Cretaceous Research 51 (2014) 1–21

Contents lists available at ScienceDirect

Cretaceous Research

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

Assessing the factors controlling high sedimentation rates from the latest Barremian–earliest Aptian in the hemipelagic setting of the restricted Organyà Basin, NE Spain

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ARTICLE INFO

Article history:
Received 17 January 2014
Accepted in revised form 15 May 2014
Available online 17 June 2014

Keywords:
Organyà Basin
Latest Barremian–earliest Aptian
High sedimentation rate
Calcareous nannofossils
High primary productivity
Terrestrial fluxes

ABSTRACT

The Organyà Basin, south–central Spanish Pyrenees, developed as a marginal depocenter during a rapid extensional phase of anticlockwise rotation of the Iberian plate. As a result of increased subsidence, an important change in sedimentation occurred from the late Barremian to the Aptian leading to unusually high sediment accumulation rates. Approximately 1000 m of hemipelagic marls and limestones accumulated during this time interval.

Here we studied the basal 85 m of the hemipelagic facies of the El Pui section, Organyà Basin, that are characterized by alternating 15 cm – ~3 m thick beds of limestone and marls. Geochemical analyses indicate high total inorganic carbon (TIC) values (average 70%) suggesting enhanced $CaCO_3$ production and deposition. SEM analyses of the samples indicate high abundance of calcareous nannofossils, which together with the absence of shallow water taxa characteristic of the Urgonian Carbonate platform of Organyà, and the lack of sedimentary facies attributable to carbonate platform components point to nannofossils as the main source for the elevated TIC. Organic-rich levels (total organic carbon (TOC) up to 1.74%) concurrent with positive excursions up to 2‰ in $\delta^{13}C_{org}$, imply enhanced preservation of organic matter (OM) in the basin. In addition, pronounced peaks of $\delta^{13}C_{org}$ higher than the global average suggest superimposed local factors related to intensified ^{12}C removal due to primary productivity. Biomarker analyses and the $\delta^{13}C_{org}$ profile suggest an autochthonous origin of the OM from phytoplankton and possible additional contributions from microbial communities.

X-ray diffraction (XRD) results attest for sustained terrestrial fluxes as the source of nutrients to the basin because of a 30% average non-carbonate bulk mineral content in the sediment. The non-carbonate fraction is dominated by quartz (average, 14%) whereas the clay mineral assemblages are characterized by high illite content (>73 relative%) with minor concentrations of kaolinite (<5%), illite /smectite mixed layers (<17%) and chlorite (<15%), consistent with a provenance from the Paleozoic metamorphic terranes adjacent to the Organyà Basin.

The integrated results suggest a high sediment accumulation rate (5 cm/ky–7.5 cm/ky) and enhanced carbon burial during the latest Barremian–earliest Aptian in the hemipelagic setting of the El Pui section.

1. Introduction

The causes of the occurrence of high accumulation rates within the Barremian–Aptian time interval (~125 Ma) [(e.g. Angles section, southern France (Wissler et al., 2002); northern Germany (Mutterlose et al., 2009); La Bédoule section southeast France,

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http://dx.doi.org/10.1016/j.cretres.2014.05.010
0195-6671/

(Kuhnt et al., 2011); Sierra del Rosario eastern Durango state Mexico (Núñez-Useche and Barragán, 2012); Blid and Ecleja Formations of the Pădurea Craiului Massif (Papp et al., 2013); see other locations in Bralower et al. (1994)] have been associated with intensified weathering and transport of continental materials to the marine environment, thereby increasing the nutrient load, especially in epicontinental seas and restricted marine settings (Arthur, 1979; Scott, 1992; Larson and Erba, 1999; Duque-Botero and Maurrasse, 2005; Föllmi and Gainon, 2008; Melinte-Dobrinescu and Roban, 2011; Föllmi, 2012; Masse and Fenerci-Masse, 2013). Such increased terrigenous fluxes within that time interval have been related to greenhouse conditions (Weissert, 1989; Erba, 1994; Weissert et al., 1998; Frakes, 1999; Pucéat et al., 2003). However, reported dry, colder periods in the late Barremian (Ruffell and Batten, 1990; Malkoč and Mutterlose, 2010) suggests that seasonality could have also been a major factor in controlling nutrient supply to restricted marine basins.

In the case of semi-enclosed basins the transport of terrestrial material may be further enhanced by physiographic conditions, as for example the proximity of landmasses and magnitude of elevation differences, as well as the nature of the surrounding terranes. As observed in modern environments (e.g. Grégoire et al., 2004; Oguz, 2006) these factors can be critical in promoting special conditions favorable to unusual sustained blooms of certain groups of organisms, particularly primary producers, and notably opportunistic or eurytopic taxa.

The paleoenvironmental record provides a glance of similar effects on primary producers that benefited from significant nutrient supply associated with sustained terrigenous input (Erba, 1994; Meyers, 1997; Aguado et al., 2013). Furthermore, the lower Cretaceous record provides evidence that in some fertile marginal basins of the Tethys Ocean enhanced productivity may have intensified both the export of carbonate and organic matter (OM) to the sediment (Koutsoukos et al., 1991a, 1991b; Mutterlose and Bockel, 1998; Stein et al., 2011; Sanchez-Hernandez and Maurrasse, 2014). Higher bottom export of OM adversely affects oxygen levels in the water column because of an accelerated respiration rate, and in basins with limited ventilation OM influx may exceed remineralization. Such process may induce severe dysoxia, which further enhance preservation of organic carbon (OC) in the sediments (e.g. Black Sea; Grégoire et al., 2004; Oguz, 2006).

In the Organyà Basin, upper Barremian–lower Aptian hemipelagic facies of mostly dark limestones and marls overlying shallow-water carbonate platform deposits of the Prada Formation suggest a deepening depocenter with similar temporal development of oxygen deficient phases (Peybernès and Souquet, 1973; Peybernès, 1976; Martínez, 1982; Caus et al., 1990; Berástegui et al., 1990; Dinarès-Turell and García-Senz, 2000; García-Senz, 2002; Bernaus et al., 2002, 2003). The section was deposited during a period of unusually high sedimentation rates of pelagic carbonate concomitant with terrigenous material. Coeval sites in the Western Tethys are also reported to include hemipelagic sediments with high accumulation rates and oxygen-deficient episodes (e.g. Arthur, 1979; Mutterlose et al., 2009; Melinte-Dobrinescu and Roban, 2011), but unlike the other sites, recent studies have demonstrated that the El Pui sequence of the Organyà Basin is predominantly calcareous (TIC: 49–88%) and to a lesser extent terrigenous (Sanchez-Hernandez and Maurrasse, 2014). So far, this apparent unusual characteristic of the semi-restricted Organyà Basin has not been addressed, and the main source and factors involved in the high carbonate accumulation at El Pui remain to be fully understood.

The present study aims to characterize the factors that controlled the high accumulation rates in the El Pui section (Fig. 1) during the latest Barremian–earliest Aptian through a comprehensive analysis of different criteria: composition of the nannofossil assemblages; geochemical analyses: carbon content and isotopic variation (TOC, TIC, $\delta^{13}C_{org}$), biomarker analysis; bulk and clay mineral content; and scanning electron microscope (SEM) with energy dispersive spectrometry (EDS).

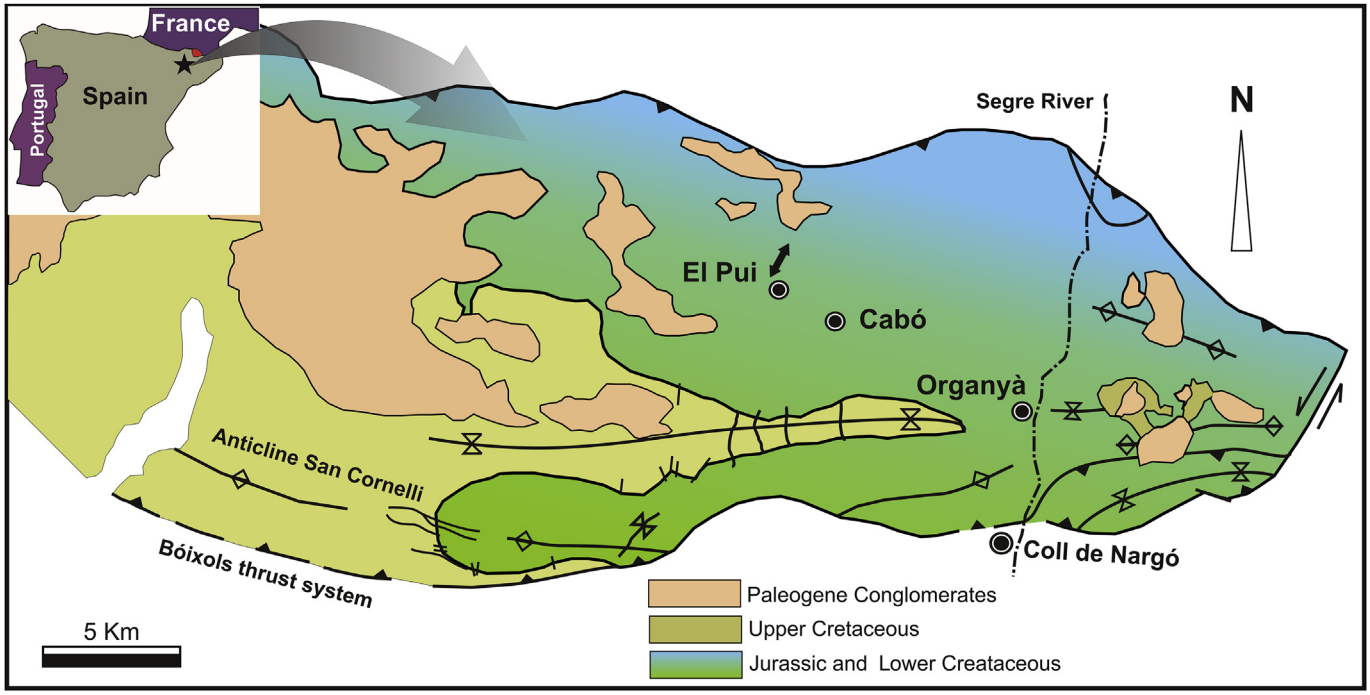

Fig. 1. General geographic location and simplified geologic map of the Organyà area modified from García-Senz (2002). The arrow next to El Pui represents the approximate location of the studied section.