New Insights of the Early Cretaceous Syn-Rift Sedimentation in the Mecella Structure (Northeastern Atlas of Tunisia): Geodynamic Evolution

Nejla Sekatni Aïch and Mohamed Gharbi

Abstract

Detailed stratigraphy and facies analysis of the Early Cretaceous successions outcropping in the Mecella structure (Northeastern Tunisian Atlas), integrated with a structural analysis, allowed us to characterize the evolution of an intraplatform basin. A syn-rift tectonic is associated with the development of the major synsedimentary normal fault systems producing the tilted blocks basin geometry in Northeastern Tunisian Atlas. Incised sandy turbidite canyon, soft-sediment deformational structures mainly represented by slumps, down-slope sliding of ancient deposits and halokinetic activity are the main features of a syn-rift intraplatform basin. The close up of this intraplatform basin history occurred in the Hauterivian and Barremian stages by the installation of a condensed shallow water carbonate platform on the higher structures. The biostratigraphic results and the facies analysis of the resedimented Triassic series allow us to ascribe the halokinetic activity to the Upper Valanginian.

Keywords

Early cretaceous • Intraplatform basin • Syn-rift tectonic
Halokinetic activity • Mecella structure

1 Introduction

Different models of extensional basin formations have been related to rifted margins. These rifted basins were derived from the strike-slip movement like the pull-apart basins or the normal faults bounding horsts and grabens structures in the tilted blocks models. The Tethyan realm offers numerous examples of the intraplatform basins during the Mesozoic [2]; Casero et Roure [1, 4]. These basins display a strict relationship between sedimentary facies and syn-sedimentary faults. During the Early Cretaceous, the Mecella structure (Northeastern Tunisian Atlas) was submitted to a rifting phase attested by a depth modification in the sedimentation and the environments associated with the syn-sedimentary and the halokinetic activities, resedimentations, soft-sediment deformation structures and incised sandstone turbidite canyon.

Based on detailed stratigraphic, sedimentological and syn-sedimentary tectonic analysis, the aim of the present study is to illustrate the main features of the Early Cretaceous pelagic series of the syn-rift phase in the Mecella structure basin.

2 Geological Setting

The Mecella structure basin is located in the northeastern part of the Tunisian Atlas foreland which constitutes the northeastern segment of the southwest–northeast-trending Atlas fold-and-thrust belt. This range is itself a result of the collision of the African and the European plates during the Cenozoic tectonic inversion. It constitutes a part of the alpine chain of the Africa named “the Maghrebides belt”. Our study area is located approximately east of the Jebel Djouf syncline (itself located east of the Jebel Oust structure), southwest of the Ressas structure, northeast of the Zaghouan, and northwest of the Jebel sidi Zid syncline structure. The Jebel Mecella corresponds to a segment of the

N. Sekatni Aïch (✉)
Faculté des Lettres et des Sciences Humaines de Sousse, Department of Geography, Université de Sousse, Sousse Ryadh, Sousse, 4029, Tunisia
e-mail: sgatninejla@yahoo.fr

M. Gharbi
Geo-resources Laboratory, Centre de Recherches et des Technologies des Eaux de Borj Cedria, B.P 273 Soliman, 8020, Tunisia
e-mail: mohamed.gharbi@certe.rnrt.tn

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famous Zaghouan Thrust Belt considered the front of the Atlasic Alpine Range.

The field geology, facies and basin analysis and stratigraphic correlations are the main methodologies used to recognize the stratigraphic successions and to characterize their sedimentological and environmental setting. Numerous thin sections have been analyzed by using the petrographic microscope and applying the Dunham classification of the microfacies. The dating and the correlations of the lithological units were based on ammonites and foraminifera biozonations.

3 Results

3.1 Stratigraphy and Facies Analysis

Two sections were logged bed by bed and sampled for the sedimentological and the biostratigraphic analysis in the study area. They display from base to top:

- Lower Valanginian: represented by dominantly greenish clay where few grey thin-bedded pelagic mudstone-wackestone are interlayered. The overall thickness is more than 130 m. The fossil content consists of abundant ammonites (rich in *Olcostephanus (Olcostephanus) atherstoni.* Sharpe pinpoints the Karakaschiceras inostranzewi Zone of latest Early Valanginian age), gastropods, aptychus and belemnite fragments, planktic foraminifera, radiolarian and sponge spiculae.

This succession suggests a deep open marine environment.

- Upper Valanginian: The transition to the Upper Valanginian age is marked by the uplift of a discontinuous reef-type Tithonian deposits. It shows a morphology in the topography. The Upper Valanginian serie displays greenish poorly-fauna detrital clay units with few intercalations of thin grey bedded wackestone limestone. This unit is characterized at the base by a 12 m thick calciturbidite succession filling a submarine canyon. The ichnofacies analysed in this fine-grained sandstone and siltstone suggests a terrace to inner levee depositional environment of the distal canyon [3]. A salt deposit is interlayered within the Upper Valanginian unit. It consists of a 4 m thick Triassic succession formed by the mass of red, green and grey gypsiferous clays, sandstone and carbonate with erosive conglomeratic base which reworks the Valanginian clay. Following this Triassic resedimented unit, abundant slumping structures and gravity slide of the Upper Tithonian resedimentation took place. The top of the Upper Valanginian series was marked by a 1.5 m thick yellow-darkish detrital limestone rich in ammonite molds indicating the Valanginian, phosphate, glauconite and quartz grains. These beds are correlated in the two logged sections and are interpreted as maximum flooding deposits following a transgressive phase at the end of the Upper Valanginian period.

The petrographic analysis shows abundant dissolution features and epikarsts affecting the Upper Tithonian beds resedimented in the Upper Valanginian series. The epikarsts are filled by Upper Valanginian pelagites during the transgressive phase.

- Hauterivian: it occurs with the variable thickness in the two logged sections (from 3.5 to 21 m). It is dominated by shales bearing planktonic foraminifera. It consists of the argillaceous deposits with the intercalation of the few slumped limestone beds. The top of the succession is marked by a 50 cm thick condensed glauconitic, phosphating and ammonites bearing sandy limestone bed which marks the maximum flooding surface. The presence of *Hedbergella hauterivica* confirms a Hauterivian age.
- Barremian: in the two sections, the Barremian deposits display low thickness in comparison with other areas. They consist of wackestone-limestone with thin argillaceous intercalation rich in foraminifera (*Epistomina, Lenticulina* and espacially *Marginolapsis djaffaensis* dating the Barremian). Sandy limestone beds mark the top of this section and the argillaceous intercalation are rich in ferruginous oolites indicating the installation of a shallow carbonate platform.

3.2 Synsedimentary Tectonics

The dynamic sedimentary of the Early Cretaceous series in the Mecella structure shows an intraplatform basin characterized by an irregular sea floor. The geometry and the facies variations of this basin are related to the regional extensional tectonics during the synrift period. Synsedimentary features recorded in the study area (slumps, sealed normal faults, thickness variation, resedimented blocs…) are governed by an extensional tectonic regime associated with slumps structures which allow us to consider the Mecella structure basin as part of the Southern Tethyan rifted continental margin [5].

The unfolded slump axis (MAM Method) and the unfold poles of axial planes (APM method) give the same paleoslope direction with WSW-trending paleoslope during Upper Valanginian time. The back-tilted fault diagrams show a ~WNW to ~NE- extension during the Early Cretaceous time which indicates that NW-, N- and NE-trending faults remain active during the Valanginian. This faulty system is interpreted as an inherited normal fault during the development of the Valanginian intraplatform basin related with the southwest submarine slope. The Hauterivian-Barremian series shows numerous small scale syn-sedimentary normal faults preserved within argillaceous sediments. During the Hauterivian-Barremian, the Mecella basin is affected by normal faulting locally characterized by a ~NE-trending minimum stress axis ($\sigma 3$).

4 Interpretations and Conclusion

Based on several stratigraphic, sedimentological and tectonic features, the Mecella structure is interpreted as an intraplatform basin experiencing an Early Cretaceous synrift stage. The facies analysis highlighted the evolution of different depositional environment during the Early Cretaceous controlled by synsedimentary normal fault tectonics.

The Lower Valanginian, well dated by ammonites during this study, was characterized by pelagic clay deposits corresponding to an open deep marine basin. From the Lower to the Upper Valanginian, the sedimentary basin of the Mecella is governed by an extensional tectonic regime associated with synsedimentary normal faulting. The tectonic activity was accompanied by an important halokinetic activity which is responsible for the uplift of the Tithonian reef and the disturbance of the topography of the sea floor. An instable sea bottom occurs during the Upper Valanginian. It was active up to the Barremian. The tectonic instability during the Upper Valanginian gives way to poorly fossiliferous deposits with often mineralized foraminifera incised sandstone turbidite submarine canyon. The soft-sediment deformational structures are mainly represented by slumps associated with the down-slope sliding of reef-type Tithonian deposits. Sandy limestone beds overlie all these deposits. This synsedimentary tectonics was characterized by thicker pelagic succession in the depressions (during the Upper Valanginian) and condensed deposits in the structural height (Hauterivian and Barremian). The install of a condensed shallow carbonate platform ends up the intraplatform basin evolution. Such a geodynamic evolution went from deep water basin to a condensed shallow platform and passed by slope area characterizing the syn-rift systems. It generated many intraplatform basins separated by small horst areas. The biostratigraphic framework of this study allows us to date the halokinetic rise as Upper Valanginian.

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