Review of Palaeobotany and Palynology 235 (2016) 51–70

Contents lists available at ScienceDirect

Review of Palaeobotany and Palynology

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

Multiphase response of palynomorphs to the Toarcian Oceanic Anoxic Event (Early Jurassic) in the Réka Valley section, Hungary

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ARTICLE INFO

Article history:
Received 2 September 2015
Received in revised form 13 September 2016
Accepted 24 September 2016
Available online 30 September 2016

Keywords:
Dinoflagellate cysts
Early Jurassic
Mecsek Mountains
Hungary
Palynofacies
Prasinophytes
Toarcian Oceanic Anoxic Event (T-OAE)

ABSTRACT

Major palaeoenvironmental and palaeoceanographical changes occurred during the Early Jurassic Toarcian Oceanic Anoxic Event (T-OAE), due to a perturbation of the global carbon cycle and a crisis in marine ecosystems. The sequence of environmental change and regional differences during the T-OAE are not yet fully understood and organic-walled phytoplankton and other palynomorphs are well-suited, but under-utilised, in research into this event. Based on quantitative palynological analyses from a black shale-bearing succession at Réka Valley in the Mecsek Mountains of southwest Hungary, five sequential palynomorph assemblages are distinguished. These reveal major shifts in organic-walled phytoplankton communities, driven by palaeoenvironmental changes. In addition, palynofacies analysis helped to document changes in the composition of sedimentary organic matter, and to quantify the terrestrial input. Assemblage 1 is characterised by a moderately diverse phytoplankton community and high levels of terrestrial palynomorphs. Assemblage 2 records a significant peak of the euryhaline dinoflagellate cyst *Nannoceratopsis*. Assemblage 3 is distinguished by dominance of highly opportunistic prasinophytes and the temporary disappearance of all dinoflagellate cyst taxa. Assemblages 4 and 5 represent distinctive phases of a prolonged recovery phase with low diversity phytoplankton assemblages and intermittently high levels of terrestrially-derived palynomorphs. The successive disappearance of phytoplankton taxa and the gradual takeover by opportunistic euryhaline species at the onset of the T-OAE were related to several phenomena. These include reduced salinity in the surface waters, establishment of a stable pycnocline and deterioration of nutrient recycling, followed by oxygen deficiency throughout much of the water column. The high amount of terrestrially-derived palynodebris indicates intense runoff and freshwater input, driven by the early Toarcian warming and the enhanced hydrological cycle. Comparison with coeval European successions proves that the palaeoenvironmental changes during the T-OAE were not entirely synchronous, and local factors played a crucial role in influencing phytoplankton communities. In the Mecsek Basin, regional freshening of the surface waters and increased terrestrial input due to the proximity of the hinterland had a greater influence on phytoplankton communities compared to the open oceanic setting of the Tethys to the south.

1. Introduction

The early Toarcian (Early Jurassic, ~183–179 Ma) was a time of severe palaeoenvironmental perturbations. Global warming, sea level rise and the associated geochemical changes in the ocean-atmosphere system led to a multiplicity of palaeoenvironmental changes which significantly stressed the biosphere and caused biotic turnovers. Marine transgression, carbon isotope excursions, other geochemical anomalies and widespread deposition of organic-rich sediments are associated with the Toarcian Oceanic Anoxic Event (T-OAE) (Jenkyns, 1988; McArthur et al., 2000; Schouten et al., 2000; Jenkyns et al., 2002; Bailey et al., 2003; Van de Schootbrugge et al., 2005a; Hesselbo et al., 2007; Suan et al., 2008; Littler et al., 2009; Korte and Hesselbo, 2011; Hermoso et al., 2013). A plausible initial triggering mechanism for the palaeoenvironmental perturbations is methane hydrate dissociation (Hesselbo et al., 2000, 2007). However the most likely, and less debated, main cause of these paleoenvironmental changes was the emplacement of the Karoo-Ferrar large igneous province (Pálfy and Smith, 2000; McElwain et al., 2005; Svensen et al., 2007; Suan et al., 2008; Burgess et al., 2015).

The T-OAE is associated with a minor mass extinction in several taxonomic groups (e.g. Harries and Little, 1999; Pálfy and Smith, 2000; Wignall, 2001; Caruthers et al., 2013; Caswell and Coe, 2013; Danise et al., 2013). Coeval environmental perturbations include increased

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http://dx.doi.org/10.1016/j.revpalbo.2016.09.011
0034-6667/

terrestrial input due to enhanced weathering and riverine influx, stratification of the water column with subsequent anoxia and ocean acidification. These changes caused severe stress for many phytoplankton groups. The effects of oceanic anoxic events on phytoplankton assemblages have been discussed extensively (Bucefalo Palliani et al., 1998, 2002; Bucefalo Palliani and Riding, 1999a; Erba, 2004; Mattioli et al., 2004, 2009; Van de Schootbrugge et al., 2005b, 2013). Dinoflagellate cysts are one of the major groups of Early Jurassic fossilisable phytoplankton. The dinoflagellates are a diverse eukaryotic protistan group of extant unicellular phytoplankton, and are important primary producers at the base of the marine and freshwater food chains (Taylor et al., 2008). Many dinoflagellates have at least two distinct stages in their life cycle. During the motile stage, they inhabit the photic zone and their distribution is affected mostly by surface water temperature, salinity, nutrient availability and light penetration (Marret and Zonneveld, 2003). Many dinoflagellates include a fossilisable resting cyst in their life cycle; these hypnozygotic cysts are extremely useful in studies of Mesozoic and Cenozoic biostratigraphy, palaeobiology and palaeoecology (Stover et al., 1996). Cyst-producing dinoflagellates are very sensitive to ecological conditions, especially oxygen availability

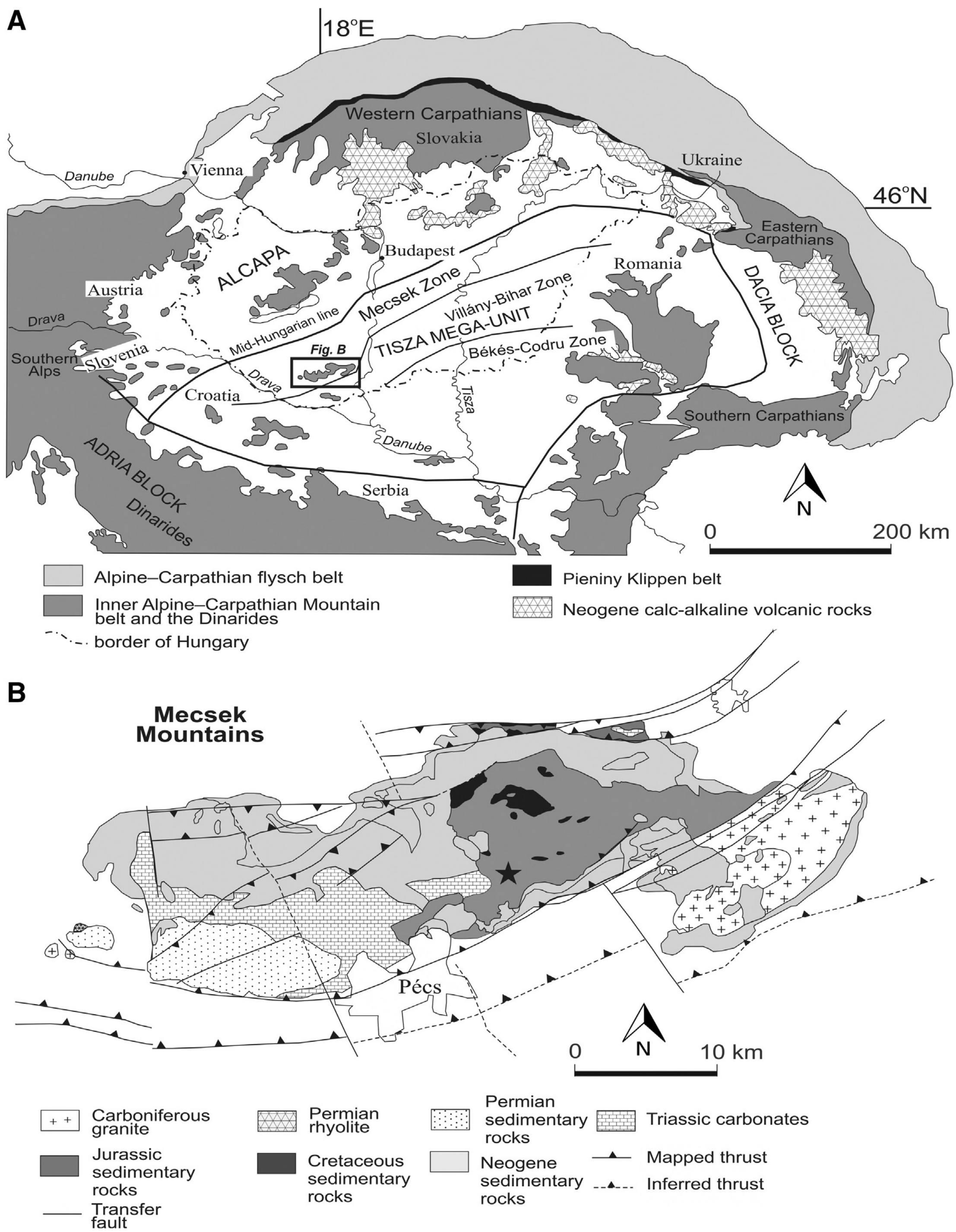

Fig. 1. A. The geological framework and the major tectonic units of the Carpathian–Pannonian area (after Csontos and Vörös, 2004). The box indicates the area shown in 1B. B. Generalised geological map of the Mecsek Mountains, southwest Hungary illustrating the outcrop area of the Jurassic formations. The location of the Réka Valley section is marked by an asterisk. Modified after Raucsik and Varga (2008a), with structural geology from Csontos et al. (2002).