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Ichnology and sedimentology of a shallow marine Upper Cretaceous depositional system (Neyzar Formation, Kopet-Dagh, Iran): Palaeoceanographic influence on ichnodiversity

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ABSTRACT

The trace fossil assemblages from the Upper Cretaceous Neyzar Formation are described for the first time from Kopet-Dagh, Iran, enhancing the record of this fossil group in the Cretaceous of the Middle East. Thirty-one ichnogenera have been identified in open marine successions: *Agrichnium*, *Asteriacites*, *Asterosoma*, *Bergaueria*, *Chondrites*, *Cylindrichnus*, *Halopoa*, *Helminthopsis*, *Gordia*, *Gyrochorte*, *Laevicyclus*, *Lockeia*, *Megagrapton*, *Nereites*, *Neonereites*, *Ophioichnus*, *Ophiomorpha*, *Palaeophycus*, *Phycodes*, *Phycosiphon*, *Planolites*, *Protovirgularia*, *Rhizocorallium*, *Rosselia*, *Scolicia*, *Sinusichnus*, *Skolithos*, *Spongeliomorpha*, *Taenidium*, *Teichichnus*, and *Thalassinoides*. The Neyzar Formation accumulated on a gently dipping shelf dominated by storm- and fair weather-wave processes and includes shelf, lower offshore, upper offshore, lower shoreface-proximal offshore, middle-upper shoreface and foreshore deposits. Identification and interpretation of ichnological signatures and the spatial arrangement of sedimentary structures in the successions are used to further refine sedimentary interpretations of parameters such as wave energy, substrate properties, the nature of the available food supply, variability in sedimentation rates and proximal–distal trends of the wave-dominated shoreface–offshore complex. The prevalent palaeoceanographic situation during the deposition of the studied successions was ideal for tropical storms, thus promoting tempestite deposition and the occurrence of a tropical and subtropical trace fossil suite. According to this study, increasing mobility and infaunality with more complex trace systems or sophisticated feeding strategies, climax population strategies and the high diversity, associated with rapid increase in the abundance and depth of infaunal structures, indicate a major reorganization of the shallow-marine benthic communities that occurred in response to the Mesozoic marine revolution.

1. Introduction

The integrated analysis of sedimentology and ichnology is a powerful tool for discrimination among lithologically similar facies. Nutrient supply, substrate consistency, salinity, sedimentation rates, temperature, oxygenation and hydrodynamic regime all exert control on the types and behavior (ethology) of fauna in a given environment (e.g., Pemberton et al., 1992a, b). In detail, the distribution of trace fossils in wave-dominated coastal settings is complex and strongly controlled by substrate conditions in terms of degree of consistency, grain size and stratinomic position. Well-preserved trace fossils of shallow-marine successions of the Upper Cretaceous Neyzar Formation, Kopet-Dagh Basin, Iran (Figs. 1 and 2) provide an opportunity to document palaeoecological, taphonomical and depositional environment controls on composition and distribution of the ichnofossils. The aims of this paper are to: (1) to describe the trace fossils assemblages; (2) to use integrated sedimentologic and ichnologic analysis for highlighting changes in the palaeoenvironmental and depositional conditions; (3) to compare the Neyzar ichnofauna with other examples from similar age in

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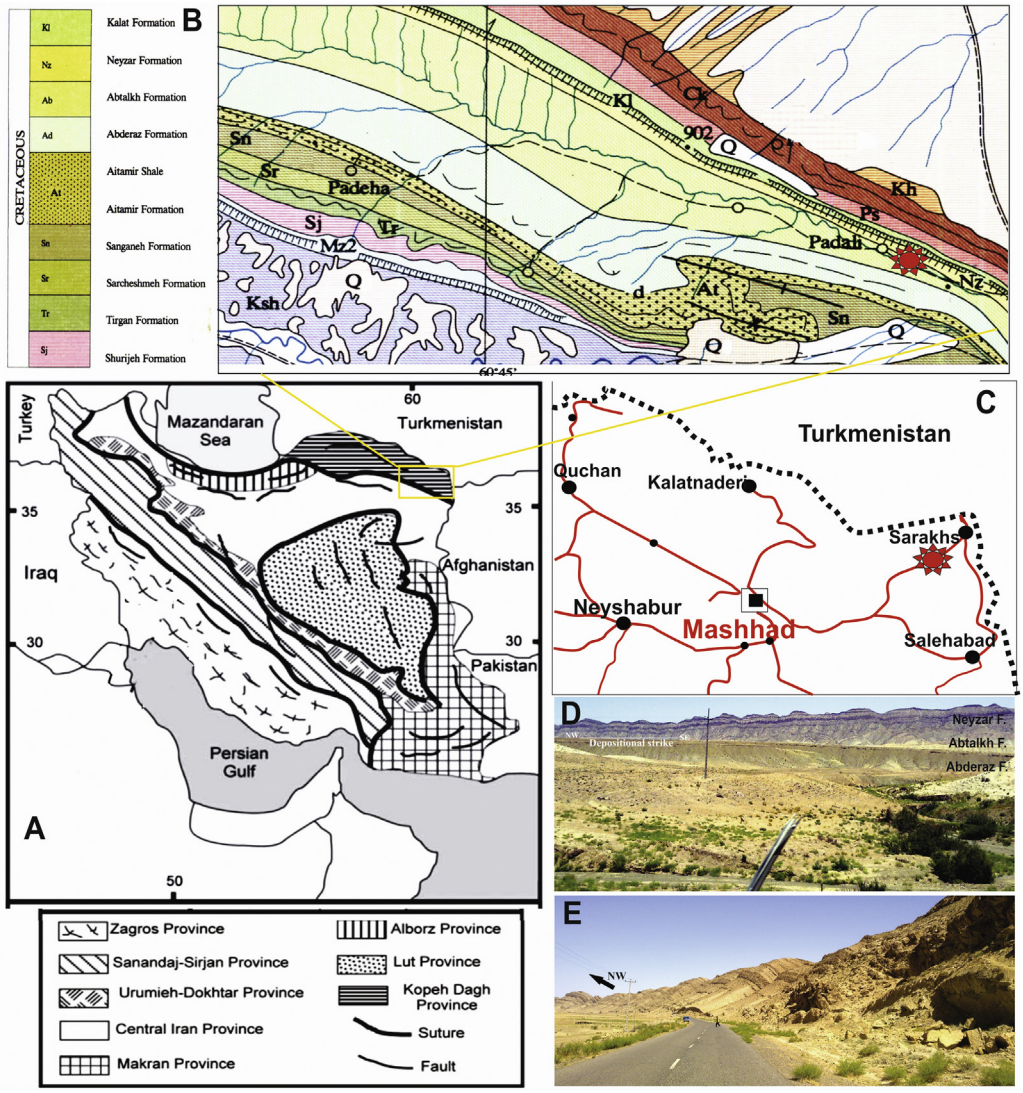

Fig. 1. A) Major geological subdivisions of Iran after Heydari et al. (2003). B) Map shows the geology of Sarakhsarea of in Khorasan Razavi Province (Afshar-Harb, 1982). C) Location map of the studied area in the road from Mashhad to Sarakhs is the principle link to the study area. D and E) Panoramic view of wave-dominated shoreface–offshore complex of the Neyzar Formation.

order to deduce latitudinal patterns in ichnofauna distribution and the impact of palaeoceanographic situation on the shallow-marine benthic communities; and (4) to understand different groups of ichnofossils based on specific combinations of organism behavior linked to the development of the Mesozoic marine revolution.

2. Geological background and study area

The Kopet-Dagh petroliferous basin was formed as a result of the southeastern extension of the South Caspian Basin by Neotethyan back-arc rifting after closure of the Palaeotethys and the early Cimmerian Orogeny (Berberian and King, 1981; Garzanti and Gaetani, 2002; Golonka, 2004; Ramazani et al., 2008; Wilmsen et al., 2009a,b; Robert et al., 2014) (Fig. 1). The Cretaceous sequence in the Kopet-Dagh Basin are divided into nine formations, composed mainly of sandstones, conglomerates, mudstones, limestones and dolomites with minor amounts of evaporates (Afshar-Harb, 1979). According to a study based on ostracods, the sedimentation during the Late Cretaceous is considered to have taken place in a shallow open marine environment with warm climate conditions (cf. Robert et al., 2014). The Neyzar Formation is one of the most widespread Upper Cretaceous formations in the eastern Kopet-Dagh.

Kopet-Dagh basin isopachs suggest a depositional strike/palaeoshoreline trend of approximately northwest-southeast (Afshar-Harb, 1979, 1994). The regional trend of the Kopet-Dagh sedimentary basin (assessed by delineating a line separating shallow marine and non-marine sequences, such as the Aitamir, Abderaz, Abtalkh, Neyzar, and Kalat formations in the east, from slope and distal basin sequences deposited on the eastern flank of the Kopet-Dagh sedimentary basin) was northwest-southeast during the Cretaceous. Exposure of the siliciclastic deposits of Upper Cretaceous units of the Neyzar Formation occurs almost extensively on the eastern flank of the Kopet-Dagh sedimentary basin (Afshar-Harb, 1979, 1994), such that stratigraphic relationships are exposed on largely north–south sections oriented parallel to depositional strike. The Neyzar Formation has an almost uniform lithological composition consisting of mudstone, glauconitic siltstone, and glauconitic sandstone with some bioclastic-rich sandstone beds. Biostratigraphic data mostly based on planktonic and benthonic foraminifers and calcareous nannofossils suggests a Campanian age for this formation (Afshar-Harb, 1979, 1994). During the Campanian, a relative sea level fall in the eastern Kopet-Dagh caused deposition