Sedimentary Geology 294 (2013) 233–250

Contents lists available at ScienceDirect

Sedimentary Geology

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

High-frequency, moderate to high-amplitude sea-level oscillations during the late Early Aptian: Insights into the Mid-Aptian event (Galve sub-basin, Spain)

Carlos Peropadre [a,b,*], Carlos L. Liesa [c], Nieves Meléndez [a]

[a] Grupo de Análisis de Cuencas Sedimentarias UCM-CAM, Departamento de Estratigrafía, Instituto de Geociencias UCM, CSIC, Facultad de Ciencias Geológicas, Universidad Complutense, C/Antonio Novais 12, 28040 Madrid, Spain
[b] Inypsa, Informes y Proyectos, S.A. Área de Geología, C/General Díaz Porlier 49, 28001 Madrid, Spain
[c] Grupo Geotransfer, Área de Geodinámica Interna, Departamento de Ciencias de la Tierra, Facultad de Ciencias, Universidad de Zaragoza, C/Pedro Cerbuna 12, 50009 Zaragoza, Spain

ARTICLE INFO

Article history:
Received 17 February 2013
Received in revised form 27 May 2013
Accepted 28 May 2013
Available online 10 June 2013

Editor: B. Jones

Keywords:
Incised-valleys
Sea-level curve
Cretaceous glacioeustacy
Mid-Aptian event
Mid-Aptian cooling
Maestrazgo basin

ABSTRACT

This paper presents a field-based stratigraphic architecture research from the Aptian of Spain in which high-frequency (7 cycles/Ma), moderate to high-amplitude (8–127 m) sea-level oscillations are evidenced by the repeated incision of palaeovalleys in a carbonate platform developed during the late Early Aptian in a rift setting. Global eustacy, tectonic uplift and mantle dynamic topography are considered as potential mechanisms to explain the observed relative sea-level record. Glacioeustacy is interpreted as the most reliable mechanism to drive the observed sea-level oscillations, however, other mechanisms as oscillations of the groundwater capacity of sedimentary basins and sudden flooding of major a basin as the south Atlantic rift are also considered. A major cooling event is proposed to occur during the late Early Aptian as a response to a large-scale episode of ignimbritic volcanism, increased burial of organic carbon during the Aptian OAE-1a, and a significant demise of carbonate platforms. This cooling event is interpreted as the origin for glacioeustatic sea-level oscillations during the Mid-Aptian.

1. Introduction

Sea level evolution is an important control on sedimentation and a may represent a significant proxy of the evolution of climate and palaeoenvironmental conditions through geological time. During the Cretaceous period, enhanced greenhouse conditions are generally accepted to occur and polar ice is commonly considered to be absent or very reduced. However, high-frequency (100 ka–1 Ma) sea-level oscillations with moderate (1–20 m) to high-amplitude (20–100 m) has been recognised along the Cretaceous using stratigraphic criteria (Grésselle and Pittet, 2005; Immenhauser, 2005; Miller et al., 2005a; Grélaud et al., 2006; Koch and Brenner, 2009; among others). Such sea-level trends are usually interpreted as evidence for the presence of cooling episodes during which Cretaceous polar ice existed, and suggest that freezing conditions existed in the poles even though the presence of a warmer global climate than today or perhaps that icehouse interludes existed during the overall Cretaceous greenhouse (Stoll and Scharg, 1996; Price, 1999; Miller et al., 2005a,b; Bornemann et al., 2008; Kuhnt et al., 2011).

This paper presents a field-based high-resolution stratigraphic analysis of the Aptian strata in the Galve sub-basin (western Maestrazgo basin) which included the analysis of seismic-scale outcrops in aerial images and exceptional outcrops, and the sedimentologic and petrologic evaluation of key surfaces. The resulting stratigraphic architecture allowed us to reconstruct a relative sea-level changes history. The aim of the study is to assess and discuss the relative sea-level evolution of the latest Early Aptian carbonate platforms in the study area, with particular focus in global eustacy and the context of the Mid-Aptian palaeoenvironmental event.

2. Geological setting

The study area is located in the eastern Iberian Chain (Teruel Province of Aragón, Spain; Fig. 1). The Iberian Chain is an inverted multipulse rift basin that was subsiding from the Permian to the Cretaceous and was folded and uplifted during Cainozoic times in the Alpine orogeny (Álvaro et al., 1979; Salas and Casas, 1993; Salas et al., 2001; Capote et al., 2002). During the Early Cretaceous the study area comprised the north-central sector of the Galve sub-basin (Salas and Guimera, 1996; Soria, 1997), which is located in the western part of

* Corresponding author at: Grupo de Análisis de Cuencas Sedimentarias UCM-CAM, Departamento de Estratigrafía, Instituto de Geociencias UCM, CSIC, Facultad de Ciencias Geológicas, Universidad Complutense, C/Antonio Novais 12, 28040 Madrid, Spain.
E-mail addresses: cperopadre@geo.ucm.es (C. Peropadre), carluis@unizar.es (C.L. Liesa), nievesml@geo.ucm.es (N. Meléndez).

0037-0738/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.sedgeo.2013.05.019

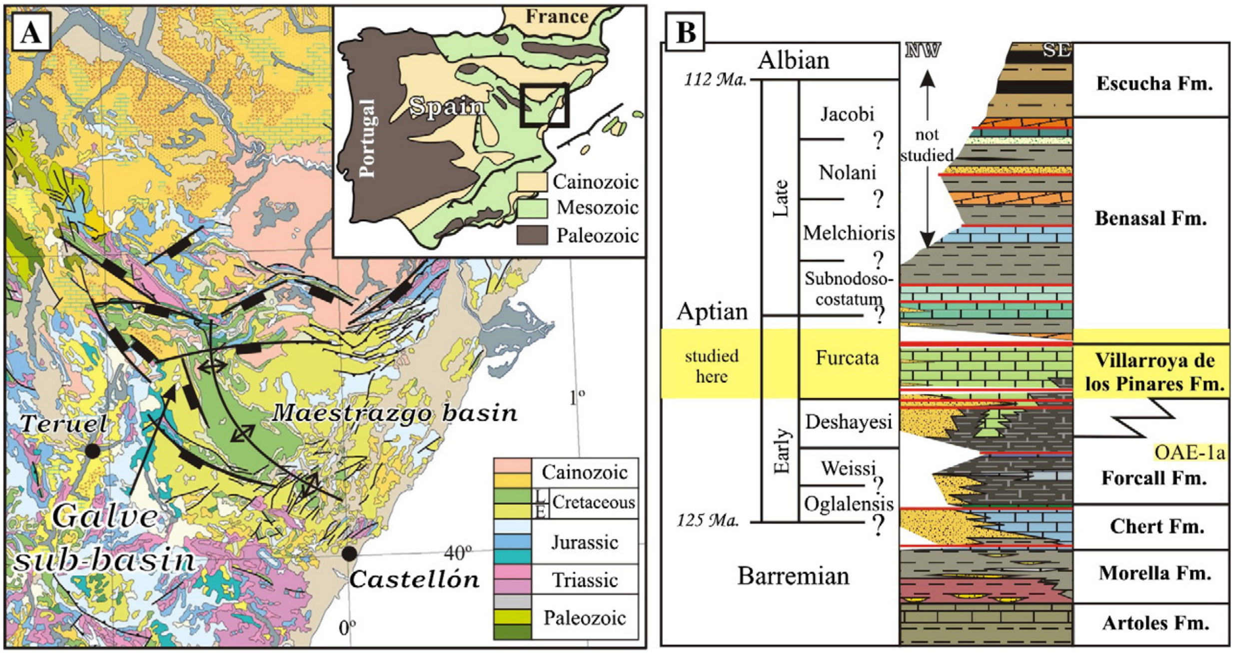

Fig. 1. A) Location and generalised geological context of the Galve sub-basin. B) Stratigraphic framework of the Aptian in the Maestrazgo basin after Peropadre (2012).

the Maestrazgo (or Maestrat) basin. This rift basin developed during Aptian times as a vast shallow epicontinental sea connected basinwards (southwards) to the Sudiberic (Betic) basin where the south-Iberian continental palaeomargin of the Tethys sea is thought to be located (Vilas et al., 2003; Martín-Algarra and Vera, 2004).

The Galve sub-basin, which represents a relative depocentre within the Maestrazgo basin, was individualised during the Early Cretaceous phase of the Iberian rifting process (Soria, 1997; Liesa et al., 2006). The earliest infill corresponds to continental sediments of the El Castellar Fm (Late Hauterivian–Early Barremian), this is overlaid by the continental and nearshore marine Camarillas, Artoles and Morella Fms (Barremian). These later units reach a thickness of about 1000 m in the study area. Over them there are the locally called Urgonian marine units, which consist of (from base to top; Fig. 1): sandstones and sandy limestones of the Las Parras Fm that pass basinwards to mixed terrigenous (shale)–carbonated (limestone) rocks of the Chert (or Xert) Fm (Late Barremian to Early Aptian); the Forcall Fm (Early Aptian) is a dominantly shaly unit with carbonate intercalations; the Villarroya de los Pinares Fm (latest Early Aptian) is mainly a carbonated unit, it is the target of this paper and the main Urgonian episode sensu stricto (rudist bearing platform carbonates) in the studied area; finally, the Puerto de Sollavientos Mb of the Benasal (or Benassal) Fm (latest Early–Late Aptian) is a mixed shaly and carbonated unit with minor sandstones. The maximum thickness of the Aptian units has been estimated at 700–900 m (Peropadre, 2012). The Early Cretaceous synrift infill finishes with the Escucha Fm (Late Aptian to Early Albian), a mainly shaly unit with carbonate, sandstone and lignite intercalations. Latest Early Cretaceous to Late Cretaceous siliciclastic and carbonated sediments filled the basin during a postrift subsidence phase (Salas and Casas, 1993). The Cretaceous stratigraphy of the Galve sub-basin is based on Aguilar et al. (1971), Canerot et al. (1982), Soria, (1997), Peropadre (2012) and Peropadre et al. (2012b).

In the study area the Villarroya de los Pinares Fm consists of three informal members, from base to top: i) a massive to poorly stratified lower member with abundant corals and orbitolines, referred to as the Deshayesi platform. It is only present in the northern part of the Camarillas syncline and Miravete anticline where it may be up to 70 m thick; it wedges out southwards into the Forcall Marl Fm (Fig. 2). The top of this unit is a subaerial unconformity. The Deshayesi platform comprises the upper part of the Deshayesi ammonite biozone and the lowermost part of the Furcata biozone (Fig. 1C). ii) A massive to poorly stratified limestone body with corals and rudist, referred to as the Furcata platform. It is recorded along the whole study area and its thickness ranges from 10 to 15 m. iii) A well-bedded (dm to m-scale) limestone body with abundant rudists and benthic foraminifera occurs on top of the unit and is referred to as the Iraquia platform. It also spreads along the study area and is about 50–60 m-thick. The Furcata and Iraquia platforms developed during the Furcata biozone of the later Early Aptian. The overall sedimentology of the Villarroya de los Pinares fm is interpreted as shallow subtidal environments representing different styles of carbonate platforms (Peropadre, 2012; Table 1).

Regarding the tectonic setting, the main synrift structure in the study area is the Miravete fault (Fig. 2), a nearly N–S oriented normal fault (currently inverted as an inverse fault) that crosses the study area (Liesa et al., 2004, 2006). During the Cretaceous, this structure had the footwall in the eastern block (the present-day eastern limb of the Miravete anticline; Fig. 2) and the hanging-wall in the western block (the Camarillas syncline area; Fig. 2). Aptian strata record important thickness variations in relation to the Miravete fault, being the footwall sections about 60% as thick as the hanging-wall ones (authors data; see also Liesa et al., 2004). The thickness variations are similar, though slightly reduced, for the Villarroya de los Pinares Fm being eastern sections roughly 70% as thick as western sections. Transversal normal faults oriented ENE–WSW also occur (e.g. Jorcas fault; Fig. 2) but its relative importance, with regards to the Villarroya de los Pinares Fm, is generally minor compared to the master Miravete fault. The extensional structure of the Galve sub-basin and its relationships to the pre-Aptian Early Cretaceous sedimentation was assessed by Soria (1997), Liesa et al. (2006), and Meléndez et al. (2009).

Fig. 2. Geological photomap of the eastern Galve sub-basin showing the studied outcrops (encircled numbers), selected formation tops and major RCS indicated as coloured lines. RCS-7 (red) represents a major Mid-Aptian unconformity that develops large scale incised-valleys. Abreviations: Ch, Chert Fm; Fo, Forcall Fm; VP, Villarroya de los Pinares Fm; Be, Benasal Fm; K, Upper Cretaceous; DP, Deshayesi platform; FP, Furcata platform; IP, Iraquia platform.