Cretaceous to Miocene, Transgressive - Regressive Sequences of Northern Zelten Platform, Sirt-Basin, Libya

***Senusi M. Harsha**

ABSTRACT:

Four marine transgressive and regressive cycles, were recognized from Cretaceous to Miocene time, one is represented when the origin of the Sirt Basin is attributed to the collapse of the Sirt arch, during Latest Jurassic to early Cretaceous time. In this cycle, the sedimentation had only taken place on the line base of the arch. The Jurassic sediments partially transgressed the arch but are only represented in the flanks due to erosion and uplift.

The second cycle of the Transgression was represented after the northern Tibesti-Sirt uplift collapsed in the beginning of the Cretaceous and during the Upper Cretaceous (Maastrichtian) time.

Big Paleocene Transgression is the third cycle recorded; the deposition was represented by shale sequence (Hagfa shale) in the study area.

The carbonate regressive sequence during the Upper Paleocene (Landanian), the Lower Eocene (Ypresian), and the Middle Eocene (Lutetian) are overlain by the fourth Upper Eocene Transgressive shale cycle. This cycle is represented by Augila shale. The sequence was followed by deposition of shallowing-upward regressive carbonates and evaporates sequence during the Oligocene and Miocene time.

Key words: Sirt Basin, Transgression, Regression, Carbonates, Evaporates, Cretaceous, Miocene

*Staff member faculty of Science University of Tripoli Libya

INTRODUCTION

At the end of the Cretaceous time the Sirt basin was developed in North Africa between the Tethys Sea and the Saharan Shield. Infilling of the basin throughout the Cretaceous -Tertiary period, resulted in the deposition of a thick sequence of clastic rocks and carbonates with minor evaporite, where the reservoirs are usually of Cretaceous, Paleocene, or Eocene age. It lies in the north central part of Libya, and has been affected by several transgressions and regressions of the sea, resulting in the accumulation of a wide variety of sedimentary rocks **(Elag, 1993)**.

The Sirt Basin has large quantity of oil and gas; it contains most of the major oil fields in Libya and is considered the most prolific oil producing basin in North Africa **(Harsha, 2000).**

The study area is located about 50 Km South of Marsa al Braygah, in Northern Zelten platform in the central part of the Sirt Basin (Fig. 1), it lies approximately 29° 30' to 30° E and 19° 30' to 20° N. The study was mainly based on available data (thirteen wire line - logs), the logs were used to examine the subsurface to establish there Transgressive - Regressive sequences from Cretaceous to Miocene time.

GEOLOGICAL AND STRATIGRAPHIC SETTING

The Sirt Basin was developed by an active subsidence and block faulting as a result of the collapse of the Sirt Arch in late Early Cretaceous time **(Gumati, 1985).**

The important structural element in Sirt Basin is the major northwest-southeast trending normal fault **(Fig. 1)**, which divides the Basin into platforms and troughs, distinguish it from other Libyan basins, and extends along the southern flank of the area **(Harsha, 2000)**.

The basin underwent regional uplift, tensional and compressional faulting, and tough subsidence, resulting in a NW trending horst and graben structural style of considerable relief. The Cretaceous continental sands, Lacuastrian and fluvial silts, and shale of the Nubian and Bahi Formations infilled the grabens by mid – to late Cretaceous time.

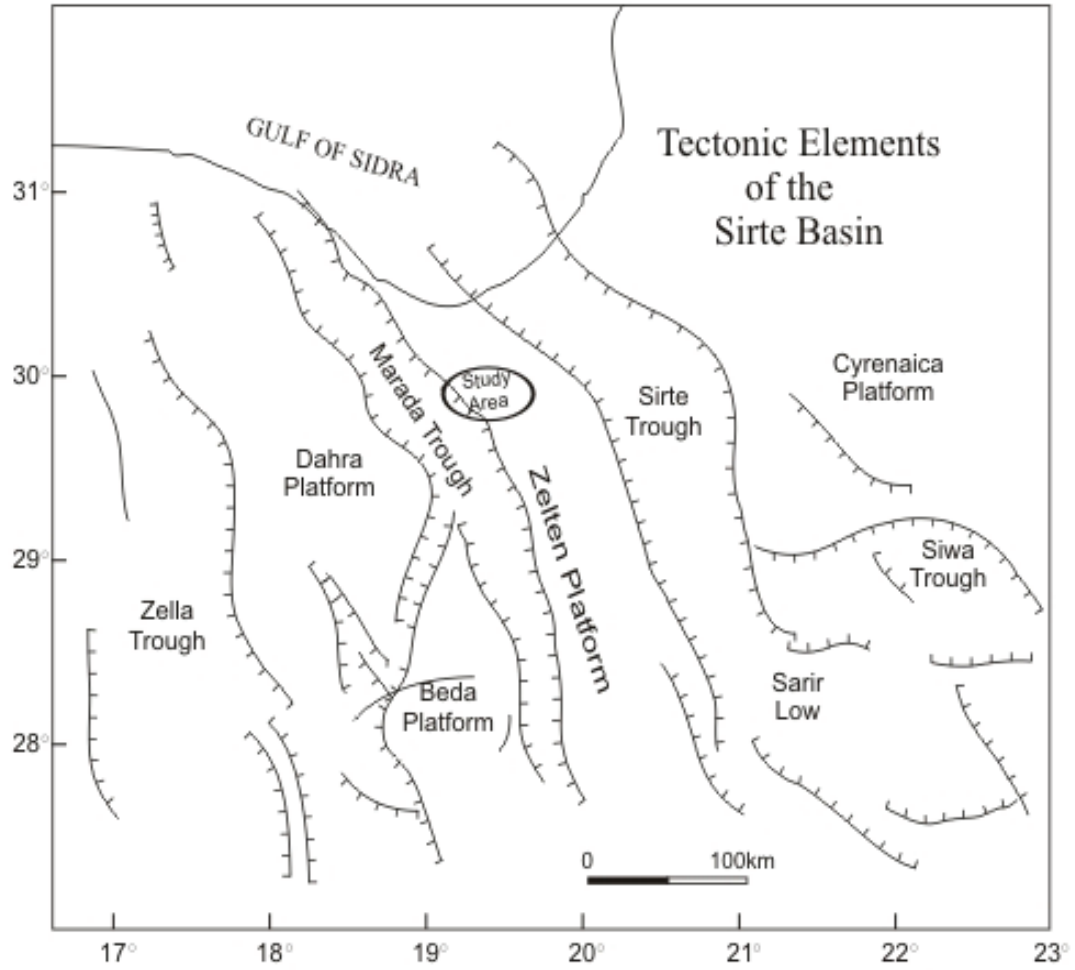

Fig.1. Location of Study area and Tectonic elements of Sirt Basin (modified after Gumati 1996).

The Tethys- seas encroached from the north and further eroded the Gargaf horsts, and reworked the basal Cretaceous sands, producing the first calcareous sand and shale with carbonate being the final stage of deposition for the Cretaceous, these marine sediments comprise the Bahi, Sirt and Kalash Formations **(Fig. 2)**.

By the end of the Cretaceous, shallow epicontinental seas covered the horsts and from the Paleocene through the Eocene, the sediment deposition was of a shallow marine environment. Limestone, marl, shale, and evaporates were cyclically deposited with sands being deposited only in the Oligocene.

The principal reservoir rocks of the Sirt Basin within the vicinity of Northern Zelten Platform sourced by Sirt shale are Cambro-Ordovician (Gargaf Group) sandstones, Lower Cretaceous (Nubian) sandstones, and Upper Cretaceous carbonates. The Hagfa shales have supplied hydrocarbons to Palaeocene and Eocene carbonates and Oligocene sandstones **(Gumati, 1996).-**

ZELTEN PLATFORM

The Zelten Platform **(Fig. 3)** is located in central part of the Sirt Basin, Libya. It covers an area of approximately over 4000 sq. Kilometers, separated from the Jahama Platform in the north by a right-lateral wrench fault. Most of the largest and important oil and gas fields are located on the Zelten Platform **(Fraser, 1967)**.

Don Hallett 2002, suggests Cambro-Ordovician quartzite subcrop the Hercynian unconformity over much of the Zelten Platform, and in the extreme south the quartzite pinch-out onto Precambrian basement.

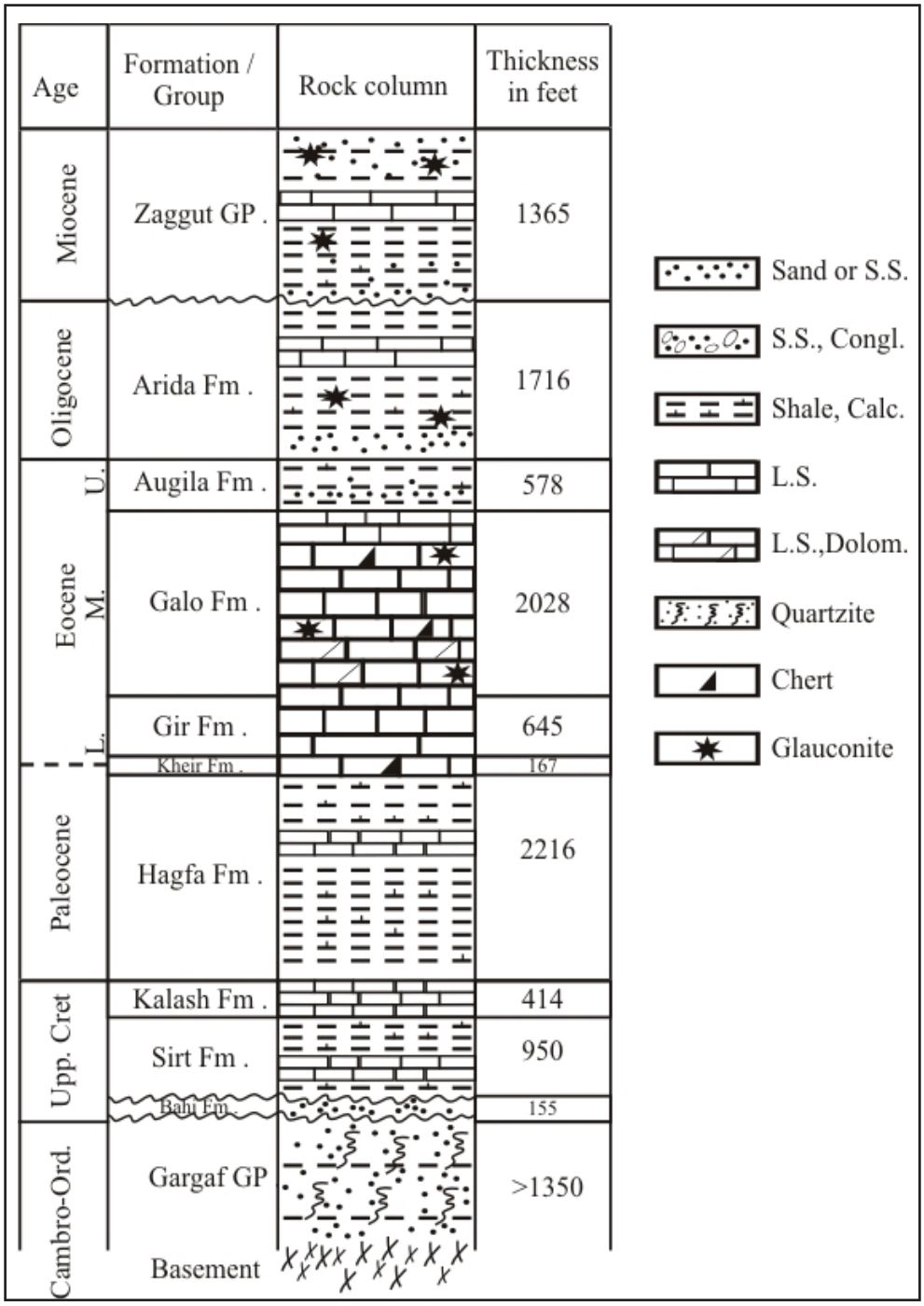

Fig.2. Generalized stratigraphic column of study area.

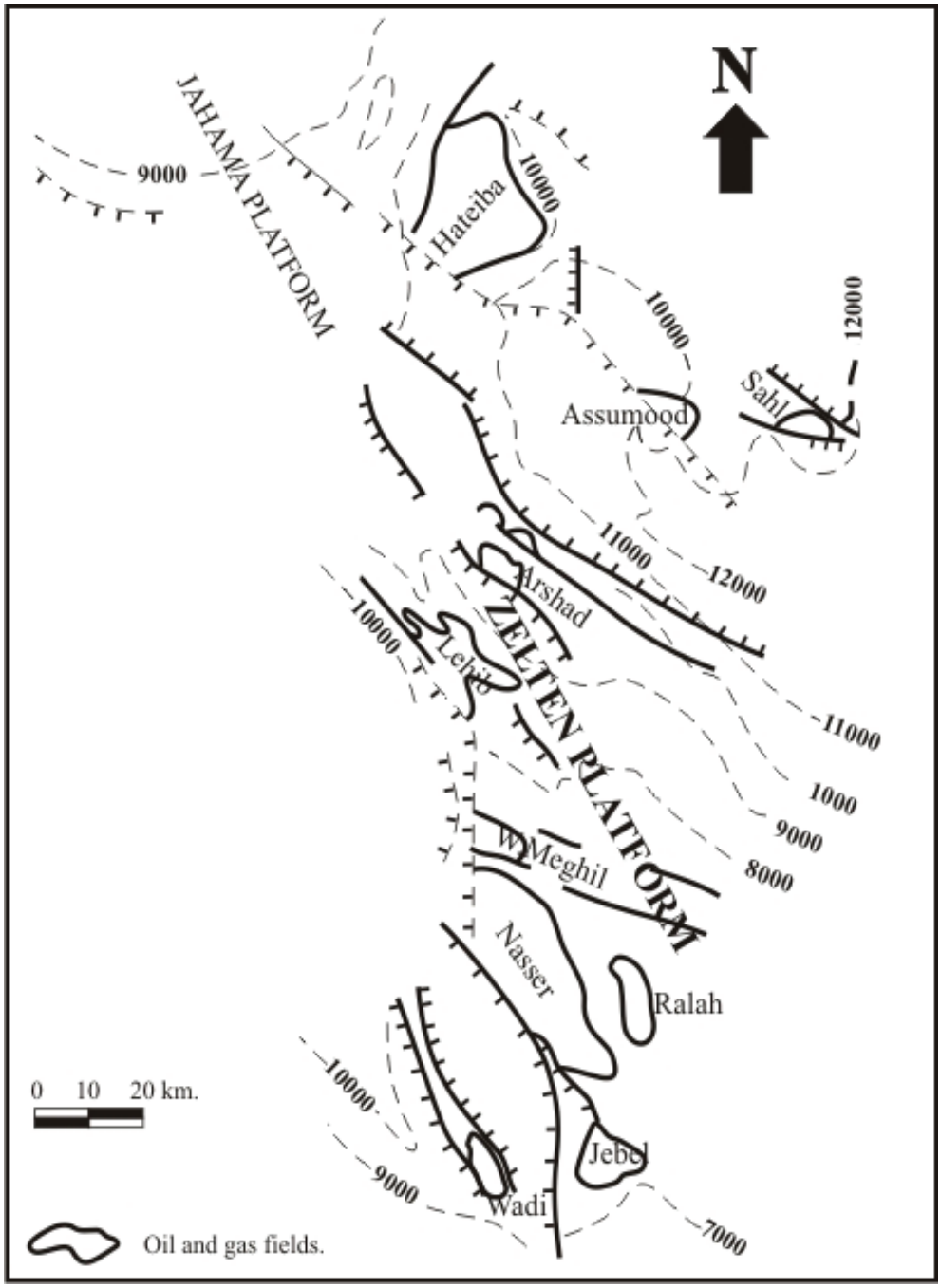

Fig.3. Simplified structure contour near top of Cretaceous and main oil and gas fields in Zelten platform, Sirt-Basin, Libya.

Wennekers 1996, demonstrated however that not all the quartzite are of Cambro-Ordovician age, and most of the fields are underlain by granite. However, Patches of Nubian or Bahi sands are present in structural lows, but in general the marine Cretaceous section is very thin. The high hydrocarbon productivity of the Zelten Platform is probably because it is adjacent to deep Agdabia Trough, where huge quantities of hydrocarbons have been generated in the Sirt and Hagfa Shale.

TRANSGRESSIVE AND REGRESSIVE CYCLES

Libya can be divided into two geologic provinces (the northern and the southern parts), each of which includes a number of sedimentary basins **(Fig. 4)**.

The northern part is situated on a tectonically active and subsiding margin and includes Sirt Basin and Cyrenaica platform. The southern part includes the Ghadames, Murzuk and Kuffrah basins. A number of transgressive and regressive cycles occurred during the Phanerozoic Marine incursions during the Ordovician, Silurian, Devonian, Carboniferous, Late Cretaceous and Tertiary, reached far south into Libya **(Gumati, 1996)**.Thus, the sedimentary section is dominated by marine shales, carbonates and evaporites in the northern part of the country as it is closer to Thetis ocean, (Sirt Basin, Cyrenaica Platform, and Pelagian Basin); whereas, it becomes increasingly non - marine clastic south words Murzuk and Kuffra Basins, with an increasing frequency of stratigraphic hiatuses **(Gumati, 1996)**.

DISCUSSION

After the examine of subsurface to establish there Transgressive - Regressive sequences from Cretaceous to Miocene time, there were four marine cycles of transgressions and regressions have been recognized across the study area **(Fig. 5)**, shale was confined to the very low energy zones during transgressive phases, whereas, carbonates were deposited on the shelf area during regressive phases **(Abushagur, 1987)**, The four depositional cycles are discussed below: -

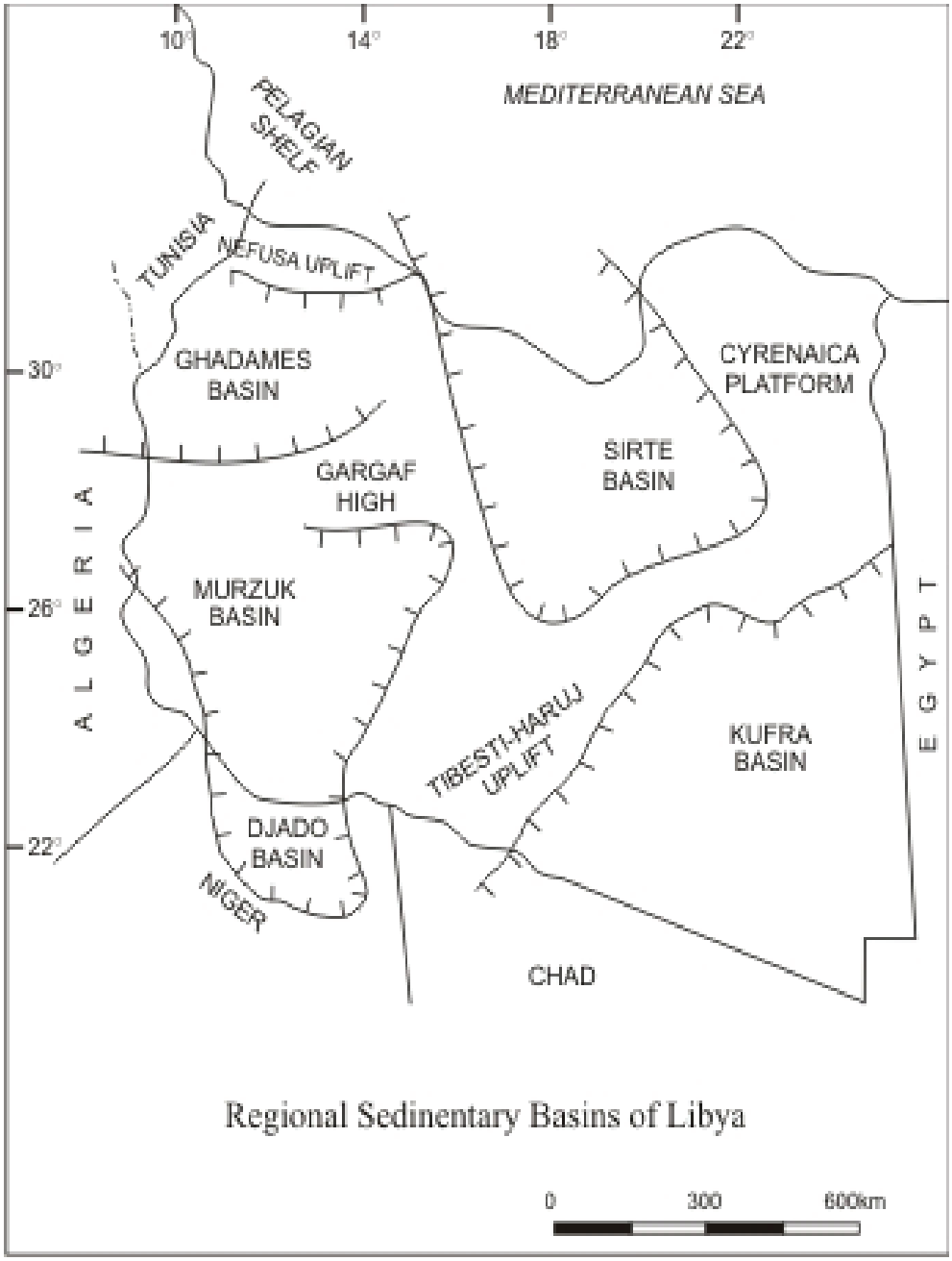

Fig.4. Major Sedimentary Basin of Libya (Modified from Gumati, 1996).

THE FIRST CYCLE

Transgression where usually starts during Early Cretaceous when the Sirt area was still an arch; in this case the sedimentation had only taken place on the line base of the arch, known as Bahi Formation (Cenomanian)..

THE SECOND CYCLE

This cycle was represented after the northern Tibesti - Sirt uplift collapsed in the beginning of Cretaceous and during the Upper Cretaceous (Maastrichtian) time. The Maastrichtian Sea encroached from the North and further, to design the first flooding surface in the area under study.

This sea eroded the Gargaf horst and reworked the basal Cretaceous sand. Thick shale of the Sirt Formation followed by deposition of shallowing-upward regressive carbonate of the Kalash Formation which was deposeted in the troughs, the top of the Kalash Limestone marks the Maastrichtian/ Danian boundary in the area **(Harsha, 2007)**.

THE THIRD CYCLE

In this cycle, the big Paleocene Transgression recorded in Libya, the deposition was represented by a deeper depositional environment, which is a thick transgressive - of low energy zones - shale sequence (Hagfa Shale). However, the shale sequence deposited along the western (Dahra Shale), central (Khalifa Shale), and eastern (Shterat Shale) parts of the Sirt Basin **(Abushagur, 1987)**.

This shale has blanketed much greater areas during transgressive phases. However, the carbonate sediments were deposited during normal regressive periods around the basin rim. The Paleocene time of the Sirt Basin is characterized by carbonate and shales deposited in a shallow inland sea. This heterogeneous series of shales, carbonates and evaporites show considerable variations in formation thickness, which are related to the residual effect of the oil structures rather than renewed tectonic activity **(Harsha, 2007)**.

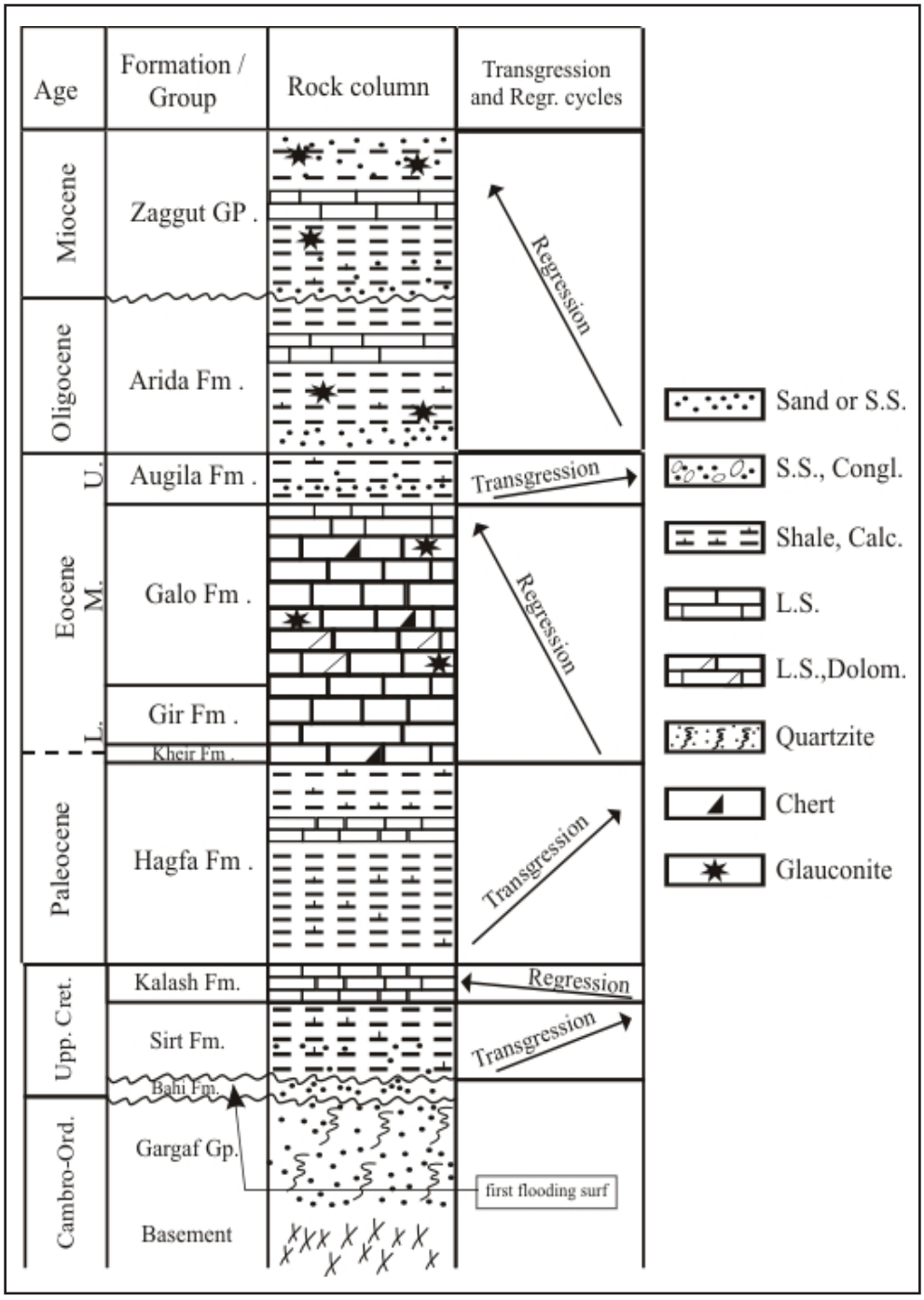

Fig.5. Cretaceous to Miocene Transgression and regression cycles, of study area (Well FF7- 6 is a representative well in this column).

This sequence was followed by deposition of shallowing - upward regressive carbonate and evaporates during the Middle and Upper Paleocene time.

THE FOURTH CYCLE

The carbonate regressive sequence deposited during the Upper Paleocene (Landanian), the Lower Eocene (Ypresian) and the Middle Eocene (Lutetian) are overlain by the fourth Upper Eocene transgressive shale cycle, which represented by Augila Shale in the area under study. The sequence was followed by deposition of shallowing-upward regressive carbonates and evaporites with some sandstone sequence during the Oligocene and Miocene time.

CONCLUSIONS

The study area affected by four marine transgressions and regressions cycles, from Cretaceous to Miocene time, the sequence contains Cambro-Ordovician, Cretaceous, and Tertiary strata, although Upper Paleozoic to Lower Cretaceous sediments are absent due to erosion or non-deposition. The sediments are mainly limestone and shale, sandstone also occurred notably at the bottom and top of the succession.

The Cambro - Ordovician Gargaf Sandstone and the Upper Cretaceous Bahi Formation represent the principal reservoir of the area. The transgressive shale (Sirt - Shale) is regarded as the main hydrocarbon source rock of the Cretaceous reservoirs and the underlying Gargaf sandstone **(Harsha, 2007)**.

The Paleocene sequence is represented by thick marine Hagfa Shale, while shallow marine carbonates were deposited on local highs. The Hagfa shales have supplied hydrocarbons to Paleocene and Eocene carbonates and Oligocene sandstones **(Shaaban, F.F, 2001)**.

REFERNCES

- Abushagur, S. A. 1987. Cyclic Transgressive and Regressive sequence and their association with hydrocarbons, Ghani Field, Sirt Basin Libya, In: The Geology of Libya. Eds. *M. J. Salem and M. N. Belaid,* Tripoli - Univ. Tripoli, Libya. **5**: 1827-1840.
- Don Hallett, 2002. Petroleum Geology of Libya. ELSEVIER Inc. 525 B Street, Suite 1900, San Diego, CA 92101-4495, USA
- Elag, M. O. 1993. Sedimentological Study of Facha Member in Southwest Sirt Basin Libya. The Geology of Sirt Basin, first symposium, Volume II. Ed. *Earth Science Society of Libya (ESSL),* Tripoli, Libya.

- Fraser, W.W. 1967. Geology of the Zelten Field, Sirt Basin, Libya. *Proc. 7th World Petrol. Congr.* **2**: 259-264. Elsevier, Amsterdam.
- Gumati, Y. D., 1996. Wiliam, H. Kanes, and S. Schamel. An evaluation of the hydrocarbon potential of the sedimentary basins of libya. Journal of Petroleum Geology, vol. 19(1), PP. 95-112.
- Gumati, Y. D. and Wiliam, H. Kanes, 1985. Early Tertiary Subsidence and Sedimentary Facies-Northern Sirt Basin, Libya, AAP Bulletin, Vol. 69, No. 1.
- Harsha, S.M., and Owaina, F. 2000. Seismic interpretation of Gargaf Group, Palaeostructures, NW of concession6, Sirt Basin, Libya. Petroleum Research Journal, Vol. 12, 18-24. Tripoli, Libya.
- Harsha, S.M., 2007. Stratigraphic Study, NW of Concession 6, Sirt Basin, Libya. The 6th PESGB / HGS African Conference. Africas Petroleum Systems: From Outcrop to Deepwater, 11th - 13th September 2007. Cape Town International Convention Center, South Africa.
- Shaaban, F. F., and Ghoneim, 2001. Implication of seismic and borehole data for the structure, petrophysics and oil entrapment of Cretaceous-Paleocene reservoirs, northern Sirt Basin, Libya. Journal of African Earth Sciences, Vol. 33, No 1, PP 110 -114.
- Wennekers, J. H. N., Wallace, E. K., and Abugares, Y. I., 1996. The geology and hydrocarbon of the Sirt Basin: a Synopsis of Libya, Geology of Sirt Basin, Vol. 1. (Eds, M. J. Salem, A. J. Mouzughi, and O. S. Hamoda, Elsevier, Amsterdam, p. 3 – 56.