Cretaceous Research 60 (2016) 28–51

Contents lists available at ScienceDirect

Cretaceous Research

journal homepage: www.elsevier.com/locate/CretRes

Depositional environments and ichnology of Upper Cretaceous deep-marine deposits in the Sistan Suture Zone, Birjand, Eastern Iran

Aram Bayet-Goll [a, *], Paolo Monaco [b], Farah Jalili [c], Mohammad-Hossein Mahmudy-Gharaie [a]

[a] Department of Geology, Faculty of Science, Ferdowsi University of Mashhad, Iran
[b] Dipartimento di Scienze della Terra, Universitá degli Studi di Perugia, Piazza dell'Universitá, 1-06100 Perugia, Italy
[c] Department of Geology, Faculty of Science, University of Birjand, Iran

ARTICLE INFO

Article history:
Received 5 March 2015
Received in revised form
4 October 2015
Accepted in revised form 16 October 2015
Available online 17 December 2015

Keywords:
Turbidites
Facies associations
Ichnocoenoses
Trace fossil assemblages
Sistan ocean
Eastern Iran

ABSTRACT

The palaeoenvironmental significance of trace fossil assemblages in the flysch deposits of the Upper Cretaceous of the Sistan ocean – the Sefidabeh basin in the Sistan Suture Zone SSZ in Eastern Iran – has been assessed for the first time. The Sefidabeh basin of turbidite origin consists of 10 sedimentary facies, which can be grouped into 3 facies associations (FA) representing submarine channel-related facies associations (FA1), lobe-related facies associations (FA2), distal fan-basin floor facies associations of a deep-water turbidite system (FA3). Thirty three ichnogenera, with many ichnospecies, have been identified in this deep sea succession: *Alcyonidiopsis*, *Arthrophycus*, *Asterostoma*, *Belorhaphe*, *Bergaueria*, *Cardioichnus*, *Chondrites*, *Cosmorhaphe*, *Desmograpton*, *Gyrophyllites*, *Halopoa*, *Helminthopsis*, *Helminthorhaphe*, *Laevicyclus*, *Lophoctenium*, *Mammilichnis*, *Megagrapton*, *Multina*, *Nereites*, *Ophiomorpha*, *Palaeophycus*, *Planolites*, *Phycodes*, *Phycosiphon*, *Paleodictyon*, *Rutichnus*, *Scolicia*, *?Strobilorhaphe*, *Taenidium*, *Teichichnus*, *Thalassinoides*, *Zoophycos* and *Urohelminthoida*. Their distribution is clearly linked with lithofacies and depositional palaeoenvironments. Changes in trace fossil assemblages and ichnocoenoses follow different environments of the turbidity system of the submarine channel to fan system of the Sefidabeh basin and are associated with variations in environmental controlling factors. Environmental controlling factors including hydrodynamic regime, oxygen level, organic content and sedimentation rates. Ten ichnocoenoses were recognized in the facies associations of the deep-sea fan system of this study. Taking into consideration the diversity, bioturbation level, and colonization order of bioturbated beds and the obvious deepening of the deep-sea depositional system from inner to outer parts of the succession, ichnocoenoses can express a bathymetric trend from shallower to deeper parts, and from higher-to-lower hydrodynamic condition of deep-sea fan systems of the Sefidabeh basin. This study reveals important sedimentological and ichnological features of turbiditic systems in deep sea settings of Iran and permits the development of predictive models for the palaeoenvironmental significance of trace fossil assemblages that can be readily translated to analogous depositional systems in the surface/subsurface.

1. Introduction

Ichnological studies provide detailed information on environmental parameters involved during deposition, and therefore can be used as a basis for sedimentary environments and facies analysis in turbidite systems (e.g. Seilacher, 1974, 1977, 2007; Książkiewicz, 1977; Uchman, 1995a,b, 1999; Bromley, 1996; Uchman, 2007; Heard and Pickering, 2008; Monaco et al., 2010, 2012a,b; Cummings and Hodgson, 2011; Callow et al., 2013, 2014; Bayet-Goll et al., 2014; Heard et al., 2014; Knaust et al., 2014). Turbidite deposits of the Upper Cretaceous of the Sefidabeh basin in the Sistan Suture Zone (SSZ), eastern Iran, host some sparse and restricted trace fossil assemblages which has been assessed for the first time. The sedimentary environment of the Upper Cretaceous of the Sefidabeh basin are poorly understood and the potential of trace fossils as tool for reconstructing depositional conditions of

* Corresponding author. Research Institute of Petroleum Industry (RIPI), West Boulevard, Azadi Sport Complex, Tehran, 14665-1988, Iran.
E-mail addresses: aram1361@gmail.com (A. Bayet-Goll), pmonaco@unipg.it (P. Monaco).

http://dx.doi.org/10.1016/j.cretres.2015.10.015
0195-6671/

these deposits has not been realized until now. Therefore, the main purposes of this paper are: (1) to describe and illustrate the trace fossils assemblages of the Upper Cretaceous flysch of the Sefidabeh Basin; (2) to evaluate their palaeoecology and ethology; and (3) to briefly discuss their palaeoenvironmental distribution. This paper develops a practical ichnocoenoses-based approach (considering pre- and post-depositional trace fossils, Książkiewicz, 1954; Seilacher, 1962, 2007; Leszczyński, 1993; Monaco et al., 2010; Knaust et al., 2014) for the use of all ichnotaxa in palaeoenvironmental analysis of turbidite systems (Heard and Pickering, 2008). It is considered that the trace fossil content, diversity, abundances, and ethologies determined from this case-study could be used as a basis for interpretation of Sefidabeh turbidite system.

2. Geological setting

The Sistan Suture Zone (SSZ) in eastern Iran extends as a N–S trending belt over more than 700 km located between the Lut continental block to the west and the Afghan block to the east from Early Cretaceous to Paleocene times (Fig. 1). The SSZ exposes a well-preserved subduction zone complex, which provides evidence for the closure of a northward-extending promontory of the Neo-Tethyan ocean during Early Cretaceous to Paleocene times due to convergence between the Central Iranian Lut block and the Afghan microcontinent (Tirrul et al., 1983). The deformed accretionary prism of the SSZ was emplaced during the destruction of a small Neotethyan ocean basin, referred to as the Sistan Ocean (Tirrul et al., 1983). In this respect, the Lut block is situated in the Central Iran plate and separated from the Afghan block by the Sistan ocean zone. This zone is one of the remnant basins that was located between two micro-continental fragments as a result of the tectonic collision and migration of the Lut block towards the Afghan block (Babazadeh, 2003; Bröcker et al., 2013). According to Tirrul et al. (1983), the Sistan suture zone can be divided in two main units: the Neh-Ratuk complex (accretionary wedge "mélange") to the west and the Sefidabeh fore-arc basin or the Sistan ocean zone (Fig. 1). Its tectonic evolution was dominated by the emplacement of the Cretaceous ophiolites and ophiolitic mélanges, followed by deposition of Upper Cretaceous–Eocene flysch (Babazadeh and De Wever, 2004; Fotoohi-Rad et al., 2009). Based on studies of Stöcklin (1972) the shallow water sea governed upon the Lut and Afghan blocks from Cretaceous to Eocene times. In contrast, the Sistan ocean zone was characterized by deep water facies including the succession described here (Babazadeh, 2003; Jalili, 2011). Both the Ratuk and the Neh complexes comprise ophiolitic mélanges, as well as metamorphosed and non-metamorphic deposits. The Sistan ocean zone, which unconformably overlies the Ratuk and Neh complexes, consists of flysch deposits (Maastrichtian to Eocene), which are

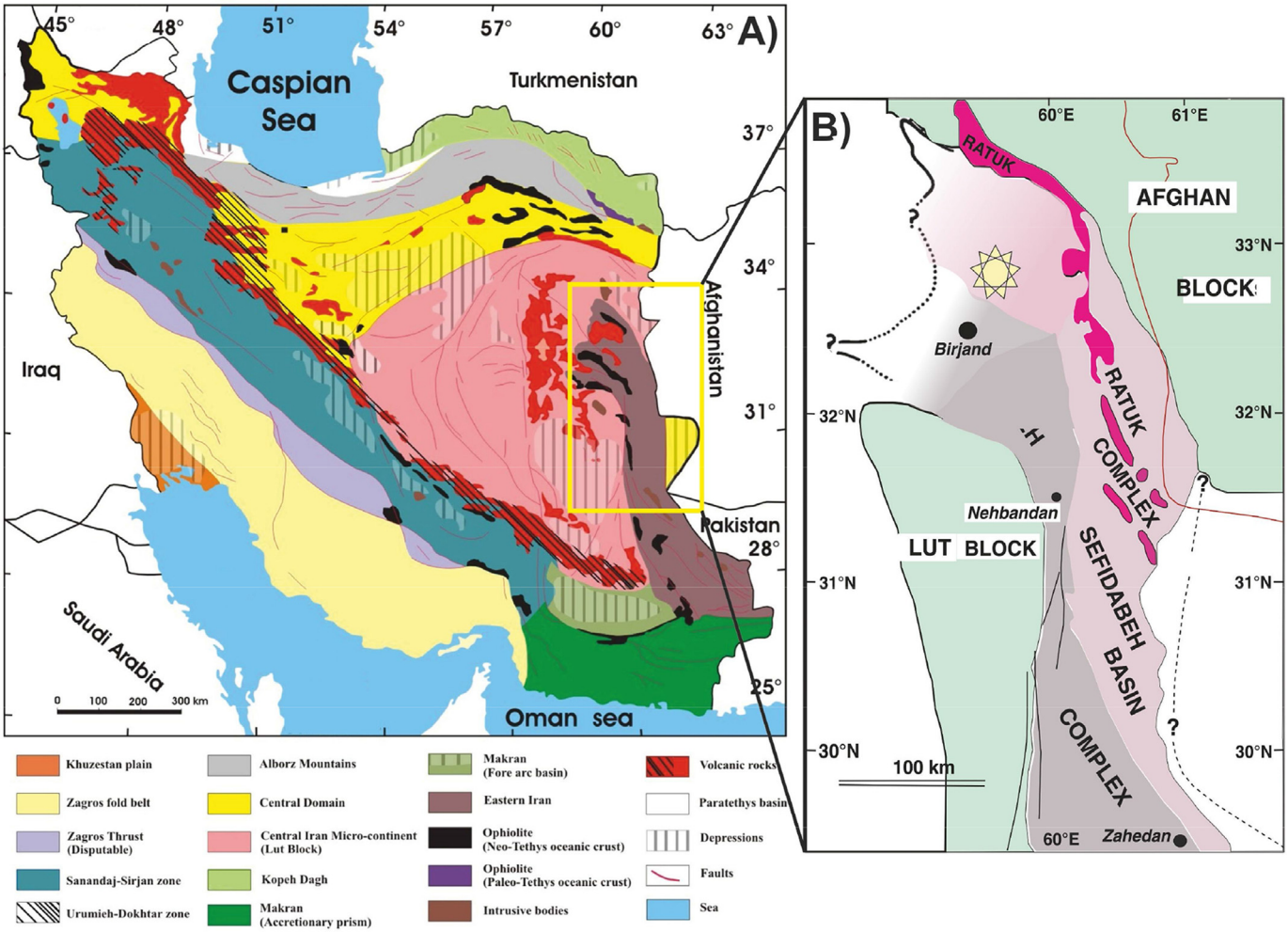

Fig. 1. A. Map shows the geology of Iran with its structural provinces (Nezafati, 2006). B. Simplified geological map of the Sistan Suture Zone (modified after Tirrul et al., 1983; Bröcker et al., 2013).