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Sequence stratigraphy of the Cenomanian Galala Formation, north Eastern Desert, Egypt

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ABSTRACT

The sequence stratigraphic framework of the Cenomanian Galala Formation (north Eastern Desert, Egypt) is estimated on the basis of the Sedimentological and obtainable biostratigraphic data, in addition to the regional correlation of the studied sections. Five sequence boundaries are identified. The first sequence boundary separates between the Galala and Malha formations. The second, third and fourth sequence boundary exhibit a differentiated nature. It is noticed that such sequence boundaries in Gebel El-Zeit are mainly represented by paleosols and caliche, while those of the Northern Galala, Gebel Ataqa and Gebel Shabraweet are mostly typified by emergence horizons of dolomites and dedolomites. The fifth (last) sequence boundary separates the Galala Formation from the overlying El-Khashm Formation at Gebel El-Zeit, the Northern Galala and Gebel Ataqa and from Maghra El-Hadida Formation at Gebel Shabraweet.

The Galala Formation in the study area is subdivided into four depositional sequences, which are built up of three systems tracts; the lowstand (LST), transgressive (TST) and highstand (HST) systems tracts. The LSTs are realized only from Gebel El-Zeit, where they are made up of clastic facies organized in coarsening- and fining-upward parasequences. The TSTs form a series of aggradational-retrogradational, shallowing-upward parasequences, which transgress across the ramp till the point of maximum flooding is reached. The HSTs are built up of aggradational–progradational, shallowing-upward parasequences of shallow subtidal to peritidal facies.

1. Introduction

Sequence stratigraphy is the study of repetitive genetically-related depositional facies bounded in part by significant surfaces of non-deposition or erosion (Galloway, 1989 and Catuneanu, 2002). A key concept of sequence stratigraphy is the interplay between eustatic sea-level changes and subsidence rate that creates the accommodation that required for sediment accumulation (Jervey, 1988 and Posamentier et al., 1988). The application of sequence stratigraphy concepts to clastic and carbonate depositional systems has been widely developed by Mitchum (1977), Vail et al. (1977), Vail (1987), Haq et al. (1987 and 1988), Posamentier and Vail, 1988; Sarg (1988), Van Wagoner et al. (1988 and 1990) and Posamentier et al. (1992).

The terminologies of Van Wagoner et al. (1988), Sarg (1988) and Handford and Loucks (1993) supported by modern concepts of Catuneanu (2006) are adopted herein. Except the term parasequence that is used in describing an upward-shallowing succession of facies bounded by marine flooding surfaces (Van Wagoner et al., 1988, 1990). Hence, we used the term cycle instead of parasequence in describing the shallowing-upward or coarsening-upward and fining-upward, or deepening-upward cycles in the present study (Khalifa, 1996). The application of sequence stratigraphic principles can however be successfully performed even in the near absence of constrained time lines, whereas the facies geometry, stacking pattern and depositional models are well understood (Catuneanu et al., 2006, 2009, 2010, 2011). The sequence stratigraphy and cyclicity of the Cenomanian rocks of the Eastern Desert was studied by few workers (e.g. El-Azabi, 1999; Khalil and Mostafa, 2001a,b; Essa, 2005; Abu El-Hassan and Tada, 2005 and Khalifa and El-Ayyat, 2007). The aim of present study is to estimate the sequence stratigraphic classification of the Galala Formation, exposed north of the Eastern Desert. This leads to clarify the relation between sequence boundaries, systems tracts and depositional sequences.

2. Geological background

During the Upper Cretaceous interval, a great transgression progressed covering Egypt from the north until latitude 23° N in south reaching its highest amplitude during the Late Cenomanian time

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(Issawi and Osman, 2000). The tectonism that affected the North African Plate and sea-level changes had a great influence on the depositional history of the Upper Cretaceous successions in Egypt, forming different topographical and structural basins. As a result, the Upper Cretaceous sequence shows a rapid facies change (Issawi et al., 1999). The Cenomanian succession is outcropped in Egypt in three main districts; the Northern and Southern Sinai, Eastern Desert (between Gebel Shabraweet and Wadi Qena) and Western Desert (Bahariya Oasis and doubtfully at Abu Roash area). These areas proved to be active areas of subsidence (Fawzi, 1963). They represent one of the major transgressive cycles during the Cretaceous Period in Egypt, that resulting in forming of very shallow seas to the lows between the elevated massifs (Said, 1990). The transgression of the Cenomanian Sea has progressed generally from the north to the south of Egypt. Generally, the thickness of the exposed marine Cenomanian diminishes gradually towards the south with more clastic facies (maximum thickness is 550 m in the north of Egypt and minimum thickness is 20 m in the south). The Cenomanian rocks form a formal rock unit (Galala Formation) in the northern part of the Eastern Desert (Awad and Abdallah, 1966). The depositional basin of the Galala Formation in the northern part of the north Eastern Desert was deeper than its southern part and free from any argillaceous influx (Metwally and Abd El-Azeam, 1997).

3. Methods

Four stratigraphic sections were measured in the northern Eastern Desert; at Gebel El Zeit, Northern Galala, Gebel Ataqa and Gebel Shabraweet (Fig. 1). In each section, we logged the lithology at decimeter scale and whenever lithologic changes are observed. Identification of fossil association and petrographic investigation of the hard specimens provide a background for interpreting lithology. The sequence stratigraphic study of the Galala Formation is mainly based on the Sedimentological data (Lithostratigraphy and petrography), regional correlation of the studied sections and the available biostratigraphic framework. Sequence stratigraphy was interpreted on the basis of several features including; (1) tracing of erosional surfaces and apparent flooding surfaces in the field, (2) patterns of upward change (fining- and coarsening-upward), (3) types of depositional cycles and 4) types of dolostones occurring in the studied sequence.

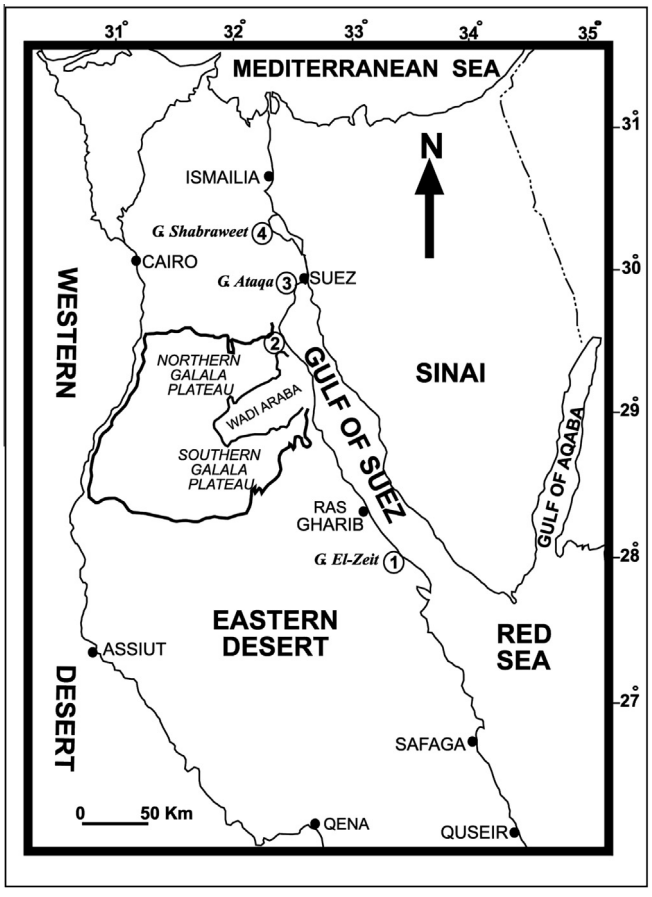

Fig. 1. Location of the studied sections.

4. Lithostratigraphy

The Galala Formation unconformably overlies the fluvio-marine clastic facies of the Early Cretaceous Malha Formation at Gebel El-Zeit and Gebel Shabraweet. The unconformity surface at Gebel El-Zeit separates between the grey, violet, brown sandy claystone of the uppermost Malha Formation and the green to yellowish green claystone of the Galala Formation (Fig. 2A). At the Northern Galala, the Galala Formation conformably overlies the Malha Formation with a sharp contact. The contact is between the red to violet, sandy siltstone of the Malha Formation and the green to yellowish green claystone of the Galala Formation (Fig. 2C). The base of the Galala Formation is unexposed at Gebel Ataqa, while at Gebel Shabraweet; the unconformity surface is represented by an intraformational conglomeratic bed (30 cm) (Fig. 2B). It is placed between the yellow, hard and ferruginous sandstone of the Malha Formation and the yellowish grey and massive limestone enriched in oysters of the lowermost of the Galala Formation.

The Galala Formation is unconformably overlain by El-Khashm Formation at Gebel El-Zeit (Fig. 2D), the Northern Galala (Fig. 3A) and Gebel Ataqa. The unconformable contact is represented by undulated, irregular zone that contains white caliche nodules. At Gebel Shabraweet, the Galala Formation unconformably underlies Maghra El-Hadida Formation. The contact is taken at the top of dark brown to black, ferruginated and cherty dolostone of the uppermost part of the Galala Formation (Fig. 3B). The lithostratigraphic classification of the studied sequence is given in Table 1.

The Galala Formation is composed of well-bedded mixed clastic-carbonate sequence, whereas the percentage of the carbonate rocks increases northward at the expense of siliciclastics. At Gebel El-Zeit, the Galala Formation is made up of claystone (43%), sandstone (31.6%), dolostone (21%), caliche (2%), siltstone (1%), marl (1%) and limestone (0.4%). At the Northern Galala, the Galala Formation is built up of claystone (53%), dolostone (18%), limestone (12%), dolomitic limestone (7.4%), marl (6.7%) and siltstone (3%). These lithofacies are arranged as shallowing-upward cycles. The cycles almost start with claystone at the base and capped by dolostone, dolomitic limestone or limestone. At Gebel Ataqa, the Galala Formation consists of dolostone (39.5%), dolomitic limestone (31%), limestone (26%), claystone (2.2%) and marl (1.3%). At Gebel Shabraweet, the Galala Formation includes dolostone (51%), limestone (19%), claystone (18%), dolomitic limestone (11.9%) and glauco-arenite (0.1%). The thickness of the Cenomanian Galala Formation diminishes southward from Gebel Shabraweet (201.25 m) to Gebel El-Zeit (71.5 m). It reaches to 93 m and 74.5 m and at Gebel Ataqa and the Northern Galala respectively.

Paleontologically, the Galala Formation is rich in the Cenomanian macrofossils. The bivalves (particularly oysters) are the most common fossils. They are represented by *Costagyra olisiponensis* Sharpe, *Ilmatogyra africana* Lamarck, *Amphidonte flabellatum* (Goldfuss), *Rhynchostreon suborbiculatum* (Lamarck), *Inocermas* (*Birostrina*) *tennuiradialis* Zakhera, *Parasea faba* Sowerby, *Dosinia delettrei* (Coquand), *Plicatula auressensis* Coquand, *Glossus solimani* (Abbass), *Venericardia forgemoli* (Coquand), *Meretrix faba* (Sowerby), *Eoradio-*