Anatomy and Development of Tectonically-Induced Middle Eocene Clastic Wedge on the Southern Tethyan Shelf, North Eastern Desert, Egypt*

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Summary

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

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 deposition with the development of the lagoonal system. The abrupt increase in the sediment supply relative to the accommodation space led to a progradation of alluvial/fan delta systems. This was followed by a decrease in the sediment supply and associated rising sea level, leading to a retrogradation of the deltaic/estuarine and 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 (Figure 1). The middle Eocene succession in Gabal Shabraweet area has very characteristic facies and geometries that differ from all exposures of the equivalent succession in northern Egypt; therefore, this succession is a subject for several studies concerned with the stratigraphic framework (e.g., El Ahwani, 1982; Shamah and Helal, 1993; Swedan et al., 1992; Abu El Ghar, 2007; Selim, 2011). All the previous studies were concern with the stratigraphic framework of the Eocene rockswithout due consideration of the depositional systems. This article concentrates on a discontinuous outcrop from north Shabraweet proper to Gabal El Goza El Hamra; it 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 in the 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).

Method

The dataset for this study consists of detailed stratigraphic profiles located in the Shabraweet area (Figure 2). These profiles are given numbers (1, 2, 3, etc). (Sh) represents abbreviation for the profiles in 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 article 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 in 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 through the area due to the general topography. The most complete and well exposed middle Eocene section is located at Gabal El Goza El Hamra (Figure 3).

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), 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 lithologic groups are recognized in the upper middle Eocene in 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, whereas 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.

On the basis of the spatial change in facies and bed geometry, the deposits can be grouped into 9 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 Fringe; Facies association IV: Lagoonal; Facies association V: Alluvial Plain; Facies association VI: Distal Floodbasin; Facies association VII: Fluvial Channels; Facies association VIII: Marginal Lagoonal; Facies association IX: Shallow Lagoonal.

Conclusion

Before this work, the middle Eocene sedimentary fill in the study area had not been studied in detail, and correlation of the sedimentary record with tectonic events and sea-evel cycles were poorly understood. This study focused on sequence architecture and facies distribution (within the sedimentary wedge) in order to explain the conditions that favored their development and define phases of evolution of the middle Eocene clastic wedge.

Internally, the middle Eocene clastic wedge consists of 10 lithofacies stacked into 9 facies associations. Our study suggests successive prograding-retrograding depositional series, including five sequences separated by several stratigraphic discontinuities and several laterally interfingering facies associations within each. 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 within longer-term cycles of base-level fall. Sequences 4-5 contain an onlapping, transgressive sequence set. Generally, two phases of evolution for the middle Eocene clastic wedge in 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 continental conditions in sequences 2-3 marked the complete withdrawal of the middle Bartonian sea and led to the creation of a consequent fluvial network developed within the basin. The paleocurrent data indicates the unimodal, persistent paleocurrent direction (SE). This paleocurrent direction is confirmed by 120º N to 160º N cross-bedding dip directions. Based on the paleocurrent directions 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 (Sehim et al., 2003). The source of these sediments probably were Late Cretaceous and Jurassic paleohighs.

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Selected References

Abu El Ghar, M.S., 2007, Eocene stratigraphy, facies, sequences and depositional history in Shabraweet area, North of Suez, Eastern Desert, Egypt: ISESCO v. 3/3, p. 23-42.

Al Ahwani, M.M., 1982, Geological and sedimentological studies of Gebel Shabraweet area, Suez Canal District-Egypt: Annal. Geol. Surv. Egypt. XII, p. 305- 381.

Catuneanu, O., V. Abreu, J.P. Bhattacharya, M.D. Blum, R.W. Dalrymple, P.G. Eriksson, C.R. Fielding, W.L. Fisher, W.E. Galloway, M.R. Gibling, K.A. Giles, J.M. Holbrook, R. Jordan, C.G.St.C. Kendall, B. Macurda, O.J. Martinsen, A.D. Miall, J.E. Neal, D. Nummedal, L. Pomar, H.W. Posamentier, B.R. Pratt, J.F. Sarg, K.W. Shanley, R.J. Steel, A. Strasser, M.E. Tucker, and C. Winker, 2009, Towards the standardization of sequence stratigraphy: Earth Science Reviews, v. 92, p. 1–33.

El Ahwani, M.M., 1982, Geological and sedimentological studies of Gabal Shabrawet area, Suez Canal District-Egypt: Ann. Geol. Surv. Egypt, V.XII, p. 305-379.

Faris, M.I., and H.L. Abbas, 1961, The geology of Shabrawet area., Bull. Fac. Sci., Ain shams University, v. 7, p. 37-61.

Hermina, M., E. Klitzesch, and F.K. List, 1989, Stratigraphic lexicon and explanatory notes to the geological map of Egypt: Conoco Corel and Egyptian General Petroleum Corporation (Cairo).

Mostafa, A., 1998, Geological and sedimentological studies of the Upper Cretaceous-Lower Tertiary rocks in the northeastern Desert, Egypt: Unpublished Ph.D. Thesis, El Azhar University, Egypt, 209 p.

Moustafa, A.R., and M.H. Khalil, M.H., 1995, Superposed deformation in the northern Suez rift, Egypt: Relevance to hydrocarbons exploration, Journal of Petroleum Geology, v. 18, p. 245-266.

Shamah, K., and S.A. Helal, 1993, Stratigraphy of the Eocene sediments at Shabrawet area, Suez Canal Zone, Egypt. Egypt Journal of Geology, v. 37, p. 275-298.

Said, R., 1962, Geology of Egypt. Elsevier, New York, 377 p.

Sehim, A., J. Ivankovic, W. Anis, and S. Leustek, 2003, Regional structure setting of the Gulf of Suez:. Oil and Gas International Conference, Zadar, Croatia.

Selim. S.S., 2011, Paleoenvironmental modeling and paleogeography for the Upper Senonian-Paleogene sequences, North of the Gulf of Suez, Egypt with especial emphasis on the red beds: Unpublished Ph.D. Thesis, Cairo University, Giza, Egypt, 350 p.

Shamah, K., and S. Helal, 1993, Benthonic foraminifera from Gabal El-Goza El-Hamra and its neighbourhood, Suez-Canal zone, Egypt: Ann. Geol. Surv. XIX, p. 245-260.

Swedan, A., A. Ibraheim, and A. Kandil, 1991, Back to the future El Ramiya Formation and rewriting the Libyan- Mokattamian stratigraphy of Gabal Ataqa and Gabal El Goza El Hamra: Geol. Surv. Egypt Ann. XVII, p. 193-198.

VanWagoner, J.C., R.M. Mitchum Jr., K.M. Campion, and V.D. Rahmanian, 1990, Siliciclastic sequence stratigraphy in well logs, core, and outcrops: concepts for high-resolution correlation of time and facies: AAPG Methods in Exploration Series 7, 55 p.

Wanas, H.A., and M.M. Abu El-Hassan, 2006, Paleosols in the Upper Cretaceous-Lower Tertiary Maghra El-Bahari Formation along the northwestern side of the Gulf of Suez, Egypt: Recognition and geological significance: Sedimentary Geology, v. 183, p. 243-299.

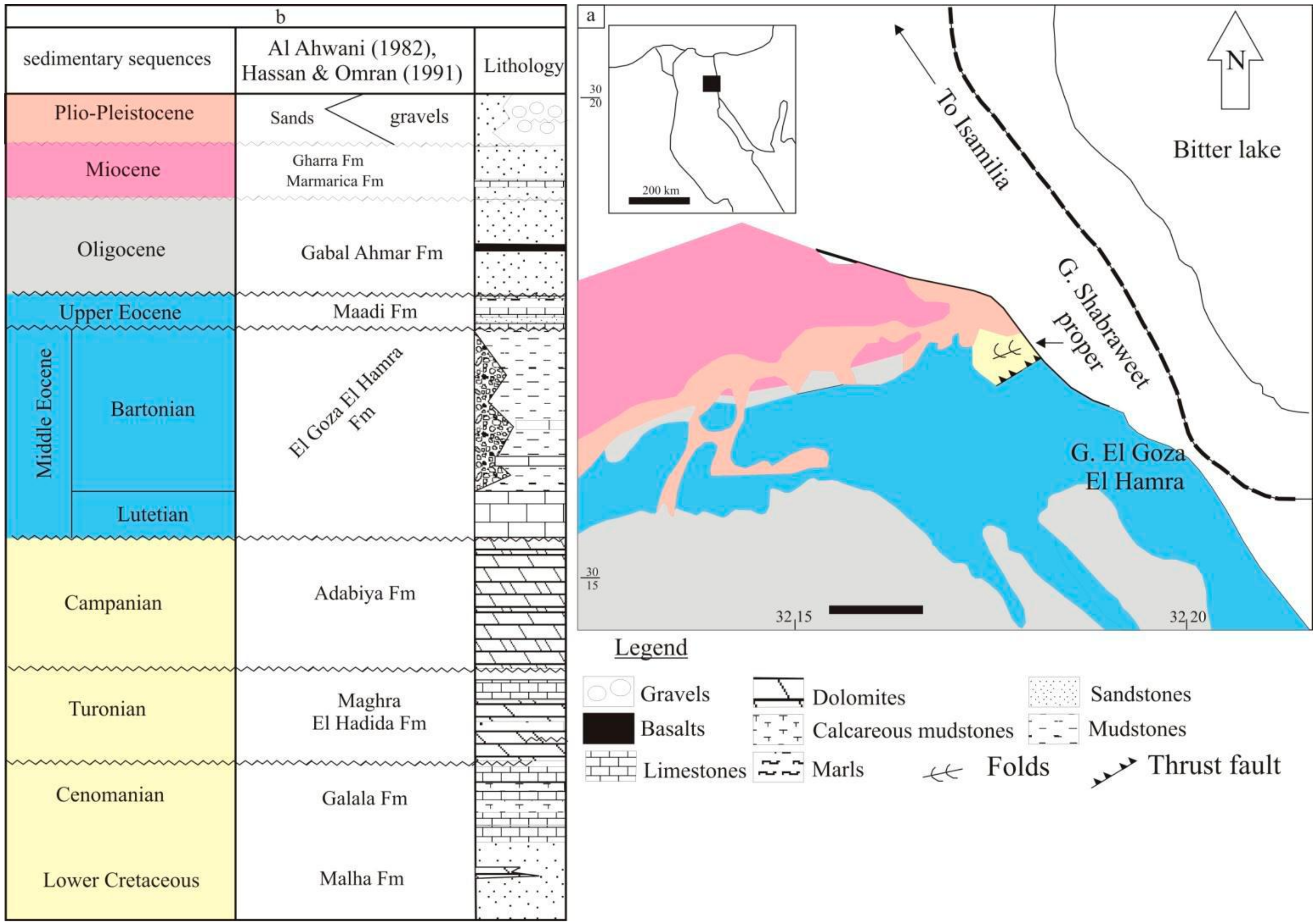

Figure 1. (a) Simplified geologic map of the study area (modified after, Hermina et al. 1989; Moustafa and Khalil, 1995). (b) Composite stratigraphic succession in the study area (modified after Al Ahwani, 1982; Hassan and Omran, 1991).

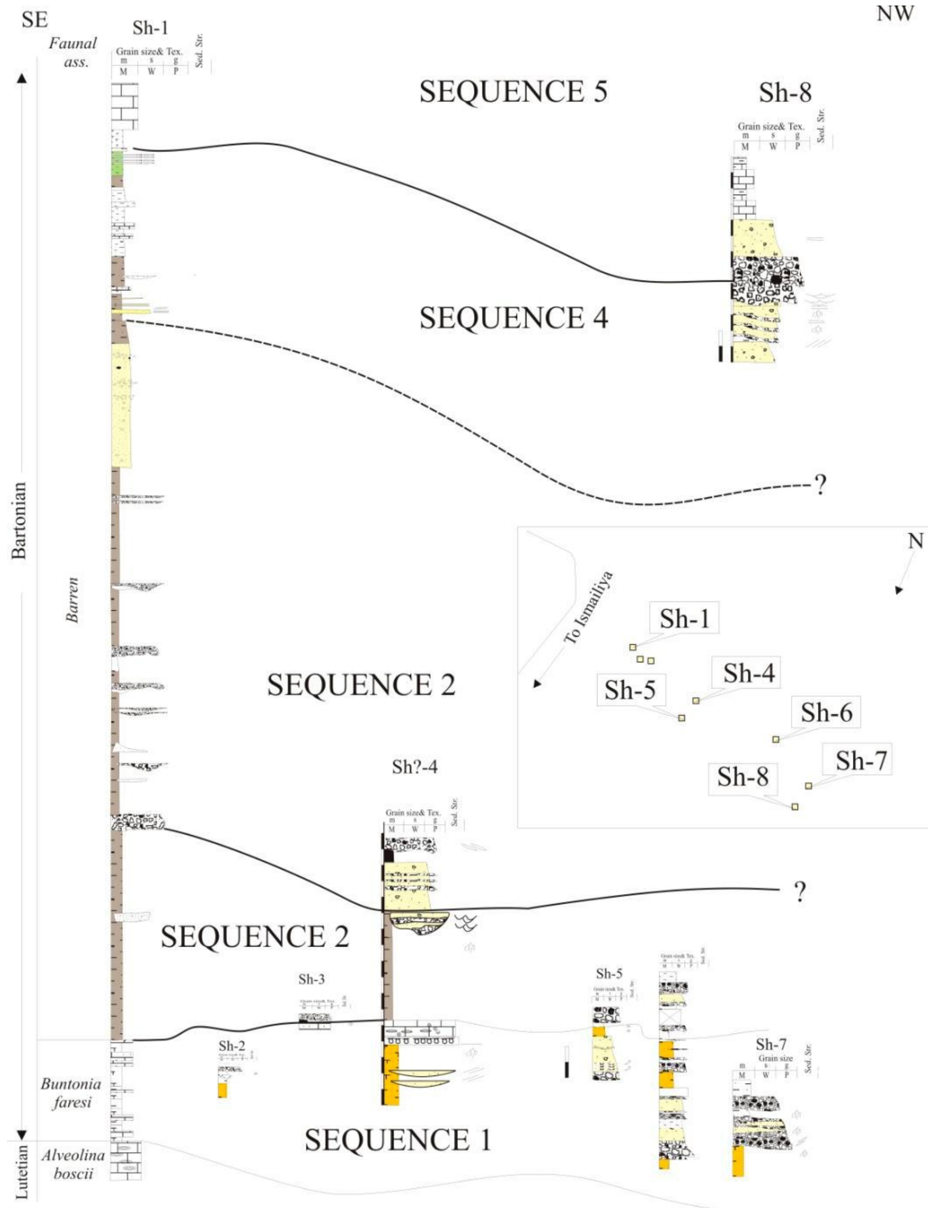

Figure 2: Stratigraphic correlation of measured profiles showings temporal and spatial relationships between the five sequences of the Middle Eocene at Shabraweet area. The inset map shows the locations of the profiles.

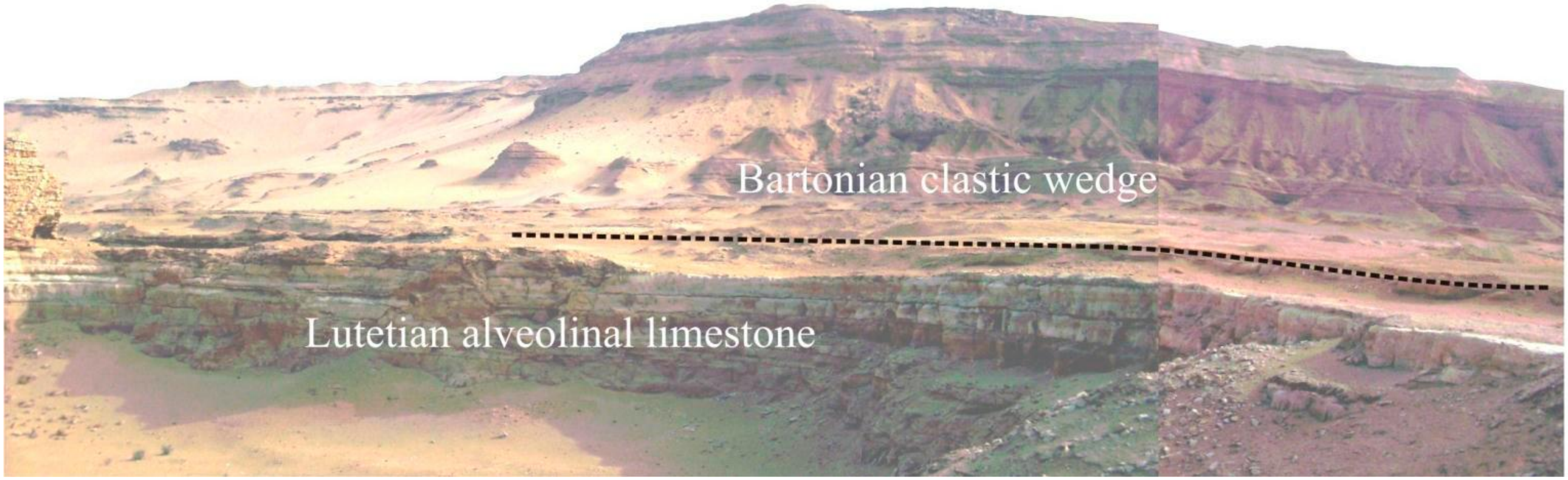

Figure 3. Field panoramic view for the middle Eocene succession at Gabal El Goza El Hamra, Shabraweet area.

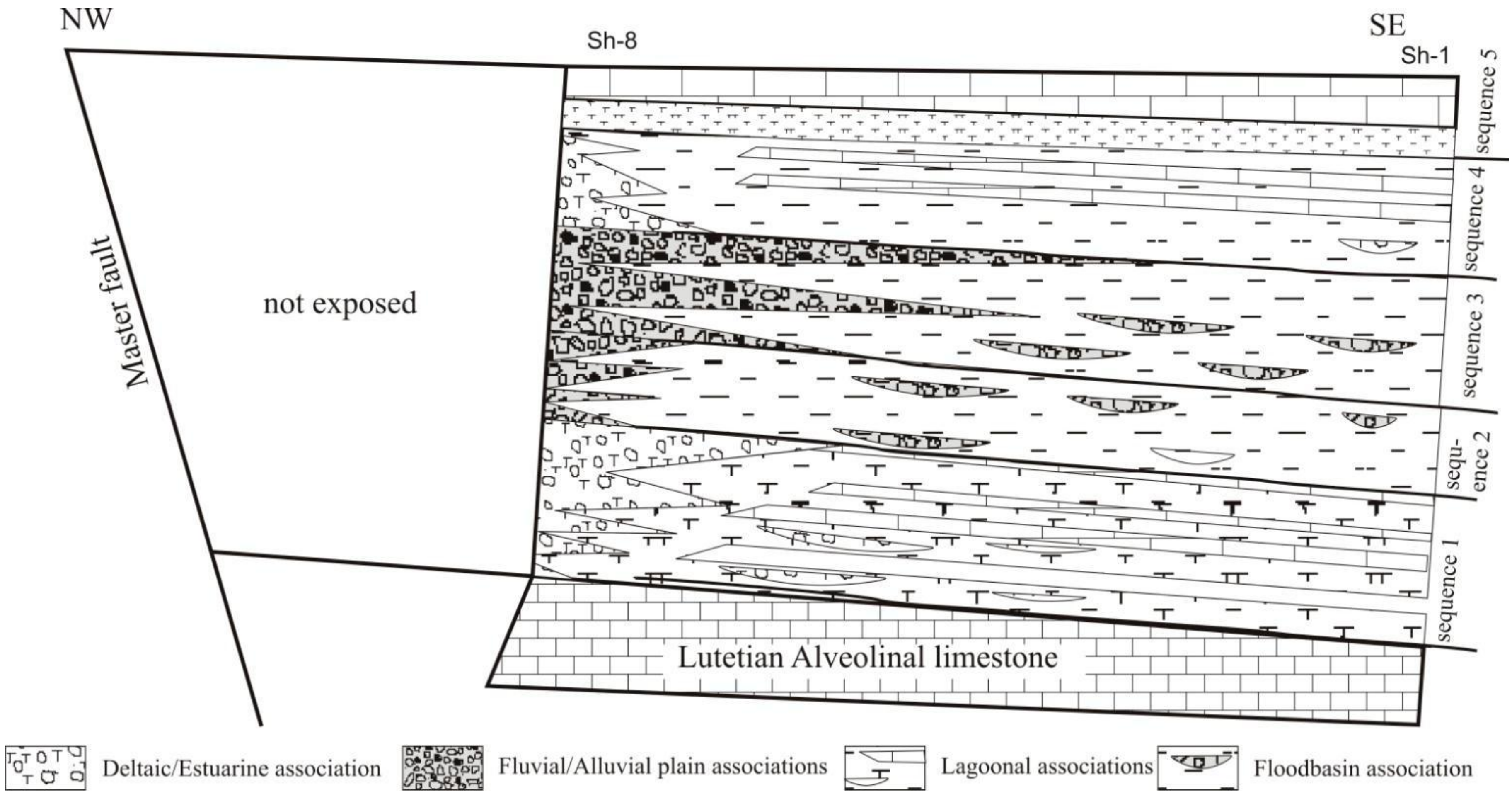

Figure 4. Schematic illustration of stratal pattern and facies distribution of the middle Eocene clastic wedge at the Shabraweet area (not to scale). Refer to Figure 2 for location.