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Bajocian-Bathonian (Middle Jurassic) sea-level changes in northeastern Egypt: Synthesis and further implications

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ABSTRACT

The global eustatic developments can benefit significantly from properly acquired regional information. Summarizing the available interpretations of the relative sea-level changes from two areas in northeastern Egypt, namely Gebel Maghara and Khashm El-Galala, allows better understanding of the Middle Jurassic sea-level changes. It is established that the Bajocian-Bathonian relative sea-level changes in these areas were coherent. The magnitude of changes was lower in the Bajocian than in the Bathonian. Significant sea-level rises occurred at the Bajocian-Bathonian and middle-late Bathonian transitions, and there was a clear tendency toward sea-level rise throughout the studied time interval. This evidence favors one of the two alternative global eustatic reconstructions that implies “stable” position of the shoreline in the Bajocian and general tendency to eustatic rise throughout the Jurassic. The tectonic regime of northeastern Egypt in the Middle Jurassic provided for strong eustatic control of the relative sea-level changes. The possible influence of hotspot activity is questionable. Filling the accommodation space with materials derived from the eroded continent may explain some sea-level falls that are regionally documented.

1. Introduction

The Jurassic eustatic (=global sea-level) changes have been studied for decades on both the global and regional scales, but the relevant knowledge remains incomplete and questionable to some extent (Ruban, 2015, 2016). About 30 years ago, Haq et al. (1987) proposed the well-known eustatic curve that depicted numerous global sea-level rises and falls. Immediately thereafter, an alternative eustatic curve was suggested by Hallam (1988). After a little more than a decade, the latter author updated the available knowledge and introduced a new vision of the Jurassic eustasy (Hallam, 2001). In particular, he rejected the global appearance of almost all Jurassic sea-level falls. Haq and Al-Qahtani (2005) also updated the earlier curve (Haq et al., 1987); although their work focused on the Arabian Platform, a global reconstruction was also included. As a result, there are two different alternative views of the Jurassic eustatic fluctuations, and it is really unclear which one of them is more realistic (Ruban, 2015, 2016). The broad correlation of unconformities attempted by Zorina et al. (2008) revealed the absence of global-scale sedimentation breaks during the Jurassic, which is in agreement with the suggestion of Hallam (2001). An elegant solution for this “puzzle” of opinions would be a global sea-level reconstruction based on the new plate tectonic developments (Seton et al., 2012). These reconstructions are available only for the Cretaceous–Cenozoic (Müller et al., 2008; Spasojevic and Gurnis, 2012), but regrettably they are still missing from the Jurassic (to the best of the authors' knowledge).

A powerful method for the development of eustatic knowledge is the interregional correlation of stratigraphical records, especially those well interpreted with regard to shoreline shifts and relative sea-level changes (Hallam, 2001; Miall, 2010; Ruban et al., 2010, 2012). If so, the accumulation of further data for particular regions allows a kind of methodological reflection. Unfortunately, such studies are rare, which can be explained by unwillingness of the modern research community to re-interpret the already available data (“out of fashion”), rather than to focus on collecting new facts. Hallam (2001) considered the regional Jurassic records of Europe, Greenland, Argentina, and the Himalayas. But what about Africa? The northern periphery of this continent was embraced by the Jurassic seas (Carr, 2003; Golonka, 2004; Guiraud et al., 2005;

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Tawadros, 2011), and really good stratigraphical records are found there. In fact, since the beginning of the 21st century, two areas with promising Jurassic sedimentary successions have been investigated in northeastern Egypt. These are Gebel Maghara (30°40′ N and 33° 23′ E) in North Sinai and Khashm El-Galala (29°34′ N and 32°20′ E) on the western side of the Gulf of Suez. In the both areas, the relative sea-level changes were reconstructed (El-Younsy, 2001; Abdelhady and Fürsich, 2015), although discussed in the context of the outdated eustatic reconstruction of Haq et al. (1987), which is so typical in the modern geoscience literature (Ruban, 2016). The main target of the present paper is to summarize the evidence of the relative sea-level changes from the noted areas and to apply this knowledge to the understanding of eustatic fluctuations on the basis of new developments. The authors wish to look back and to think deeper on the further implications of what have been found by others. However, this is not a repetition of the other authors' work; the employed method is able to bring new, original conclusions. This paper focuses on the Bajocian-Bathonian interval, which is especially well studied in the two noted areas.

2. Geologic setting

The geology of northeastern Egypt, including the stratigraphy of the sedimentary successions and the geological history, is well described (Said, 1962, 1990; Keeley et al., 1990; Keeley and Wallis, 1991; Wycisk, 1994; Wilson et al., 1998; Issawi, 2002, 2005; Carr, 2003; El Kelani et al., 2003; Guiraud et al., 2005; Tawadros et al., 2006; Issawi et al., 2009; Tawadros, 2011; Gaina et al., 2013; Abdelhady and Fürsich, 2015). Large-scale reconstructions have allowed an insight into the Jurassic palaeogeography (Stampfli and Borel, 2002; Golonka, 2004; Seton et al., 2012). The geological structures of northeastern Egypt, including the Sinai Peninsula, are generally complex (Fig. 1). During the Middle Jurassic, this region was a passive continental margin, characterized by some tectono-magmatic activity. The sea did not extend far into the continent relative to its present-day shoreline, although marine sedimentation of siliciclastics and carbonates persisted over large areas. River systems developed on the nearby land.

The Bajocian-Bathonian deposits are well represented in several sections at Gebel Maghara in North Sinai, where carbonate rocks prevail over sandstones and shales (Fig. 2), and these sections are well documented by Shahin (2000), Orabi (2001), El Kelani et al. (2003), Ghandour et al. (2003), and Abdelhady and Fürsich (2014, 2015). Depositional environments were diverse; shelfal conditions dominated, although alluvial facies did also exist. The Bajocian-Bathonian siliciclastics-dominated deposits (with some carbonates) crop out in several sections at Khashm El-Galala

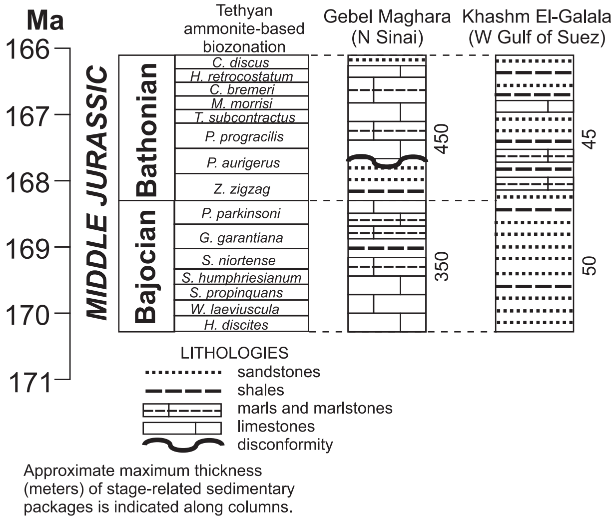

Fig. 2. Simplified composite Bajocian-Bathonian sections of North Sinai and the West Gulf of Suez (based on El-Younsy, 2001; El Qot et al., 2009; Abdelhady and Fürsich, 2015). Columns are given for only general comparison, and direct correlation should be done with serious caution. The geologic time scale follows the recommendation of the International Commission on Stratigraphy (stratigraphy.org), and the biozonation is given according to Gradstein et al. (2012).

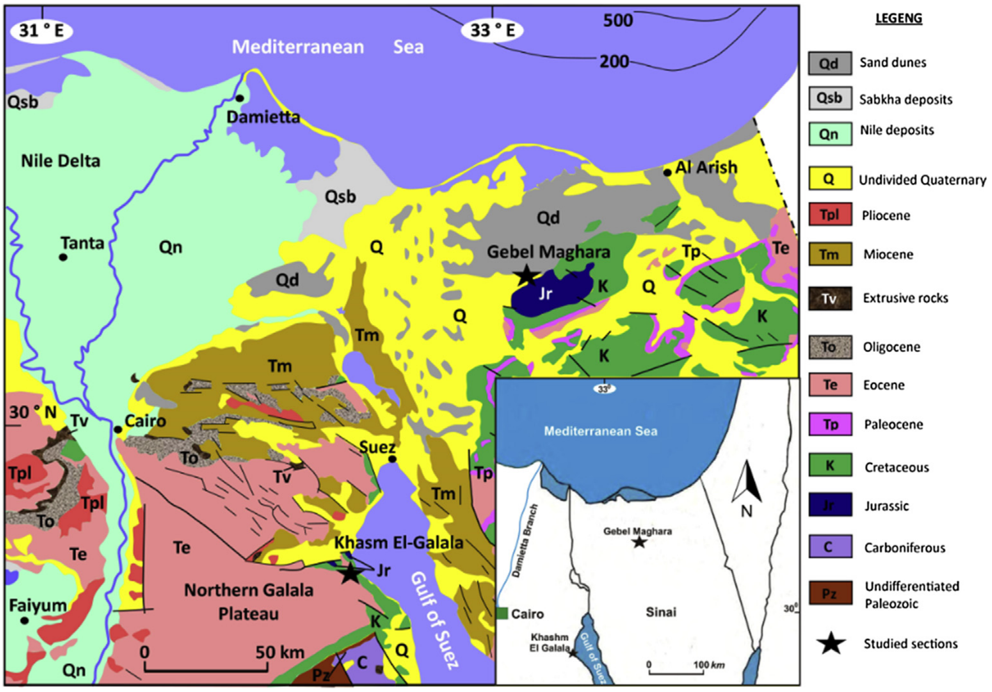

Fig. 1. Location of the areas discussed in the present paper. Geological map is modified from Geological Survey of Egypt (1981).