Global and Planetary Change 148 (2017) 79–95

Contents lists available at ScienceDirect

Global and Planetary Change

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

Western Tethys continental-marine responses to the Carnian Humid Episode: Palaeoclimatic and palaeogeographic implications

J. López-Gómez [a,*], M.J. Escudero-Mozo [a], J. Martín-Chivelet [b], A. Arche [a], M. Lago [c], C. Galé [c]

[a] Instituto de Geociencias (UCM, CSIC), c/José Antonio Nováis 2, 28040 Madrid, Spain
[b] Departamento de Estratigrafía, Facultad de Ciencias Geológicas, Universidad Complutense, and Instituto de Geociencias (UCM, CSIC), c/José Antonio Nováis 2, 28040 Madrid, Spain
[c] Facultad de Ciencias, Departamento de Ciencias de la Tierra. Facultad de Ciencias, Universidad de Zaragoza, C/Pedro Cerbuna 12, 50009 Zaragoza, Spain

ARTICLE INFO

Article history:
Received 24 June 2016
Received in revised form 18 November 2016
Accepted 26 November 2016
Available online 05 December 2016

Keywords:
Carnian Humid Episode
CHE
CPE
Western Tethys
Julian
Late Triassic
Keuper

ABSTRACT

This case-study examines correlations in the continental-marine sedimentary record for the Late Triassic Carnian Humid Episode in the western Tethys domain of present-day E Spain and islands of Majorca and Minorca.
The study area was divided into five sectors from west to east. Sectors 1 to 3 comprise the continental sedimentary record of this humid episode in eastern Iberia, which is represented by the three subunits (K-2.1, K-2.2 and K-2.3) of the K-2 Fm or Manuel Fm; each subunit records a fluvial episode with marine intercalations in distal areas. Sector 4 corresponds to Majorca Island and represents volcaniclastic input into a marginal continental-marine transitional environment. Finally, sector 5 on Minorca Island comprises a karst surface developed on middle ramp deposits of the Arenal d'en Castell Fm, and separating this formation from the overlying Fontanelles Fm. Based on the ages of the units, estimated through palynomorph assemblages and ammonites, the Carnian Humid Episode was located in both the continental and marine sedimentary records.
A detailed sedimentary study focused on facies analysis identified allogenic controls on both continental and marine records. Hence, in continental areas influenced by sea-level fluctuations, fluvial deposits appear integrated within standard lowstand, transgressive and highstand system tracts. This connection based on sedimentary sequences and unit ages indicates that subunits K-2.1 and K-2.2 are represented by a karst surface on the subaerially exposed shallow marine deposits, while subunit K-2.3 already reflects a return to the normal Late Triassic semi-arid to arid conditions that laterally correspond to the transgressive stage represented by the Fontanelles Fm in sector 5.
Late Triassic tectonics activated previously developed N·NE-S·SW and NW-SE conjugate fault lineaments in eastern Iberia. This rifting episode controlled sedimentation in sectors 1 to 3, allowing volcanic activity at the fault lineaments junction in sector 4, and configuring a palaeogeography of elevated and subsiding blocks, which controlled both continental and marine sedimentation in the study area.

1. Introduction

The Late Triassic period was part of a broad greenhouse time interval dominated in the Tethys domain by semi-arid, warm climate conditions with brief hot phases (Royer et al., 2004; Preto et al., 2010; Lucas and Orchard, 2013). However, in the early Julian to Tuvalian of the Carnian stage, regional basins experienced dramatic changes reflected in their sedimentary records. Carbonate platforms developing in the tropics were abruptly interrupted, while river systems occupied vast surfaces on land and left widespread sandstone across coastal regions (Berra, 2012). This humid episode was initially described by Simms and Ruffell (1989, 1990) as the Carnian Pluvial Episode and later coined the Carnian Humid Episode (CHE) by the same authors (Ruffell et al., 2016). A few years later, Gianolla et al. (1998) also suggested the worldwide effect of this Carnian climatic humid phase. The onset and cessation of this episode has been linked to significant biotic changes, including both extinctions and diversifications (Simms et al., 1994). However, this hypothesis was not initially embraced (e.g. Visscher et al., 1994) and more than two decades since it was first proposed, it is now gaining mounting support as described in a detailed review by Ruffell et al. (2016). Thus, the CHE is today considered a global event, and has been so described in many different basins (Bechstadt and Schweizer, 1991; Berra and Jadoul, 2002; Rigo et al., 2007; Preto et al., 2010; Kozur and Bachmann, 2010; Shukla et al., 2010; Roghi et al., 2010; Sýkora et al., 2011; Rigo et al., 2012; Haas et al., 2012; Lukeneder et al., 2012; Bialik et al., 2013; Arche and López-Gómez, 2014; Ogg, 2015, and those included in Ruffell et al., 2016). However, in a recent study of this episode, Wignall (2015) reported that its effects seem to be masked in some places. Although the origins of the CHE are

* Corresponding author.
E-mail address: jlopez@geo.ucm.es (J. López-Gómez).

http://dx.doi.org/10.1016/j.gloplacha.2016.11.016
0921-8181/

not yet clearly understood (Gattolin et al., 2015), most observations suggests it relates to the Wrangelia large igneous province (Furin et al., 2006; Nakada et al., 2014; Ruffell et al., 2016; Mueller et al., 2016, among others). Synchroneity between this igneous province and the CHE was also noted by Xu et al. (2014). In addition, Dal Corso et al. (2012, 2015) and Sun et al. (2016) specifically related the carbon isotope excursion of Carnian age to the Wrangelia event. This igneous province may have been the trigger for abrupt carbon-dioxide-induced warming and associated increased rainfall, although its duration, global impacts and relatively rapid termination are not fully understood and require more intercalibrated terrestrial and marine data.

Elevated rainfall increased river competence and large amounts of sediments shed into the seas fringing Pangea. As a result, limestone ceased formation due to swamping of carbonate-producing organisms, and fluvial and marine sandstone deposits covered vast extensions of the marine platforms. Gattolin et al. (2015) interpret this climate episode as a first step, just before a second one, also before the drop in sea-level that caused microbialites to vanish and gave rise to shallow water carbonates in the Dolomites, Italy. In the Calcareous Alps in Austria, this episode even saw a change from limestone to siliciclastics (Mueller et al., 2016). Further, recent papers (Rigo et al., 2007; Bonis et al., 2010; Preto et al., 2012; Nakada et al., 2014; Dal Corso et al., 2015) even document the sudden input of siliciclastics in deep-marine settings related to this episode, reinforcing the global climate episode hypothesis.

The Carnian Humid Episode is probably not represented by a single pulse. In recent studies, both in marine (Breda et al., 2009; Stefani et al., 2010; Kolar-Jurkovsek and Jurkovsek, 2010; Franz et al., 2014) and continental (Arche and López-Gómez, 2014) environments, the episode is recorded by three or four separate humid fluctuations before a return to the almost persistent aridity of the Late Triassic. Roghi et al. (2010) considered these different inputs to indicate alternating humid and arid periods in the CHE. These data add to the complexity of understanding this enigmatic humid episode in continental and marine areas, as it was accompanied by the tectonic reorganization of the Tethys domain, including final closure of the Palaeothethys (Ziegler, 1988), a sea-level fall (Haq and Al-Qahtani, 2005), and by the general development of rift system branches related to the break-up of Pangea (Ziegler and Stampfli, 2001).

This palaeogeographic context described for the CHE lacks detailed data on continental-marine connections. Most studies investigating this episode have focused on marine or continental sediments, but have not related the two for the same time span. Indeed, base-level fluctuations in fluvial systems may be related with sea-level changes, continental sediment fluxes across coastal regions, and the demise of carbonate platforms. The present study focuses on continental-marine lateral transition between two different dated stratigraphic units related to the CHE in eastern Iberia and the Balearic Islands, two nearby areas in the subtropical westernmost Tethys area during early Carnian times. The continental deposits examined here are represented by the Manuel Fm, described as the result of the "Carnian Pluvial Event" record in E Spain by Arche and López-Gómez (2014), while its equivalent marine record in Minorca Island has been recently described by Escudero-Mozo et al. (2014).

2. Geological and stratigraphic setting

The present study examines an area of the E Iberian Peninsula and of the Balearic Islands Majorca and Minorca (Fig. 1). During the Late Triassic, the peninsula spanned the latitudes 8°N to 15°N (Perri et al., 2013) and the islands were closer to the peninsula than they are today (Edel et al., 2014; Arche and López-Gómez, 2014), though their precise palaeogeographic location is still unknown. During this time, general plate reorganization involved, among other factors, syndepositional extensional tectonics and frequent sea-level oscillations affecting the Early Mesozoic in Western and Central Europe (Biddle, 1984; Brandner, 1984; Gianolla and Jacquin, 1998) and the Tethys sea advanced westward to encircle the Iberian Massif (Ziegler and Stampfli, 2001). This massif was then an elevated area where continental fluxes, arising during humid stages, sometimes crossed different subsiding trough systems, in which continental sediments accumulated. During periods of falling sea-level and desiccation, "Keuper salts" were deposited in areas of rapid subsidence. The present work focuses on continental-marine responses of the CHE in the eastern Iberian plate, a subtropical area in the westernmost zone of the Tethyan domain (Fig. 1). Three lithostratigraphic units were examined: one of continental origin, the Manuel Sandstones Formation, and two of marine origin, the Arenal d'en Castell and Fontanelles formations. The Manuel Fm was basically deposited in SE Iberia, while the latter two formations were deposited in its fringe marine environments, today found on Minorca Island.

The Manuel Fm, or K-2 unit, was defined by Ortí (1973) as a siliciclastic unit in the middle of the so-called Valencia Group

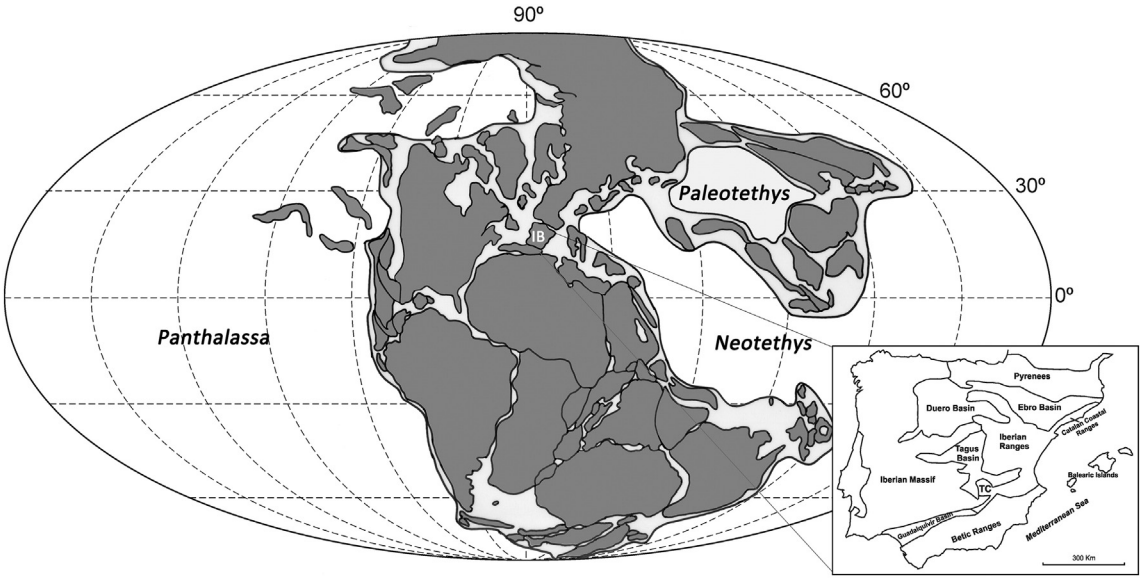

Fig. 1. Present-day geographical location of the studied area and palaeogeographic framework of the Iberian plate (IB) during the Late Triassic (modified from Nakada et al., 2014). This plate was placed within the intertropical belt, at about 15° latitude North, at the westernmost area of the Tethys realm.