Significance of ichnofossils in high resolution sequence stratigraphy: Upper Maastrichtian, Kopeh- Dagh Basin, NE Iran

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Abstract

This study shows that ichnology can be used to refine sequence stratigraphy as well as to interpret the depositional environment of the Kalat Formation (Upper Maastrichtian) in the Central Kopeh- Dagh Basin (NE Iran), Dareh-Gaz section. Field studies and petrography of these deposits led to recognize four lithofacies and nine subfacies that formed in the tidal flat (lithofacies A), lagoon (lithofacies B), shoal (lithofacies C), and open marine (lithofacies D) within a carbonate ramp system. Trace fossils in this succession consist of Psilonichnus quietis, Thalassinoides suevicus, Diplocraterion parallelum, Rhizocorallium jenense and Ophiomorpha isp. that are classified in the Psilonichnus ichnofacies and Thalassinoides suevicus, Diplocraterion parallelum, Rhizocorallium jenense, and Ophiomorpha isp. in the Cruziana ichnofacies. Based on lithofacies and ichnofacies analyses, two depositional sequences (DS1 and DS2) were identified, that are composed of transgressive and highstand systems tracts. The maximum flooding surface (MFS) in DS1 is characterized at the top of the bed containing Rhizocorallium jenense, while this surface in DS2 is recognized by Diplocraterion parallelum grading into Ophiomorpha isp. in similar lithofacies. This study is an example where ichnology provides additional support for high-resolution sequence stratigraphy in carbonate deposits. Moreover, our study demonstrates that trace fossils could be useful in identification of the MFS in similar lithofacies elsewhere.

Key Words: Ichnofacies, Maastrichtian, System tract, Kalat Formation, NE Iran

Introduction

The main applications of ichnology in sequence stratigraphic analysis are (1) the enhancement of environmental interpretations; and (2) the identification of key surfaces and erosional discontinuities particularly where there is a significant temporal break between the eroding event and the deposited strata (Savrda, 1991; Pemberton and MacEachern, 1995; Pemberton et al., 2001, 2004; Rodriguez-Tovar et al., 2007). Integration of ichnological analysis with sedimentological data can also be used to determine facies and sequence variations depend upon water depth and energy conditions (Pemberton and MacEachern, 1995). In the eastern Kopeh-Dagh Basin, sequence stratigraphic analysis of the Upper Maastrichtian Kalat Formation was carried out by characterizing the lithofacies (Mahboubi et al., 2006). However, identifying sequence stratigraphic trends within the central part of the basin was more difficult due to poor facies expression and scarcity of well-differentiated key boundary surfaces. Here, we combine ichnological and lithofacies studies (based on field observations and the examination of 100 thin-sections) to infer depositional environments, changing environmental conditions, and sequence development within the Kalat Formation in northeast Iran in the central Kopeh-Dagh Basin in the Darh-Gaz region, southeast of the Greater Caspian Region (Fig. 1).

Geological setting

The Kopeh-Dagh Basin was formed after the Middle Triassic orogeny as a result of the closure of the Hercynian Ocean in northeast Iran (Berberian and King, 1981; Şengor, 1987; Şengor et al., 1988; Ruttner, 1993; Alavi et al., 1997; Golonka, 2004). In this basin, sedimentation was nearly continuous from Jurassic through the Neogene (Afshar-Harb, 1969, 1979, 1994; Kalantary, 1987). Five major transgressive and regressive sequences have been identified in the eastern part of the Kopeh-Dagh Basin (Moussavi-Harami and Brenner, 1992). Shallow marine to shoreline sediments of the Early Maastrichtian Neyzar Formation were deposited during relative sea level fall (Moussavi-Harami & Brenner, 1992), while during the Late Maastrichtian, relative sea level rose again and the Kopeh-Dagh Basin became a region of shallow marine environments (Smith et al., 1994; Mahboubi et al., 2006). At this time, the carbonates of the Kalat Formation were deposited in shoreline to inner ramp settings (Mahboubi et al., 2006). In the Early Paleocene time, the redbed