Journal of African Earth Sciences 78 (2013) 28–50

Contents lists available at SciVerse ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Sedimentology, sequential analysis and clay mineralogy of the lower Eocene sequence at Farafra Oasis area, Western Desert of Egypt

Abdalla M. El Ayyat *

Geology Department, Faculty of Science, Assiut University, Assiut 71516, Egypt

ARTICLE INFO

Article history:
Received 28 December 2011
Received in revised form 10 September 2012
Accepted 14 September 2012
Available online 5 October 2012

Keywords:
Farafra Oasis
Facies analysis
Depositional model
Sequential analysis
Stacking pattern
Clay mineralogy

ABSTRACT

Integrated sedimentological studies, sequential analysis and clay mineralogy on the lower Eocene rocks in the Western Desert provided important information on the reconstruction of the depositional basin, cyclicity, and paleoclimatic conditions. Two formations are recognized; the Esna and Farafra formations, with a gradational contact in-between. The studied sequence exhibits lateral facies changes as revealed from field and microfacies investigations. Eight facies were recognized and summarized in a carbonate ramp model. It represents also a general regressive trend, which records a transition from an outer ramp into a peritidal zone. The facies stacking patterns constitute several kinds of meter-scale, shallowing-upward cycles. Two different types of depositional cycles are here defined. The stratigraphic sections show a hierarchical organization of many cycles defined by five depositional sequences. It is suggested that composite eustatic sea level oscillations caused by cyclic perturbations of the Earth's orbit played a fundamental role in determining the formation of the observed hierarchical cyclic organization. Summing up, it is believed that the paleotopography had resulted from the impact of the Syrian Arc Folding System. A confusing additional complication is introduced by syndepositional sedimentary structures, especially during the late Cretaceous/Eocene times, coupled by several tensional forces. Clay mineralogy has revealed the presence of smectite, kaolinite and illite. Their origin may be attributed to the gradual increase in the amount of erosion of the newly elevated crystalline source rocks to the south of Egypt, in areas of moderate rainfall and rapid weathering and/or to reworking processes of soils which presumably developed on basement rocks. Changes in source rocks or climatic influence during the early Eocene may account for the observed differences in clay mineral abundances.

1. Introduction

The Farafra depression is an isolated irregular oval-shaped depression in the middle sector of the Western Desert (Fig. 1). This depression is carved out of upper Cretaceous Khoman Chalk. It is the second largest depression in the Western Desert and sits at longitude 27°20′ & 28°59′ E and at latitude 26°18′ & 27°42′ N. The escarpment rings the depression on three sides. The eastern and western scarp are both steep-sided, formidable barriers.

Since the earliest days of the geological investigation in Egypt; the upper Cretaceous/lower Tertiary outcrops of the Farafra Oasis have been the subject of many studies that focus on general geology, stratigraphy and micropaleontology (Youssef and Abdel Aziz, 1971; Barthel and Herrmann-Degen, 1981; Hermina, 1990; Keheila and Kassab, 2001; Khalifa et al., 2005; Obaidalla et al., 2006). However, little has been done on detailed sequential analysis and depositional history of the lower Eocene rocks exposed west and east of the Farafra Oasis. Moreover, many questions related to some stratigraphical and sedimentological problems remained without satisfactory answers.

2. Geological setting

The Farafra Oasis (Fig. 1) lies within an oval shaped depression, which is bounded by scarps from the eastern, northern and western sides, where it is open due to south. The larger axis of the depression is 102 km whereas its eastwest axis is about 90 km. It covers an area of about 980 km^2. Its floor is covered by the Dakhla Formation in its southern part. Northwards at latitude 26 45° N, the Dakhla Formation gives place to a coeval chalk unit of Maastrichtian age named Khoman Formation (Hermina, 1990).

The eastern part of the depression is covered by the Karawein sand sheets with some seif dune on top. Its altitude is about 144 m above sea level at its southern parts, decreasing in height northward to only 32 m at Ain El Wadi (Wadi Hennis) and Wadi El Maqfi areas. These areas are covered by wet sabkhas. The eastern scarp face extends in an undulating line running generally in a NNW–SSE direction. The scarp abruptly changes its direction to

* Tel.: +20 0882412183 (O), +20 0882271822 (H), +20 01146889094 (M); fax: +20 088 2342708.
E-mail addresses: Abdallaelayyat1961@hotmail.com, abdallaelayyat@yahoo.com

1464-343X/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jafrearsci.2012.09.011

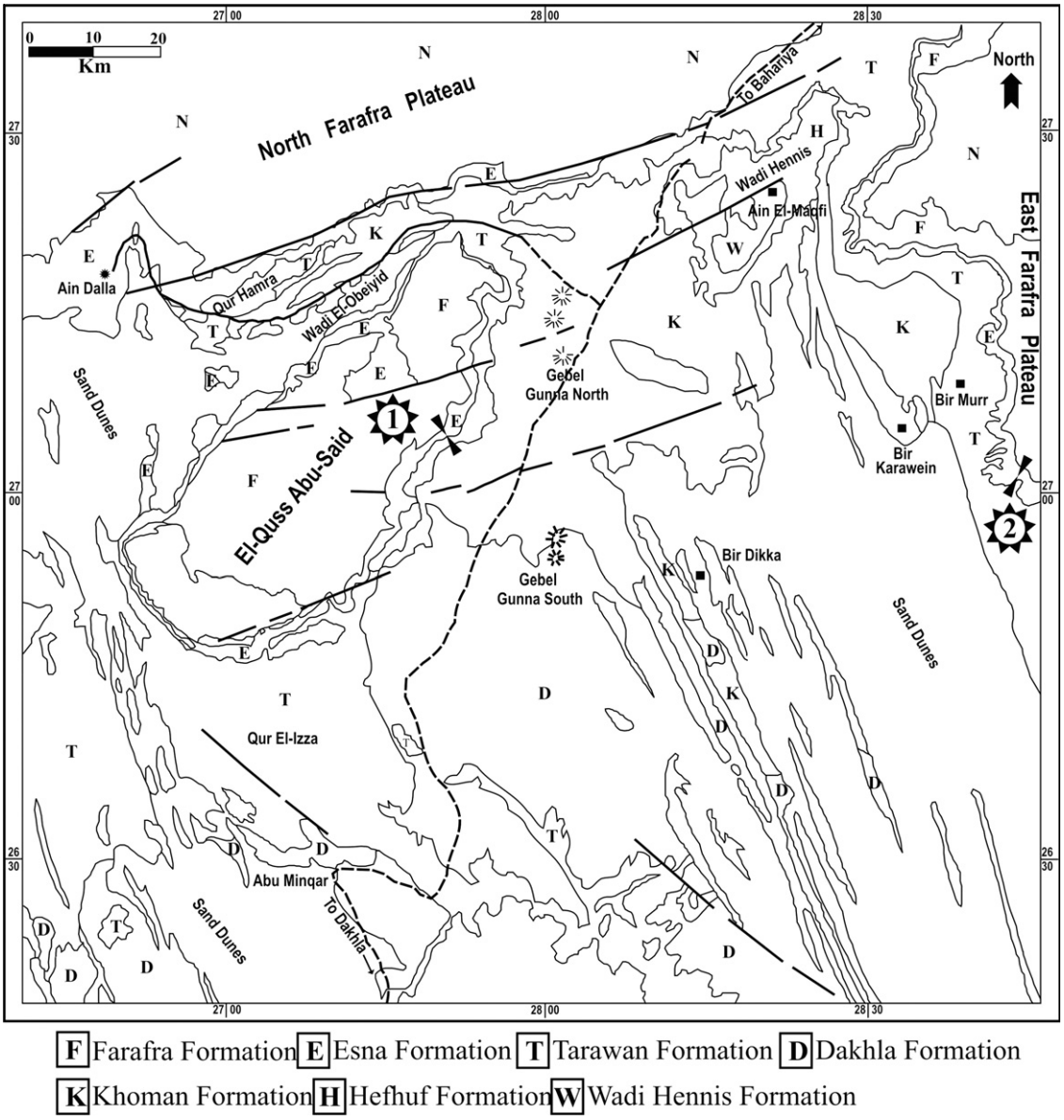

Fig. 1. Simple geological map (after Hermina, 1990) for the study area and the measured sections.

ENE–WSW to form the northern Farafra scarp. Most probably this change in direction is due to faulting and folding (Said, 1990). The western scarp is named El Guss Abu Said syncline. It is one of the most important folds in the west central latitudes of Egypt between Libya in the west and the Bahariya high in the northeast. The structure is located between El Maqfi and Ain Dalla anticlines. The axis of this syncline trends N 40° E parallel to the axis of El Maqfi anticline and extends for about 80 km. The syncline covers an area of 400 km^2. The axis of this structure is located very close to the western face of El Guss Abu Said plateau. On the other hand, it was cut by two major faults which run parallel to the present eastern and western sides of the plateau. About two thirds of the surrounding scarp faces consist of shales (Esna Formation) which are overlain by hard, fractured, jointed and dolomitic limestone (Farafra Formation). The different lithologies of the scarp in addition to the fracture lines dissecting the area are the main factors controlling the retreat of the scarp mainly by wind and to a less degree by water erosion (Khalifa et al., 2005).

The Farafra Oasis was affected by tectonic movements, which extended from late Cretaceous to late middle Eocene (Zaghloul, 1983). Such movements may belong to the Syrian Arc Folding System (NE–SW direction), that had affected the northern part of the Egyptian territory (Moustafa and Khalil, 1995). According to Neev and Hall (1982) the distribution pattern of the lineament swarms across Africa puts the Farafra Oasis within the Pelusium Megashear System or the seismoactive Pelusium line of Said (1971) which extends subparallel to the east Mediterranean shores of Levant and continues inland across the Nile Delta to Niger Delta on the Gulf of Guinea. The shear joints and the majority of the fault directions are both due to the folding system of upper Cretaceous origin. On the other hand, the tectonism during the post deposition led to the formation of a few positive anticlines and negative syncline structures.

There are, in fact, evidences that tectonic movements affected the Farafra Oasis at various stages before the end of the Cretaceous to the late middle Eocene. During the Maastrichtian to the early Eocene time, the syndepositional growth of folds were responsible for the variations in the thickness of Khoman Formation on the structural high areas and unconformity between the Maastrichtian and the middle Eocene as recorded in many parts of north Egypt along these arcs. This unconformity was recorded by El Akkad and Issawi