Role of sea-level change and syn-sedimentary extensional Tectonics on Ladinian-Carnian Alpujarride carbonates (Alpujarride Complex, Betic Internal Zone, SE Spain)

Introduction

During the early stages of rifting of Pangaea, the westernmost part of the Palaeo-Tethys was the site of deposition of Alpine- and Germanic-type Triassic se- ries (shallow-marine sedimentary successions). Evidence of Triassic rifting has recently been recognized in the thick Ladinian-Carnian carbonate succession of the Gador-Turon unit (Alpujarride Complex, Internal Betic Zone, SE Spain; Martin-Rojas et al., 2009). This succession represents a useful outcrop for the analysis of the interference between the syn-sedimentary extensional Tectonics and the sea-level changes during sedimentation. In this paper, we report the results of a multi-disciplinary study focussed both on the analysis of litho- and biostratigraphy, tectono-sedimentary relationships, and on the facies and environmental evolution of the Alpujarride Triassic carbonates of the Gador-Turon unit.

Geological setting

The Betic Cordillera is formed by the External and Internal zones. The External Zone is composed of a Mesozoic-Cenozoic sedimentary cover deriving from deformation of the southern palaeomargin of the Iberian Subplate. Particularly, the basal Triassic sediments are characterized by Germanic-type facies. By contrast, the Internal palaeo-domain includes Mesozoic-Cenozoic sedimentary successions derived from areas located on the Mesomediterranean Block (Martin-Rojas et al., 2009 and references therein). Their Triassic successions show facies with intermediate features between Alpine- and Germanic-type facies. Alpujarride Complex, focus of this research, belongs to the Betic Internal Zone and is tectonically interposed between the overlying Malaguide Complex and the underlying Nevado-Filabride Complex.

The Alpujarride Triassic successions comprise continental clastic and shallow marine carbonate rocks. The Triassic carbonates studied in the Gador-Turon unit crop out in the Sierra de Gador (NW of Almeria).

The Meta-carbonate fm

Litho-biostratigraphy

The Gador-Turon unit is composed of the Meta-detrital fm (Middle Triassic?) in the lower part and the Meta-carbonate fm (Ladinian-Carnian) in the upper part. The Meta-carbonate fm, topic of this research, is formed by six members of regional significance and shows a total thickness of 1300 m. These members, recently analysed by Somma et al. (2008) and
Martin-Rojas et al. (2009), have been denoted, from base to top (Fig. 1): (1) marly-calcareous-dolomitic mb., (2) dolomitic mb., (3) fossiliferous calcareous-marly mb., (4) cherty calcareous mb., (5) mineralized calcareous-dolomitic mb. and (6) marly-calcareous mb. In each mb., several lithostratigraphic intervals have been recognized (Fig. 1). Mb. 1 is Ladinian in age and consists of dolostones, limestones, and marly limestones. Fossil lithostratigraphic intervals have been recognized (Fig. 1). Mb. 1 is Ladinian in age and consists of dolostones, limestones, and marly limestones. Fossil
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The fossiliferous calcareous-marly mb. (mb. 3) is Ladinian in age and consists of thin-bedded limestones, bioturbated and nodular limestones, marly limestones and marls. The fossil content is represented by an assemblage of molluscs, echinids and foraminifers. Lumachella beds are abundant in the upper part of the member. The overlying Ladinian limestones of mb. 4 are formed by cherty limestones with local concentrations of dasycladacean algae. Bioturbated and nodular limestones are also present. The fossil assemblage is formed by molluscs, echinids, sponge spicules, ostracods and foraminifers. The mineralized calcareous-dolomitic mb. (mb. 5), Ladinian-?Carnian in age, records a syn-sedimentary extensional Tectonics episode (Martin-Rojas et al., 2009). This mb. consists of four intervals (I-IV), separated by sharp contacts and formed by a lower calcareous level evolving to an upper dolomitic level. Limestones usually show a fossil assemblage characterized by pelagic gastropods and bivalves, crinoids, algae, sponge spicules and foraminifers (Lagenidae and involutinids). Dolostones and limestones are locally characterized by centimetre-thick red layers, evaporitic minerals, convolute laminations, algal mats, oncoids and coated grains. The succession is topped by the marly-calcarenaceous mb. (mb. 6). This is formed by marls with intercalations of limestones and dolostones. In the upper part, lumachella beds are present. In the middle part of mb.6 discontinuous gypsum bodies up to 20-m-thick occur. The presence of Bactryllium sp. suggests a Late Triassic (probably Carnian) age for these deposits.

Ladinian - Carnian syn-sedimentary extensional tectonics

Direct evidence of syn-sedimentary extensional Tectonics related to the Pangea continental rifting is provided by the recognition of macro- to meso-scale normal faults overstepped by younger strata. The fault activity is capped by beds of mb. 6, locally defining a post-fault unconformity between mb. 5 and 6 (Fig. 1). Mb. 5 presents a wedge-like shape at regional scale. This shape is probably related to the above mentioned faults. In mb. 5, as a matter of fact, soft-sediment deformation, gravity-flow deposits and unconformities are widely developed. Syn-tectonic mafic igneous intrusions cutting the studied formation have also been identified. The age of this syn-sedimentary extensional tectonics is constrained as Ladinian-Carnian.

Facies analysis and palaeo-environmental interpretation

18 facies (Table I), several facies associations and intervals have been distinguished in the six mbs. of the studied Meta-carbonate fm (Fig. 1). Table I synthesises the main features of the analyzed facies and the related depositional environments, identified mainly on the base of the cyclicity and trend of facies as observed on the field. According to that, facies from E to N presumably developed in different areas of an homoclinal carbonate ramp, while...
facies from O to V probably formed in shallow waters on a shelf with intra-shelf basins (Fig. 1, Table I; Somma et al., 2009). An environmental interpretation for each of the studied mbs. is proposed below (Fig. 1, Table I). Facies of mb. 1 (Fig. 1, Table I) record an evolution from the inner (?) ramp to the distal zone of the inner (-middle?) ramp. Consequently, this mb. presents a general deepening-upward trend. Mb. 2 (Fig. 1, Table I) consists of recrystallized dolostones (lacking any evidence of peritidal structures). An offshore-shoreface transition zone could be proposed as the probable environment. Facies of mb. 3 (Fig. 1, Table I) developed from the distal part of the outer ramp to the inner ramp, recording a general shallowing-upward trend. We interpret mbs. 1, 2 and the lower and middle intervals of mb. 3 as a transgressive system tract (TST, Fig. 1), while the upper interval of mb. 3 could represents an high-stand system tract (HST, Fig. 1). The lower part of mb. 4 is characterized by the most distal facies of the ramp (Fig. 1, Table I). In this lower interval, the presence of a maximum flooding surface can be postulated (Fig. 1). Above this surface, an evolution from the distal area of the outer ramp to the proximal zone of the outer ramp is hypothesized. Accordingly, mb. 4 represents the next TST (lower part) and HST (middle-upper part). A para-conformity, interpreted as sequence boundary, can be identified between mbs. 3 and 4. Facies of mbs. 5 and 6, differently from those of the underlying succession, formed in very contrasting depositional environments (Fig. 1, Table I) suggesting a sedimentation onto a platform limited by fault scarps. In mb. 5, at the interval scale a general shallowing (from the calcareous level to the dolomitic one) can be identified. Differently, the sharp contact between two successive intervals testifies an abrupt deepening. We interpret this deepening trends as parasequences as probably depending on the extensional Tectonics widely developed in this member. At the scale of the mb. 5 deposited during a long-term shallowing-upward trend corresponding to a HST (Fig. 1). The evolution of para-sequences is in contrast with that observed in Germanic and Alpine Triassic, and so suggests a local tectonic control on sedimentation. The syn-sedimentary normal faults recognized by Martin-Rojas et al. (2009) provide a significant support to this scenario. Mb. 6 (Fig. 1, Table I) formed after the end of the main syn-sedimentary Tectonics. It should have been deposited on coastal areas of a carbonate platform characterized by arid climatic conditions (Facies Z, Sabkha).

Conclusions

The interference between the syn-sedimentary extensional tectonics and the sea-level changes has been analyzed in the Meta-carbonate fm of the Gador-Turon unit. Tectono-sedimentary analysis suggests that the lower part of the succession (mbs. 1-4) was deposited on a carbonate holomical ramp and in the absence of tectonic activity, while the upper part formed on a carbonate platform limited by fault scarp (mbs. 5-6). Particularly, mb. 5 formed during alternating phases of activity and quiescence of syn-sedimentary extensional tectonics. The change of platform morphology was recorded by mb. 5 during the Ladinian time. The deposition of mbs. 1-5 occurred during two sequences (Fig. 1): a lower sequence showing mb. 1, 2 and 3 (lower and middle intervals) as TST, while the upper interval of member 3 represents de HST. An upper sequence presenting the lower interval of mb. 4 as TST, and the middle-upper intervals of mb. 4 and mb. 5 as HST. The sequences identified correlate with those recognized in the Germanic- and Alpine-type Triassic. The sequence stratigraphy evolution of mb. 5 does not correlate with eustatic cycles probably because it was mainly controlled by local active tectonics. Consequently, the control of the sea-level fluctuations has been recorded only at the scale of the entire member.

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References