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ScienceDirect
Palaeoworld 23 (2014) 50–68
Palaeoworld
www.elsevier.com/locate/palwor

Trace fossils analysis of fluvial to open marine transitional sediments: Example from the Upper Devonian (Geirud Formation), Central Alborz, Iran

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Received 27 November 2012; received in revised form 26 August 2013; accepted 17 October 2013
Available online 31 October 2013

Abstract

This study integrates ichnological and sedimentological data to interpret depositional environments of the mixed siliciclastic-carbonate fluvial to marine sediments of the Geirud Formation (Upper Devonian) in the central Alborz, northern Iran. Lithofacies analysis shows that these sediments are deposited in fluvial, tidal, shoreface, and shelf environments. Fluvial and tidal deposits are characterized by the presence of bi- to multi-directional cross beddings, reverse directional current ripples, low angle cross beddings, and herringbone cross beddings, with a few scattered *Skolithos* and *Palaeophycus*. Shoreface sediments, accumulated in a storm-influenced setting, are characterized by a preferentially interface and low diversity *Cruziana* ichnoassemblage (*Rhizocorallium*, *Thalassinoides*, *Palaeophycus*, *Chondrites*, and *Ophiomorpha*). In contrast to the fluvial-tidal assemblage, the storm-influenced shelf sediments display a highly diversified, mixture of dwelling and feeding forms (*Arenicolites*, *Protovirgularia*, *Diplocraterion*, *Palaeophycus*, *Thalassinoides*, *Chondrites*, and *Helminthopsis*), reflecting the presence of adequate food resources both in substrate and water column under normal salinity conditions. A fluvial-shelf replacement of the weakly to scarcely bioturbated sediments by the *Rhizocorallium-Thalassinoides* suite (*Cruziana*) – *Chondrites-Helminthopsis* (distal *Cruziana*) suite from the lower to upper parts of the succession clearly indicates an overall deepening upward in the Geirud Formation. In contrast to the lower part, generally of restricted environment, the upper part of the succession mainly shows open marine conditions. Ichnofabric development is controlled primarily by depositional conditions, e.g., bottom water oxygenation, sediment type, food abundance, and hydrodynamic level, which all exert control on substrate colonization style.

Keywords: Fluvial-marine transition; Trace fossil; Devonian; Geirud Formation; Depositional environment

1. Introduction

The Upper Devonian Geirud Formation in the Central Alborz of the northern Iran consists of mixed siliciclastic-carbonate sediments. These sediments represent an overall deepening-upward succession that was accumulated on a gently sloping continental ramp on the northern continental margin of the Gondwana landmass (Fig. 1). The most tide-dominated estuarine deposits were accumulated in the fluvial to marine transition zone. The transition zone between terrestrial (river) environments and the open-marine shelf represents one of the most profound spatial changes in depositional condition. A monotonic seaward increase in salinity from fresh through brackish to fully marine on the shelf characterizes estuaries. The brackish water conditions in the transition zone, accompanied by the high turbidity and physically harsh conditions, produce a biologically stressed environment, in which bioturbation is generally not pervasive. The ichnofossil assemblage in this zone is characterized by the low diversity of ichnogenera and small size of the individual burrows. This transition zone is characterized by remarkable changes in rate and direction of sediment movement, which is unidirectional and continuous to seasonal or flashy in the river, mutually evasive transport pathways in tidal settings to episodic and either coast parallel in shelf settings. In general, these zones display a simple decrease in energy level as water depth increase (Dalrymple and Choi, 2007). As a result of this monotonic trend in energy level, there is a predictable correlation between water depth and facies. Vertical trend is represented by a coarsening upward succession that passes from mudstones or thin-bedded limestone (offshore or shelf), through deposits with thin, discrete sandstone beds with ripples and hummocky cross beddings (HCS) (offshore transition), into amalgamated sandstones with HCS (lower to

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1871-174X/$ – see front matter
http://dx.doi.org/10.1016/j.palwor.2013.10.004

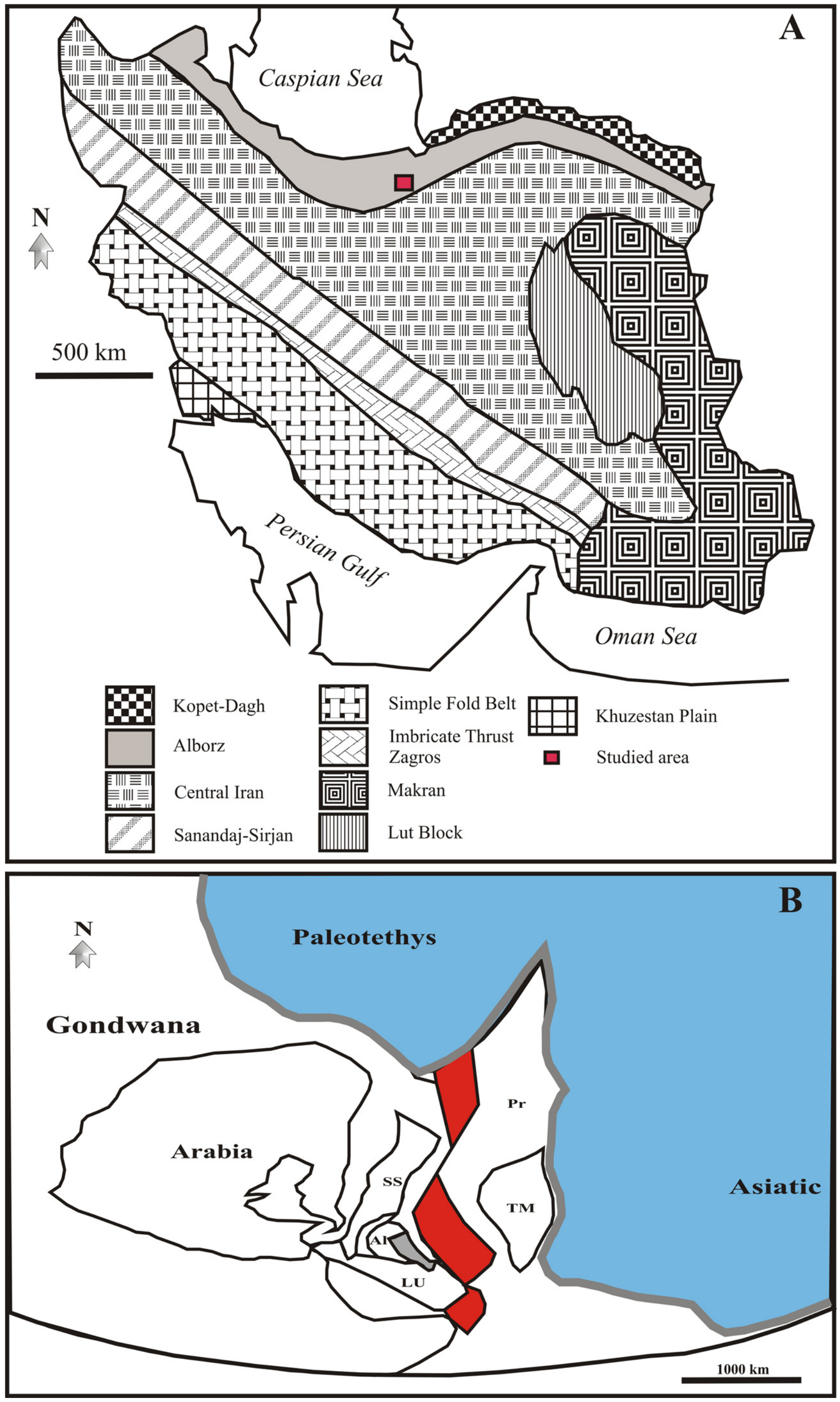

Fig. 1. (A) Map of Iran showing the nine geological-structural zones (modified from Stöcklin, 1968). (B) Generalized palaeogeography of the Upper Devonian of the north Gondwana and the southern shore of the Palaeo-Tethys Ocean, displaying the passive margin of the north Gondwana (thickened gray line) and the northward drift of the Tarim (TM) and Pamir (Pr) continents (modified from Golonka, 2007; Bagheri and Stampfli, 2008). AL: Alborz; LU: Lut block; Pr: Pamir; SS: Sanandaj-Sirjan; TM: Tarim. The area in red is a rift zone. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

middle shoreface) and eventually into sandstones with abundant HCS and planar to trough cross bedding (upper shoreface) (e.g., Walker and Plint, 1992). Ichnological analysis has become a valuable tool in basin analysis, especially for recognizing and interpreting genetically related sedimentary packages (e.g., Tovar et al., 2007). The primary controls on the distribution of different burrowing behaviors and lifestyle of the existing fauna and the trace markers in the marine realm are widely considered to be nutrient supply, hydrodynamic energy (Seilacher, 1967), salinity (Pemberton and Wightman, 1992), rate of sedimentation (Pollard et al., 1993), oxygenation of the water column (Bromley and Ekdale, 1984), substrate consistency (MacEachern and Burton, 2000), and water turbidity (Gingras et al., 2008). These factors also control diversity, abundance,