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Review

Stacked, Lower Miocene tide-dominated estuary deposits in a transgressive succession, Western Desert, Egypt

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ABSTRACT

The net transgressive Lower Miocene Moghra Formation of Egypt is a sandy estuarine complex consisting of a series of stratigraphic units that reflect repeated transgressive to regressive shoreline movements across the Burdigalian (Lower Miocene) coastal landscape. The transgressive part of each unit is preserved atop a deep erosional scour surface, and consists of tidal–fluvial sandstones with tree logs and vertebrate bones that transition up to cross-stratified, tidal estuarine channel deposits and then to open-marine, shelf mudstones and limestones. In contrast, the regressive part is thinly developed and consists of thin-bedded, fossiliferous shelf mudstones that pass upward to thin, tide-influenced delta-front deposits. Each of the nine transgressive–regressive units of the Moghra Formation is capped by a river-scour surface that severely truncates the underlying regressive half-unit. Regional tectonic subsidence and an overall decreasing influx of clastic sediment accounts for the accumulation of the Moghra Formation and its overall transgressive character. The high frequency relative base-level changes reflected by the transgressive–regressive units (averaging <350 kyr) that punctuate the overall transgressive stratigraphic trend are thought to have been driven by (1) sea-level changes caused by recently-documented variations in East Antarctic ice-sheet volume during the Lower Miocene, and/or by (2) variation in the large-scale influx of sediment to the region (during continuous tectonic subsidence). The relative importance of the sea-level (eustatic fall) vs. supply drive (deep fluvial scour) mechanisms for producing the repeated and widespread Burdigalian incision surfaces in the Moghra succession cannot easily be determined.

1. Introduction

The stratigraphy of incised-valley infills (e.g., Dalrymple and Zaitlin, 1994) and estuary-infills (not necessarily within valleys, e.g., Dalrymple, 2006) has been a widely discussed topic since the early 1990's. The growing interest in estuaries and incised valleys arises from their sequence stratigraphic complexity and from their key position spanning the land–sea transition. There is also an economic perspective as numerous oil and gas reservoirs are made up of sand-dominated bodies forming part of estuary valley fills (Chaumillon et al., 2011). The estuarine and marginal marine succession of the Lower Miocene Moghra Formation, cropping out in the Qattara Depression of northwestern Egypt (Fig. 1), are examined in this study. Of key interest is the vertical architecture of the succession; a series of estuarine units that are stacked in a net transgressive stratigraphy. The study transect covers a distance of 35 km, and is oriented slightly oblique to the depositional strike direction. The aims of the study are: 1) to provide a description and interpretation of the facies associations within the Moghra Formation and from these to construct a depositional model for the individual units; 2) to trace the extent of the erosional surfaces that underlie each of the depositional units across the study transect and to interpret the possible causes of the erosion; and (3) to evaluate the dominantly transgressive character of the individual depositional units as well as of the Moghra Formation.

1.1. Broader significance of transgressive depositional successions

1.1.1. Why net-transgressive successions?

The study of the Moghra Formation has some broader significance because of its overall transgressive character and its apparently transgressive-dominant units, and for this reason some analogous successions are briefly reviewed. Thick, net-transgressive successions are not uncommon in the geological record. Some of the best known are the Cretaceous Western Interior Seaway successions, such as the Almond Formation in southern Wyoming (Martinsen, 2003), the Cliff House Sandstone in New Mexico (Laramide example, Donselaar, 1989) and the Upper Bow Island Formation in SW Alberta (Pedersen

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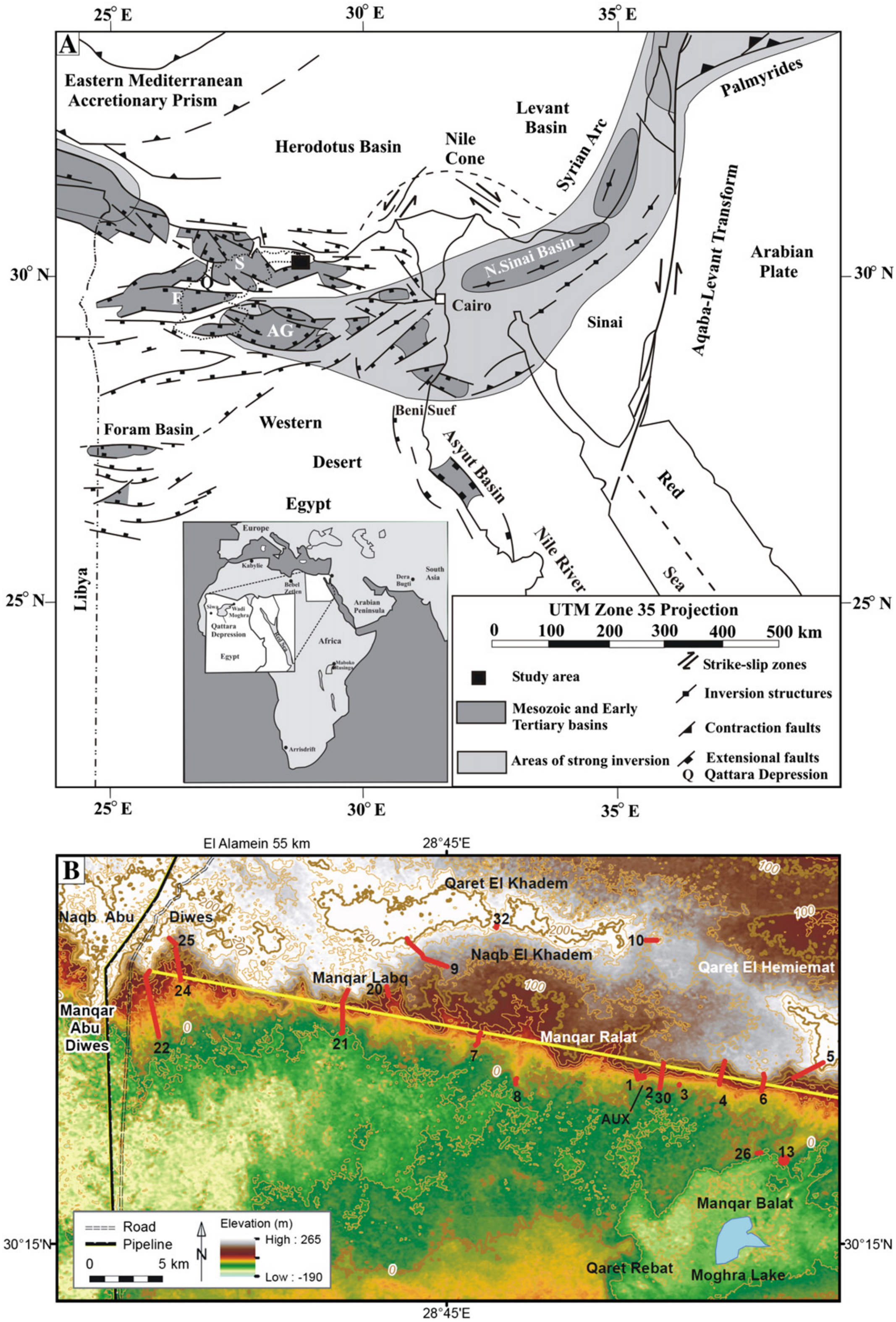

Fig 1. A) Map of the coastal basins of Egypt, with location of the study area (modified after Bosworth et al., 2008). B) Location of measured sections in the study area.

et al., 2002). Others include the mid to late Jurassic syn-rift succession of the Northern North Sea (Hampson et al., 2009), and in particular the North Sea Tarbert Formation (Løseth et al., 2009). Others are the Woburn Sands of southern England (Johnson and Levell, 1995; Yoshida et al., 2004), and the El Marcet transgressive sandstones in the Ebro Basin (Steel et al., 2000). These formations usually record long-term (Myr plus) sea-level rise and net transgressive coastline conditions, though generally punctuated by shorter term regressions. Estuary and barrier-lagoon depositional systems are the prominent shoreline types during transgression, whereas deltas and strandplain systems normally characterized the intervening short-term regressive phases (see also Boyd et al., 1992). The long-term transgressive character of such