covering a long time span starting from the Turonian up to the Priabonian. This long time includes other recognizable units by their fossil and lithologic characteristics e.g. in El Galala El Bahariya, Ataqa, northwest Sinai and others, where the succession is almost complete except for the missing and conglomeratic units within the section. The thick conglomerate in Shabrawet area represents a magnafacies **(Teichert, 1958)**, where almost identical lithology was deposited along a wide time span. This proves that the area of the Shabrawet Group has been a dumping continental basin for that long time.