

# Anatomy and development of tectonically-induced Middle Eocene clastic wedge on the southern Tethyan Shelf, North Eastern Desert, Egypt

S. S. Selim\*, A.A.El Araby\*, M. Darwish\*, and A. M. Abu Kharadah\*

Selim@sci.cu.edu.eg

\* Cairo University, Giza, Egypt

## GeoConvention 2012: Vision

### Summary

The Middle Eocene red beds are well exposed at the North Eastern Desert (Shabraweet area) and they show a spectrum from proximal alluvial fan to lagoonal sediments. The depositional history and development of the clastic wedge at the Shabraweet area are controlled by the tectonic inversion pulses along the Syrian Arc inverted belts (Abu Sultan-Abu Hammad belt) and the sea-level fluctuation in the southern Tethyan domain. In order to evaluate the development and the controlling factors of middle Eocene clastic wedge at the Shabraweet area, detailed sedimentologic anatomy, facies, paleoflow direction, clast composition, clast variation in the downstream were evaluated and interpreted.

The study leads to the subdivision of the middle Eocene clastic wedge into five main stacked depositional sequences from base to top. Sequence 1 shows variation from stream-dominated fan-delta in the north to lagoonal deposits through fan-delta fringes. Sequence 2 shows downstream variation from stacked fluvial channels to alluvial fan fringes to distal alluvial floodbasin. Sequence 3 shows downstream variation from amalgamated fluvial channels to alluvial plain deposits. Sequence 4 shows downstream variation from alluvial deposits to lagoon margin deposits. Sequence 5 shows variation from transitional environ (estuarine/deltaic) to off-shore lagoonal environment.

The sedimentary evolution is interpreted as a progradation of an alluvial system, to a lagoonal system, with deltaic environments. This was followed by a tectonic quiescence, sea-level rise and retrogressive alluvial deposits with the development of the lagoonal system. The abrupt increase in the sediment supply relative to the accommodation space leads to a progradation of alluvial/fan delta systems. This was followed by a decrease in the sediment supply and associated by rising in the sea level leading to a retrogradation of the deltaic/estuarine and prevailing lagoonal system.

### Introduction

The Shabraweet area is one of the best exposures for the Syrian Arc inverted structures and the Cretaceous-Eocene contact in the north Eastern Desert of Egypt (Figure1). The Middle Eocene succession at Gabal Shabraweet area has very characteristic facies and geometries that differ from all exposures of the equivalent succession in northern Egypt, so this succession is a subject for several studies concerned with the stratigraphic framework such as El Ahwani (1982), Shamah & Helal (1993), Swedan et al. (1992), Abu El Ghar (2007), and Selim (2011). All the previous studies concern with the stratigraphic framework of the Eocene rocks and show a failure in the understanding of the depositional systems. This paper concentrates on a discontinuous outcrop from north Shabraweet proper to Gabal El Goza El Hamra. This paper presents a detailed analysis of the facies and the stratigraphic

framework of the clastic wedge, and explores external controls on its development, including the potential influence of the basin dynamics.

Specific goals are to:

- 1) Describe the external geometry and internal stratigraphic architecture of a clastic wedge that developed at Shabraweet area and its relationship with the surrounding non-clastic deposits.
- 2) Draw the most suitable depositional model for the Middle Eocene clastic wedge based on the surface exposures.
- 3) Highlight the development of the clastic wedge in relation to key tectonic drivers (Syrian Arc inversion).

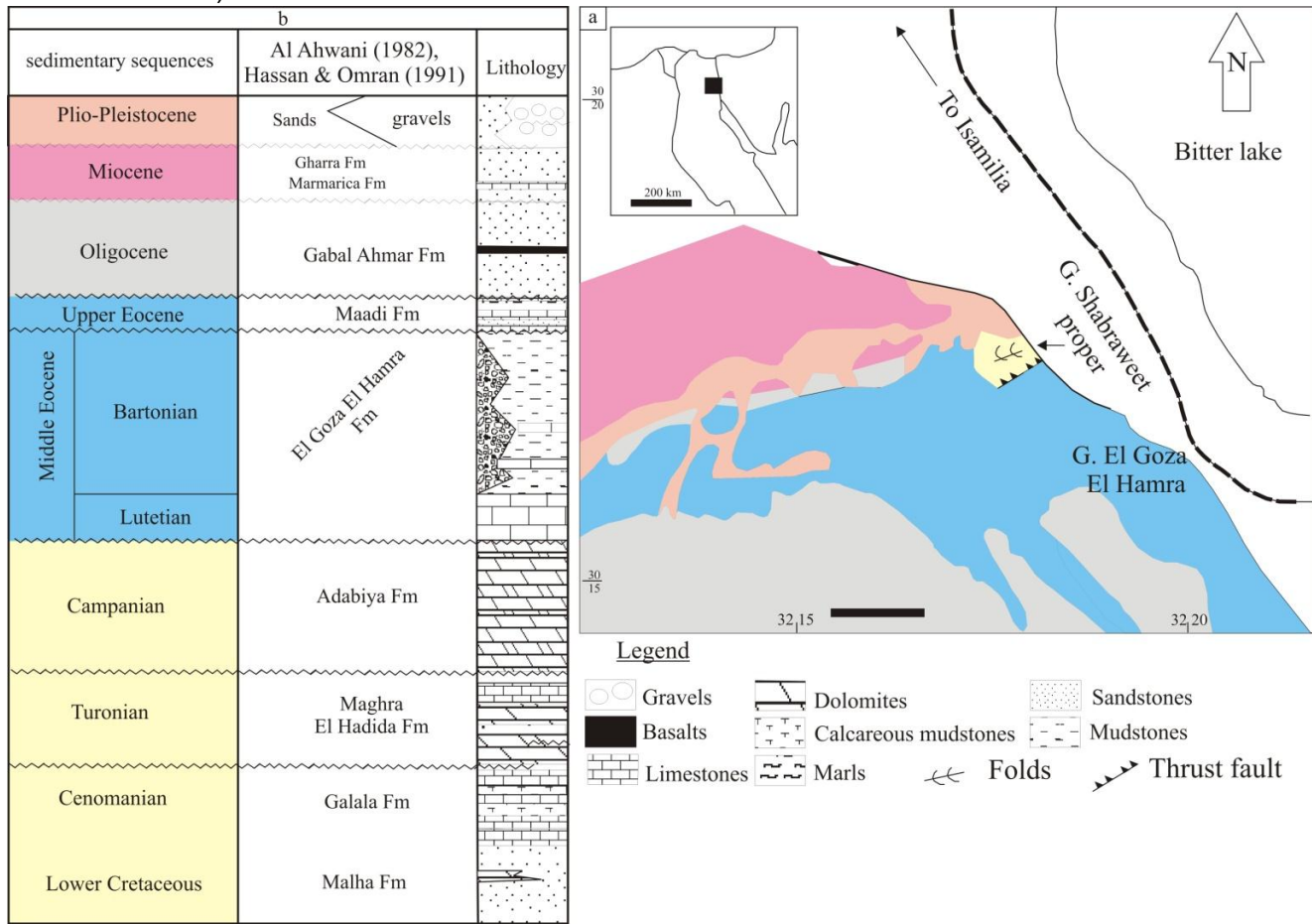


Figure 1. (a) Simplified geologic map of the study area (modified after, Hermina et al. 1989 and Moustafa & Khalil, 1995). (b) Composite stratigraphic succession at the study area after Al Ahwani (1982) and Hassan & Omran (1991) with its modifications.

**Method**

The dataset for this study consists of detailed stratigraphic profiles located in the Shabraweet area (Figure 2). These profiles are given the numbers (1, 2, 3, ....., etc). (Sh) represents abbreviation for the profiles at the Shabraweet area. These stratigraphic profiles were measured and many units were investigated in order to characterize their regional extent and architecture.

Stratigraphic divisions are based on the vertical stacking of depositional facies, vertical and lateral shifts in facies, stratigraphic position relative to surfaces that mark changes in the base level (i.e., flooding

surfaces and sequence boundaries), and strata geometries such as offlap, onlap, toplap, downlap and truncation. A hierarchy of stratigraphic cycles (cycle, cycle sets, sequences and sequence sets) helps to define qualitatively cycle durations and the processes controlling those cycles (VanWagoner et al., 1990; Catuneanu et al., 2009). This paper uses the term “sequence” in the sense of a “depositional sequence” and defines it as an unconformity bounded succession of genetically related strata.

Detailed geological mapping of the Shabraweet area reveals distinct lithologic boundaries in the Middle Eocene rocks. These boundaries are mostly sharp, occasionally erosional, and laterally persistent across the study area. The Middle Eocene succession at the study area is differentiated into five depositional sequences; sequence 1 through 5. The lower two sequences are well exposed and traced laterally through the study area, while the upper three sequences are difficult to be traced laterally at the other profiles due to the general topography. The most complete and well exposed Middle Eocene section is located at Gabal El Goza El Hamra (Figure 3).

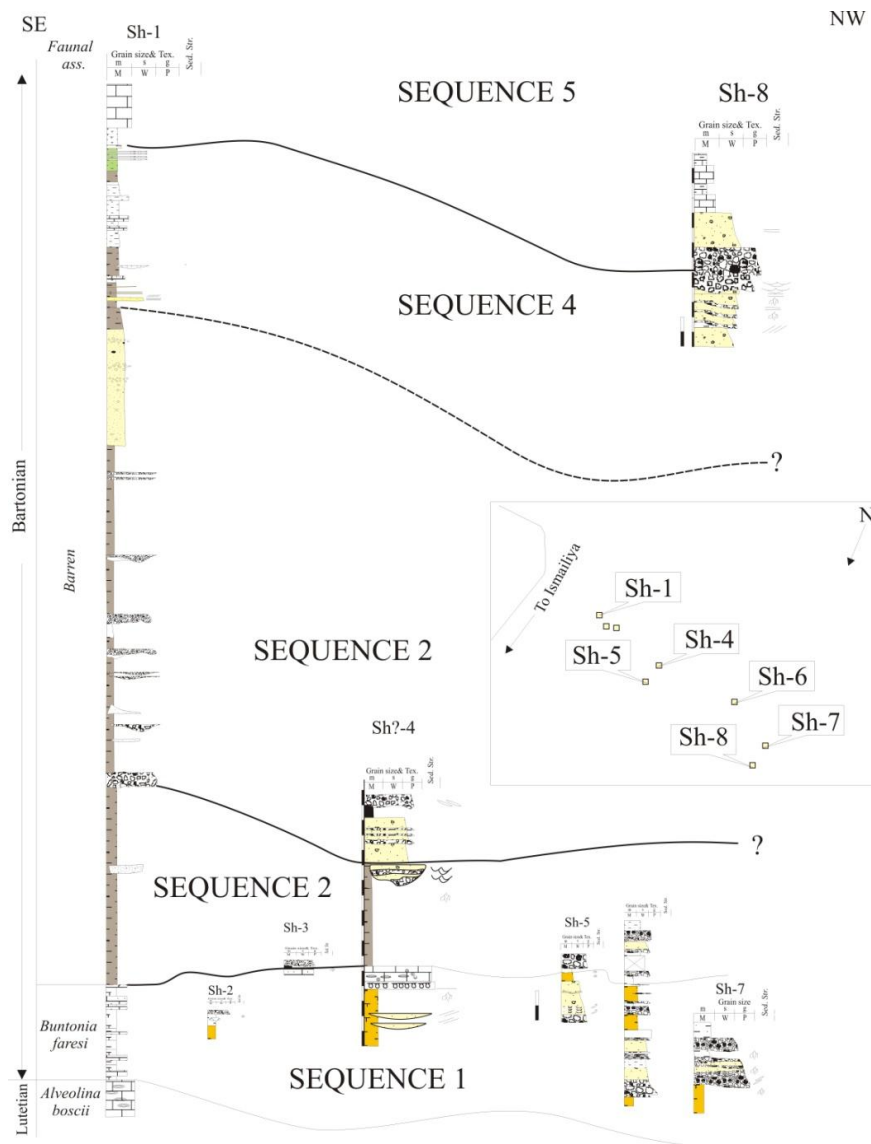


Figure 2: Stratigraphic correlation of measured profiles showing temporal and spatial relationships between the five sequences of the Middle Eocene at Shabraweet area. The inset map shows the locations of the profiles.

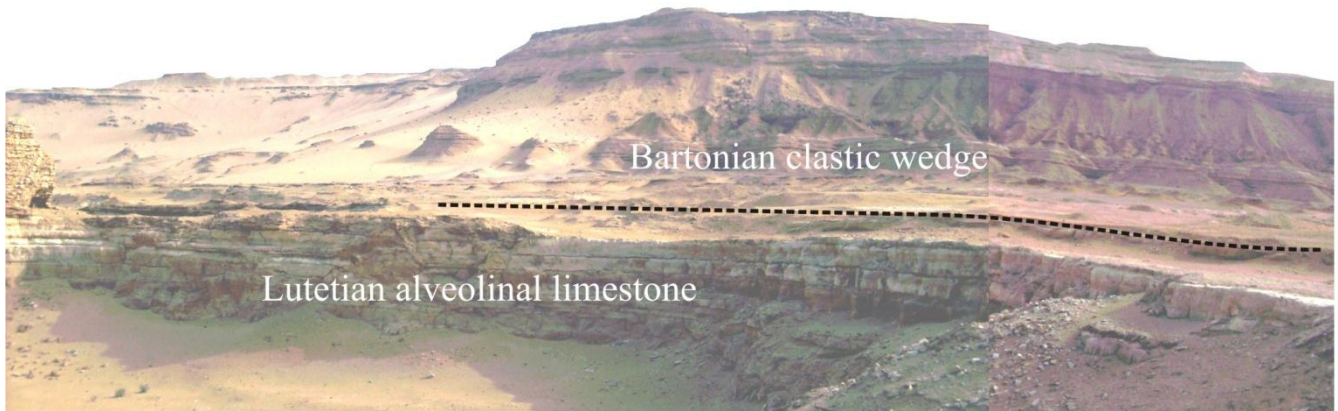


Figure 3. Field panoramic view for the Middle Eocene succession at Gabal El Goza El Hamra, Shabraweet area.

A broad definition of lithofacies was used here to simplify the wide range of facies present in the regional transect; lithofacies were defined based on the characteristic bedding style(s), constituent sedimentary structures, fabric, grain-size and grain composition. Lithofacies assemblages were non-genetic, and were defined based on the relative abundance of conglomerate, sandstone and mudstone. Four lithological groups are recognized in the Upper Middle Eocene at the Shabraweet area: a) conglomerates b) sandstones c) mudstones, and d) carbonates. The conglomerates and sandstones are the dominant facies groups in the northern profiles, while the mudstones and carbonates are the dominant facies groups in the southern profiles. The vertical distribution of facies and their associations is shown in Figure 4.

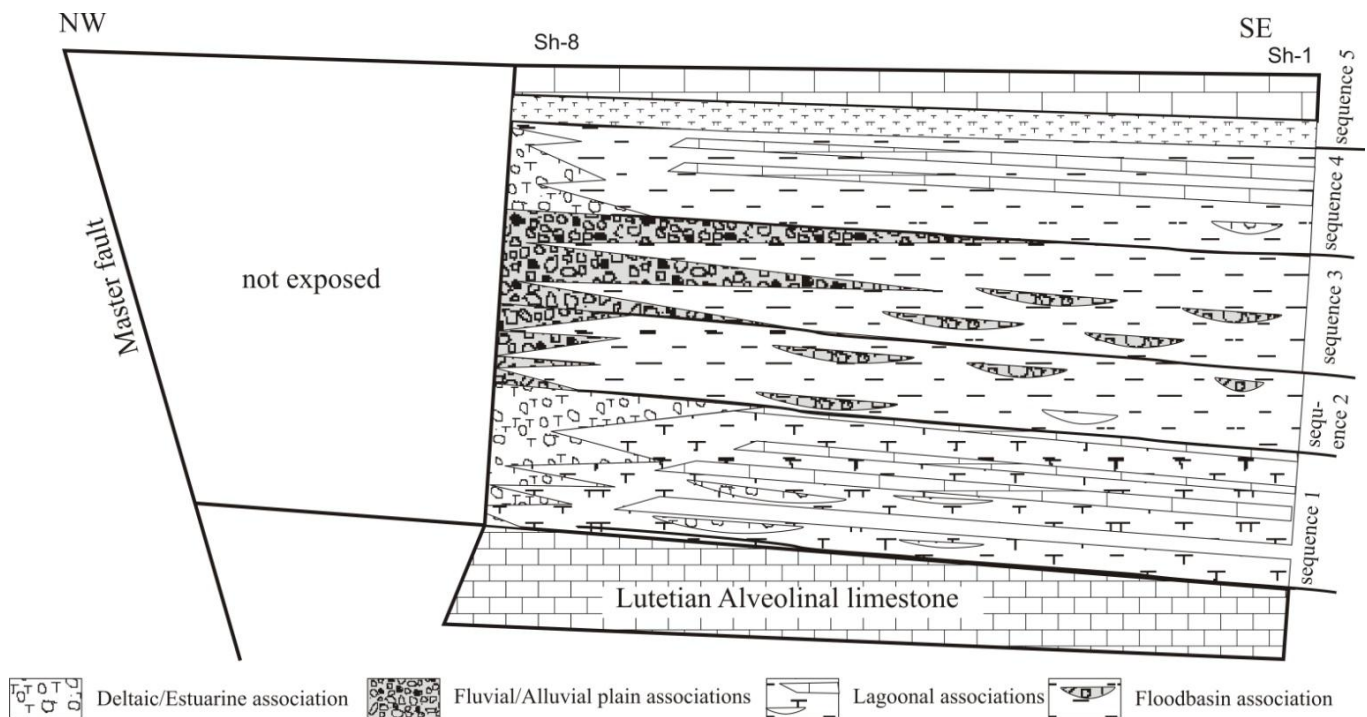


Figure 4. Schematic illustration of stratal pattern and facies distribution of the Middle Eocene clastic wedge at the Shabraweet area. Not to scale (refer to figure 2 for location)

On the basis of the spatial change in facies and bed geometry, the deposits can be grouped into 10 facies associations representing several depositional sub-environments: Facies association I: Stream-dominated Alluvial fan, Facies association II: Stream-dominated Fan Delta, Facies association III: Fan-delta fringes, Facies association IV: lagoonal, Facies association V: alluvial plain, Facies VI: distal floodbasin, Facies association VII: fluvial channels, Facies association VIII: marginal lagoonal, Facies association IX: shallow lagoonal.

## **Conclusion**

The Middle Eocene sedimentary fill of the study area has not been, however, properly mapped and understood before this work, hampering correlation of the sedimentary record with tectonic events and sea level cycles. Details about the sequence architecture and facies distribution within the wedge help in elucidation of the conditions that favor their development, and define phases of evolution of the middle Eocene clastic wedge.

Internally, The Middle Eocene clastic wedge consists of 10 lithofacies stack into 9 facies associations. Our study suggests successive prograding-retrograding depositional series including five sequences separated by several stratigraphic discontinuities, Several laterally interfingering facies associations within each. The sequences 1-3 typically stack as basinward-stepping, sequences and are characteristic of forced regressive and lowstand sequence sets, suggesting short-term cycles of base-level fall superimposed on longer-term cycles of base-level fall. The sequences 4-5 contain an overlapping, transgressive sequence set. Generally, two phases of evolution for the Middle Eocene clastic wedge at the Shabraweet area were interpreted; a lower prograding sequence set and an upper aggrading/retrograding sequence set based on the detailed analysis of the facies and sequence architecture.

Paleogeographic reconstruction documents the progressive inversion of the Middle Eocene marine basin. Lower fan-delta sequence records the first evidence for fluvial inputs into the receding marine basin. The establishment of the continental conditions in the sequences 2-3 marks the complete withdrawal of the Middle Bartonian Sea and leads to the creation of a consequent fluvial network developed within the basin. The paleocurrent data indicates the uni-modal persistent paleocurrent direction (SE). This paleocurrent direction is confirmed by 120° N to 160° N cross bedding/ imbrications directions. Based on the paleocurrent direction and the polymictic nature of the reworked clasts, the provenance of these sediments is probably the central uplifted belts along Abu Hammad-1 and Abu Sultan subsurface inverted structures of Sehim et al. (2003). The source of these sediments probably ranges between Upper Cretaceous and Jurassic paleohighs.

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