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An overview of the Cretaceous stratigraphy and facies development of the Yazd Block, western Central Iran

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ABSTRACT

The Cretaceous successions of the Yazd Block, the western of three structural blocks of the Central-East Iranian Microcontinent (CEIM), have been studied using an integrated approach of litho-, bio- and sequence stratigraphy associated with litho-, bio- and microfacies analyses. The Cretaceous System of that area is in excess of 5 km thick and a generalized relative sea-level curve can be inferred from the facies and thickness development. This curve can be subdivided into two transgressive–regressive mega-cycles (TRMs), separated by a major tectonic unconformity in the Upper Turonian. TRM 1 comprises the Early Cretaceous to Middle Turonian, TRM 2 the Coniacian to Maastrichtian. TRM 1 starts with up to 1500-m-thick conglomerates and sandstones covering Palaeozoic–Triassic basement rocks, metasediments, or Upper Jurassic–lowermost Cretaceous granites. The basal tectonic unconformity, related to the Late Cimmerian event (Jurassic–Cretaceous boundary interval), shows a pronounced palaeo-relief that is levelled by the basal siliciclastic formations. Sparse biostratigraphic data from calcareous intercalations in the upper part of these strata indicate a Hauterivian to Barremian age. The Aptian facies development is marked by the onlap of thick-bedded, micritic carbonates with abundant orbitolinid foraminifera and rudists representing a large-scale shallow-marine carbonate platform system that fringed the Yazd Block in the north and west. These platforms are up to 1000 m thick and drowned during the middle to Late Aptian, followed by up to 1500-m-thick basinal marly sediments of Late Aptian to mid-Late Albian ages, representing the maximum relative sea-level during TRM 1. During the latest Albian–Middle Turonian, a gradual shallowing is indicated by progradation of shallow-water skeletal limestones separated by marl tongues, representing a carbonate ramp system. Strata of TRM 2 overlie older units along a regional angular unconformity and indicate tectonic stability and lowered subsidence rates as shown by widespread uniform Coniacian–Maastrichtian facies and thickness development. Above a thick basal conglomerate, the Coniacian–Campanian facies is characterized by shallow-water limestones of a large-scale epeiric platform. Relative sea-level peaked in the Late Campanian, followed by Maastrichtian infilling. The Cretaceous succession is truncated along a tectonic unconformity at the base of the Palaeocene. The major tectonic unconformities recognized at the base of the succession (Late Cimmerian Event), in the Late Turonian, and in the Cretaceous–Palaeogene boundary interval are evidence of significant tectonic activity of the Yazd Block. Their formation is probably related to plate tectonic processes in response to the opening and closure of ocean basins surrounding the CEIM.

1. Introduction

Cretaceous strata are very thick, widely distributed and superbly exposed in the Khur and Yazd areas of Central Iran (Fig. 1). They are part of the sedimentary succession of the Yazd Block, the western structural element of the Central-East Iranian Microcontinent (CEIM, Takin, 1972), an independent structural unit within the complex Mesozoic plate tectonic mosaic of the Middle East (Fig. 2). During the Cretaceous, the CEIM was detached from the southern Eurasian margin (Turan domain) and surrounded by small oceanic basins (Sistan, Sabzevar, Nain–Baft oceans) which opened and closed in response to (inferred) counter-clockwise vertical axis tectonic rotations of the entire block assemblage (see Section 2). The Cretaceous sedimentary succession

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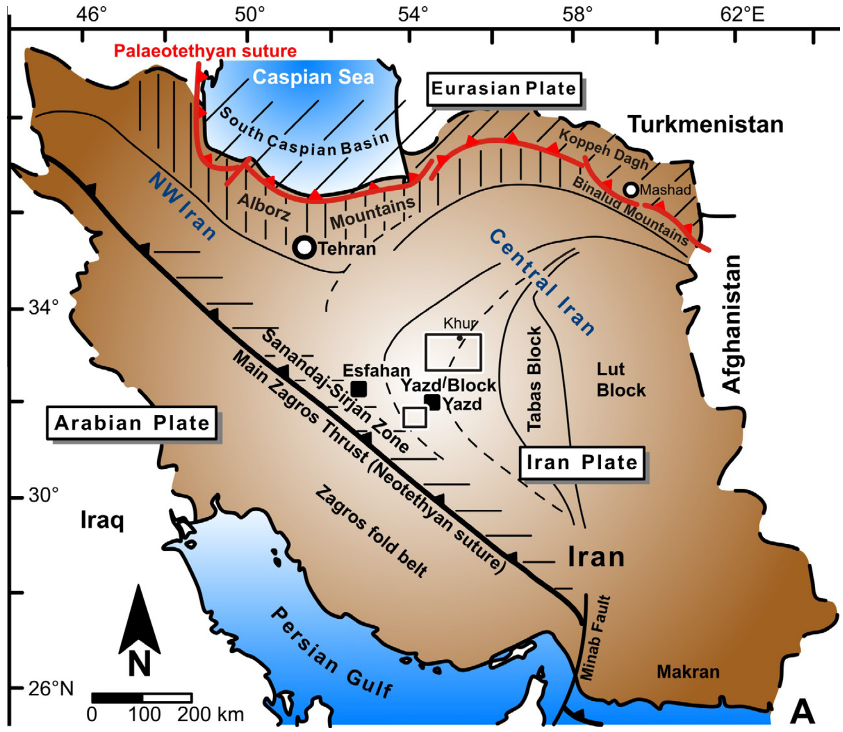

Fig. 1. Simplified structural map of Iran showing the main sutures and domains (course of the Palaeotethyan suture after Zanchi et al., 2009). The study areas near Khur and Yazd are marked by small rectangles.

of the Yazd Block thus bears important information for the geodynamic history of the larger area. However, apart from lithostratigraphical mapping, little was hitherto known about the exact chronostratigraphy of the successions and their facies development (see Wilmsen et al., 2011 for a brief overview on the Khur area). Here we provide new information on the stratigraphy, facies development, depositional environments and geodynamic significance of the Cretaceous succession of the Yazd Block.

2. Material and methods

Numerous stratigraphic sections totalling more than seven km of strata have been logged bed-by-bed in considerable detail, mainly in the area south of Khur but also around Yazd (see Tables 1 and 2). The sections have been investigated by means of sedimentary and palaeontological field methods (Goldring, 1999; Stow, 2005; e.g., evaluations of sedimentary structures as well as body and trace fossil contents, taphonomic observations, grain-size and component analyses using a hand-lens, study of stratal architectures and mapping of stratigraphic geometries, tracking of key surfaces such as major unconformities and maximum flooding intervals). For precise logging, a Jacob's staff has been used, fossils have been collected bed-by-bed, and numerous samples for micro-facies analysis have been taken in carbonate units. Thin-sections and macrofossils are stored in the palaeozoological collection of the Senckenberg Naturhistorische Sammlungen Dresden (repository AsK). Based on the field observations and subsequent thin-section analysis (Flügel, 2004), a Cretaceous standard section of the Khur area with relative sea-level curve has been developed, the chrono-stratigraphy of the formations in the Khur and Yazd areas has been considerably refined based on the macro- and microfossil content, and their depositional environments have been identified. Furthermore, the dating and lateral tracking of major, tectonically triggered unconformities increased the understanding of the geodynamic evolution of Central Iran during the Cretaceous Period.

3. Geological setting

The study area belongs to the so-called Central-East Iranian Microcontinent (CEIM; Takin, 1972) which forms the central part of what today is the Iran Plate. In the Mesozoic, the CEIM was an independent structural unit within the complex plate tectonic mosaic of the Middle East, consisting, from east to west, of three structural units, i.e., the Lut, the Tabas, and the Yazd Block (Figs. 1 and 2; see Berberian and King, 1981; Berberian et al., 1982, and Davoudzadeh, 1997 for geological overviews). Jurassic strata are superbly exposed, very thick and well studied on the Tabas Block (see Wilmsen et al., 2003, 2009a) while Cretaceous strata have not (or only locally) been deposited, especially in the northern part of the block (e.g., Wilmsen et al., 2005). In contrast, Jurassic strata are largely absent in the western part of the CEIM (Yazd Block), but Cretaceous strata are in fact very thick and widespread (Nabavi, 1972a,b; Aistov et al., 1984).

During Cretaceous times, the CEIM was separated from the southern Eurasian margin by narrow oceanic basins (Sistan Ocean in the east, Sabzevar Ocean in the north, Nain–Baft Ocean in the west; see Fig. 2 and Lindenberg et al., 1983; Tirrul et al., 1983; Dercourt et al., 1986; Philip and Floquet, 2000; Barrier and Vrielynck, 2008a,b). These oceanic basins opened in early Early Cretaceous ('Neocomian') times (e.g., find of Valanginian tintinnids and ammonites from the Sabzewar Zone; Seyed-Emami et al., 1972) and their development may be connected to an inferred post-Triassic tectonic rotation of the CEIM around a vertical axis of about 135° with respect to Eurasia (e.g., Davoudzadeh et al., 1981; Soffel et al., 1996; see Mattei et al., this vol. for synopsis). Rotation most probably took predominantly place in post-Jurassic times (Esmaeily et al., 2007; Bagheri and Stampfli, 2008; Wilmsen et al., 2009a; Mattei et al., this volume) although both timing and amount of rotation (if occurring at all) have repeatedly been questioned (e.g., Muttoni et al., 2009a,b). However, Cifelli et al. (2013) demonstrated that the movements at the block-bounding fault between the Tabas and Lut blocks of the CEIM changed from