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Tectonics

Albian extrusion evidences of the Triassic salt and clues of the beginning of the Eocene atlasic phase from the example of the Chitana-Ed Djebs structure (N.Tunisia): Implication in the North African Tethyan margin recorded events, comparisons

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Abstract

In the northern part of Tunisia, close to Testour/Slouguia, new observations and updated biostratigraphy make it possible to highlight the relation between the Triassic saliferous mass and the surrounding Mesozoic beds (T. M.). Near the (T. M.) boundary, the formations observed consist dominantly of Triassic evaporites reworked in the Early and Late Albian deep-water sedimentary deposits. Throughout the studied area, Jurassic rocks are absent. We propose to interpret the Chitana-Ed Djebs structure originally emplaced as gravitational stretch masses in a passive margin in the same way as the salt bodies of widespread salt province in the Gulf of Mexico. A reconstructed schematic position of the Chitana-Ed Djebs salt body displays a scenario of setting of the salt mass on a submarine palaeo-slope. Moreover, the starting clues of the paroxysmal event of the Late Mesozoic tectonic inversion clearly fossilized through the discordance of the Middle Eocene–Early Lutetian limestone on the Albian series. ***To cite this article: M.-M. Slama et al., C. R. Geoscience 341 (2009).***

Résumé

Preuves d'épanchement du sel triasique à l'Albien et indices de l'amorce de la phase atlasique éocène d'après l'exemple de la structure de Chitana-Ed Djebs, (N. Tunisie) : implication dans les événements enregistrés par la marge Nord-Africaine de la Téthys, comparaisons. Au Nord de la Tunisie, près de Testour/Slouguia, nous avons collecté de nouvelles observations et données biostratigraphiques. À la lumière de ces apports, il est possible de mieux interpréter la relation entre le sel triasique et les séries mésozoïques encaissantes (T.M.). Auprès de la limite (T.M.), on trouve du matériel salifère remanié dans la série marno-argileuse de l'Albien inférieur. Dans tout le secteur, le Jurassique est absent. Nous proposons d'interpréter la mise en

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place du sel triasique de la structure de Chitana-Ed Djebes, d'une manière gravitationnelle dans une marge passive à l'Albien, à l'image des corps salifères de la province salifère du *Golf Coast* du Mexique. Un schéma rétro-tectonique de la structure salifère Chitana-Ed Djebs montre que cette mise en place s'est effectuée sur une paléo-pente sous-marine. En outre, on établit les indices de l'amorce de l'inversion tectonique post-Campanien et son paroxysme de l'Éocène moyen à supérieur. Cette dernière est clairement fossilisée par la discordance de l'Eocène moyen-Lutétien sur les séries albiennes. ***Pour citer cet article : M.-M. Slama et al., C. R. Geoscience 341 (2009).***

Keywords: Tunisia; Triassic; Salt "glacier"; Albian; Medjarda valley; Eocene phase; Garamantians

Mots clés : Tunisie ; Trias ; « glacier » de sel ; Albien ; Vallée de Medjerda ; Phase éocène ; Garamantes

1. Introduction

Located within Medjarda valley straddling the main road G.P.5 leading to Teboursouk, the Chitana-ed Djebs outcrops is a well-known field Triassic salt body from the salt province (Fig. 1). It is traditionally considered as a diapiric body started in the Late Aptian-Early Albian compression episode [11,48,49,55,57] and has been the focus of numerous studies over the last 30 years [7,10,22–25,57]. It is also a classical destination for petroleum excursions [6,43].

However, several controversial issues regarding the structural dynamics of salt systems, in the northeastern African margin, were discussed in the literature [35,50,52,53,60,63–65]. The Triassic contact and related salt/surrounding Mesozoic strata in the area were still devoid of detailed cartographic revision based on tight sampling and of accurate observations due to the complexity of these structures and the influence of the anterior interpretations.

Remarkably, salt masses from the Chitana-ed Djebs area were initially mapped more than an 80 years ago: in 1925, Solignac documented a Triassic/Mesozoic limit as thrust nappe contact with a normal succession strata dipping under salt rocks [56] while in 1973 Bajanik and Biely mapped the same area as an inverted series [2].

However, no reliable new detailed cartograph was ever produced on the area in spite of several attempts [19,22,23].

As an additional effort, we chose to apply specific detailed cartographic investigation previously developed on numerous salt structures disrupted in northern Tunisia salt province [28,29,39,54,55,66], an approach which eventually led to the recovery of one structural diagnostic assemblage.

The corresponding interpretations will be compared with local salt structures data. These data will then be discussed within a broader northern African Tethyan margin setting and compared with the salt bodies from Golf coast of Mexico, Northern America salt province [20,29,34,46,58].

2. Geological setting

The studied area is composed of two main sedimentary series. The Mesozoic strata comprise Triassic material including salt mass. The Jurassic and the Lower Cretaceous deposits display no outcrops in the area. The Early Cretaceous strata are composed of Late Aptian–Early Albian sediments such as black clayey marls (sedimentary nodules with carbonate matrix); the Upper Albian consists of alternate black marly and bright brown limestone series. These later are covered by platy limestone with *P. buxtorfi*. These series are overlaid by Cenomanian marls. Turonian sediment corresponds to clear limestone beds. Coniacian-Santonian marls overlie the previous sequence. The Upper Senonian deposit is represented by the Abiod Fm with alternate bright limestones and marls. The Cenozoic deposits are composed of Paleocene marls rich in pelagic microfauna, Eocene limestones rich in Nummulites; the Oligocene formation is composed of deltaic deposits such as siliceous sandstones sedimentary features (sandstone nodules). The Neogene formation is caracterized by thick Miocene marls. The Pliocene-Quatenary deposit is composed of conglomeratic beds on the base and of sandy clay ones on the top [19,23,56].

3. Observations

3.1. Distinguished locality

The Triassic saliferous complex overlies via clear "apparent sedimentary" contacts on the different Lower Cretaceous series (Fig. 2, Fig. 3, P2 + P3). It is devoid of well-developed sedimentary cover due to its peristaltic movements during several geological episodes. This observation does not exclude posterior

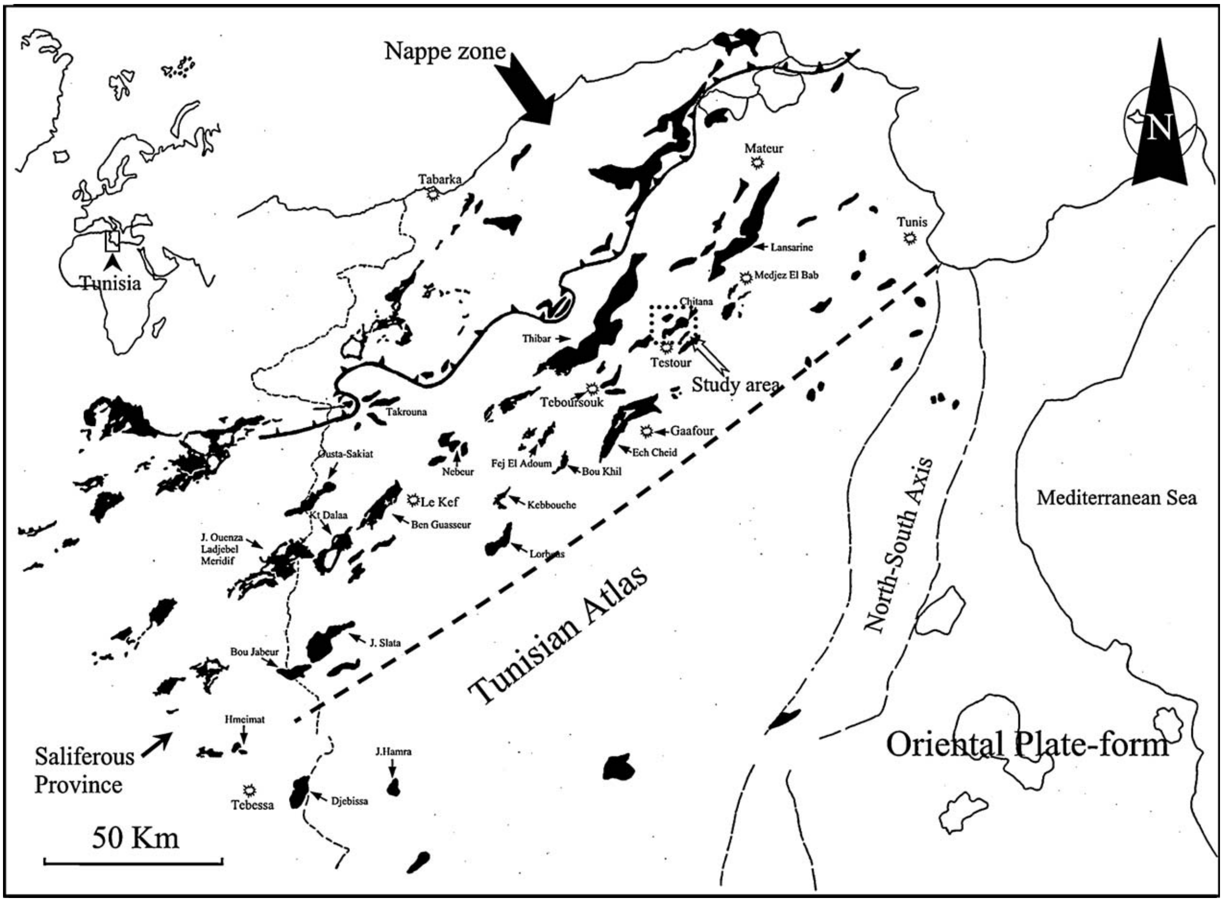

Fig. 1. Summary sketch map of Triassic evaporites in northern Tunisia.

Fig. 1. Esquisse sommaire des affleurements triasiques du Nord de la Tunisie.

tectonic activity or salt movement in compression context.

In the J. Tellet Mabrouka area (Fig. 3B), this complex covers precisely a marly bed of Albian age as attested by a pelagic foraminiferal association among which *Ticinella primula*.

Within the J. Sene Ed Jemel, the overburden consists of Upper Albian (Vraconian) in which is observed a platy limestone/marls alternation exhibiting slumps and septaria as indicated by the association of *Rotalipora* and the index microfossil *Planomalina buxtorfi*.

The same Triassic deposits are covered, through an erosional surface, by Cenomanian and/or Early Campanian deposits as confirmed by the association: *Rotalipora greeborvensis* and *Rotalipora Cushmani/ G. elevata*, *G. stuartiformis*, *G. buloides*, *G. arca* and *Rosita fornicata*. In addition into W. el Blidha, we examine a clearly ‘‘apparent sedimentary’’ limit in a substratum strata dipping under the salt rocks (Fig. 3A).

Inside W. el Begi fold (Fig. 3D, Fig. 4 X-X’), the Triassic rocks are included within the Late Aptian/ Lower Albian and Late Albian formations and show, underneath and on top, tow originally ‘‘apparent sedimentary’’ limits. From southeast to northwest, we check up on the underside of the Triassic mass, the Early Albian marls; the core of the fold is occupied by Late Aptian marls. Then the same salt mass is covered by Late Albian marls via clearly ‘‘apparent sedimentary’’ contact. This succession was repeated because of the existence of transversal faults.

4. The Eocene phase clues

The North-East Moghrebian passive margin was considered in a rifting regime during Aptian and Early Albian times [9,10,12,18,28,31,32,41,61]. Its inverted basins that were in compression regime began to form in the transition between Lower and Upper Senonian

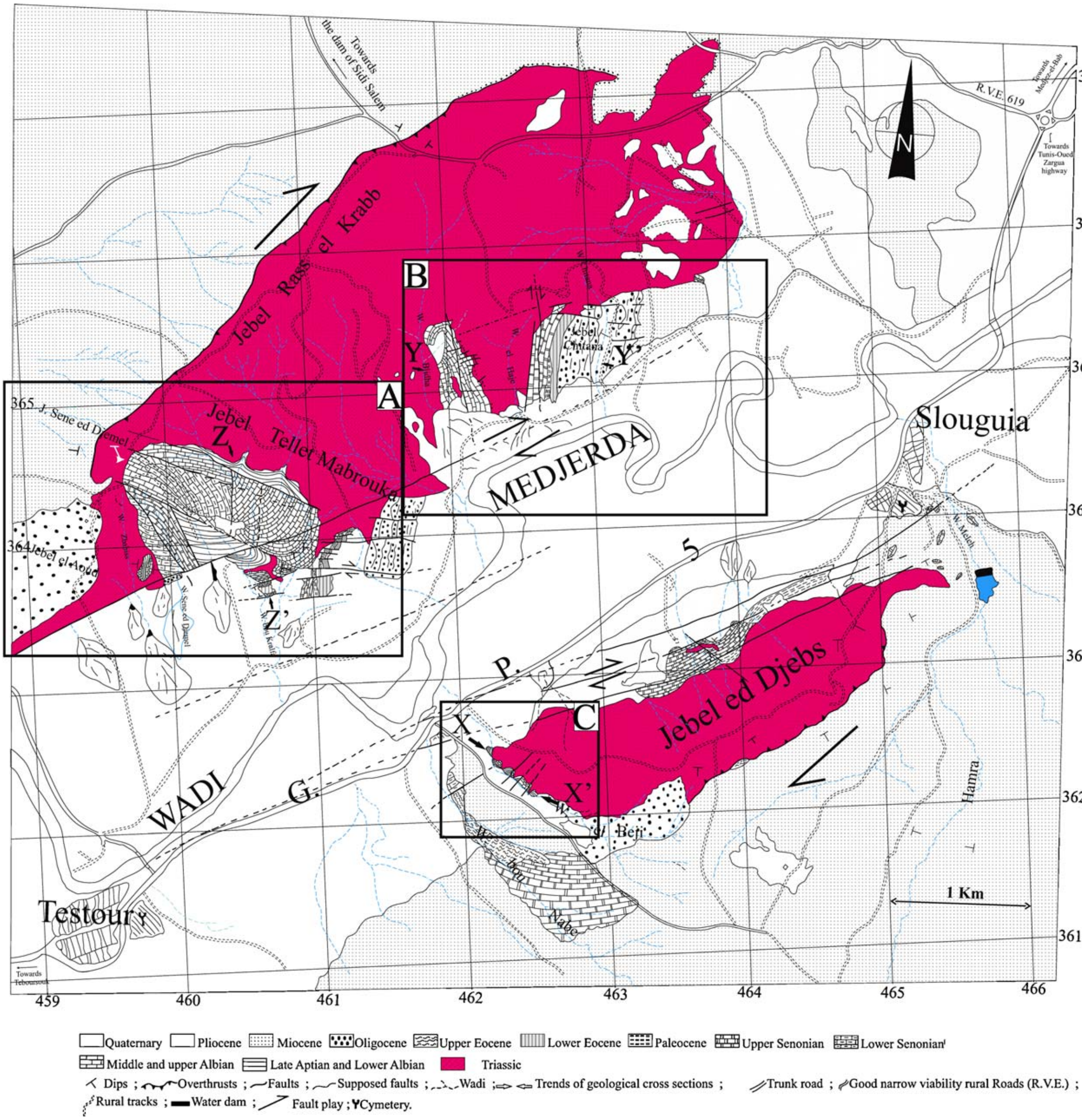

Fig. 2. Geological map of the study area.

Fig. 2. Carte géologique du secteur d'étude.

[15,32,40,61] and its paroxysmal event started in the Middle–Late Eocene episode. This event is well documented in the North Moghrebian margin [3,15,21,26,27,30,37,40,44,61].

Within Jebel Chitana (Fig. 5Y, Fig. 4 Y-Y') above the Paleocene marly levels and a conglomeratic bed a sandstone bar is observed which is rich in glauconite and phosphates. This bar is covered by the Ypresian carbonates that are elongated in a NW–SE band forming the major topographic altitude points in the area. The succession is followed by massive *Nummulites*-rich limestone beds alternating with sandstone levels. These later show a metric thickness with shaly and marly joints intercalations; they bear Echinid remnants, small *Nummulites* specimens, *Globigerina*, *Lepidocyclina*, Globorotalia and *Algae*.Eastward of J. Chitana (Fig. 5Z), the cross-section shows from the base to the top: Campanian-Maatrichtian carbonate displaying

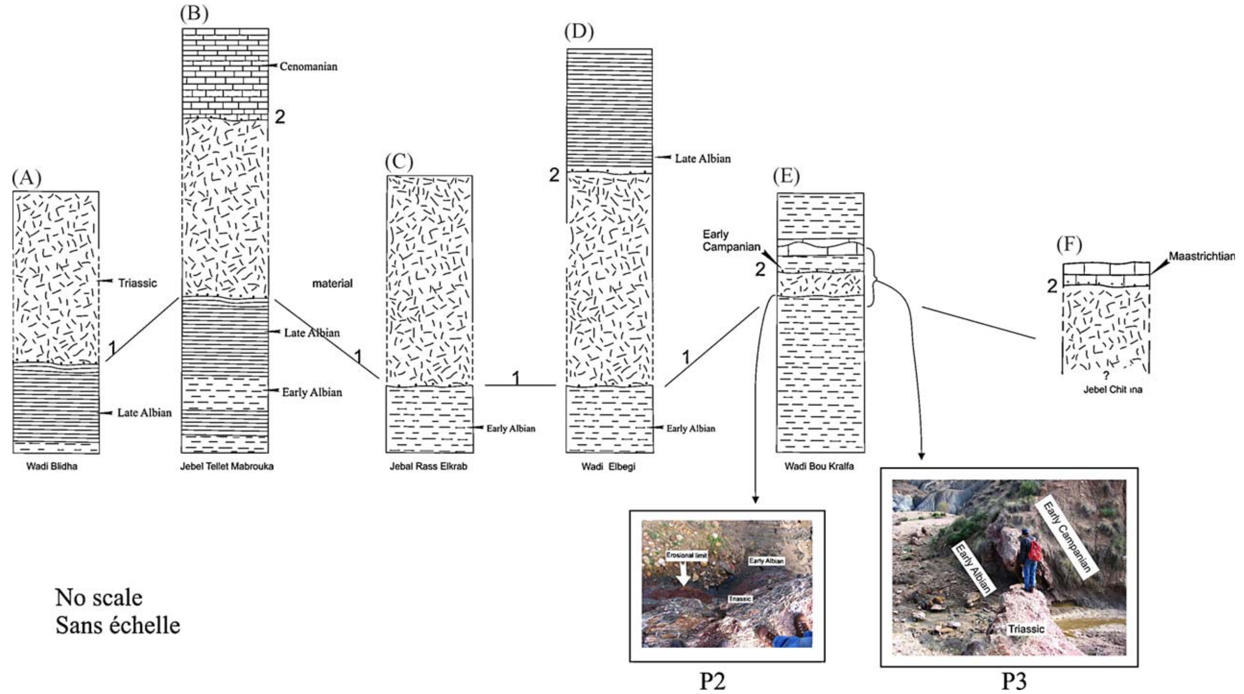

Fig. 3. The correlation panel across the area showing visible cross sections. 1: lower limit of the composite submarine salt "glacier" of Chitana-Ed Djebs; 2: upper limit of the latter.

Fig. 3. Corrélation des coupes visibles. 1 : contacts inférieurs du matériel salifère triasique du « glacier de sel » sous-marin composite Chitana-Ed Djebs ; 2 : contacts supérieurs de ce dernier.

planktonic microfaunal association that characterizes the Abiod Formation. A polygenic conglomeratic horizon with an erosional surface separates this Formation from the adjacent Eocene Nummulites carbonates.

Inside W. Bou Kralfa (Fig. 5V, Fig. 4 Z-Z'), we observe a 20 m-thick limestone succession with disseminated chert nodules. These sediments were dated to the Albian. These later are covered by 1m-thick conglomeratic horizon. On these series lie the Middle Eocene–Early Lutetian limestones composed of *Nummulites*, Rotalia, Discocyclines, glaucaunites and organic remnants, as observed on thin-section. This transgressive Upper Eocene limestone overlay many Cretaceous deposits outcropping in the area.Thus, it appears that various Triassic rocks, Cretaceous strata and Palaeocene marls are unconformably overlain by Middle Eocene-Early Lutetian limestones. This discordance was observed also in the W. Bou Kralfa, J. Tellet Mabroka and J. Chitana outcrops (Fig. 5).

From east to west, the Oligocene lumachellic sandstone beds overlie, with a low angle unconformity, various substratums (from Triassic to Eocene). This discordance too is observed in several localities in the studied area such as in the West of J. Sene ed Jemel on Triassic rocks as well as on eastern edge of the W. Blidha anticline. Indeed, many authors have noticed that [29,39,42,47,54,66].

5. Basin fault systems

The described Lower Cretaceous is either limited by N45, a left strike-slip often coexists with N130 Late Quaternary faults, which indicates a right lateral movement [51]. These variations could be related to pre-existing faults. These later control the thickness of sedimentary deposits (Fig. 3, Fig. 4). The observed geomorphologic features (offsets of valleys, etc.) testify to the late oblique left-lateral strike-slip movement. Moreover, they reveal several evidences of instable sea floor, consequence of an extensive regime in the Mesozoic subsidence episode. Nevertheless, the major inherited Early Cretaceous extensional faults trends N40-50, N 110-120 [8,13,28] and folds of this studied area show a N40E trend.

In the investigated area, inherited normal faults (I.N.F.) were the cause of the first Triassic salt extrusion N40-50 and N 110-120 trends. This later shows a disposition of tilted blocks developing first in Upper Aptian [18,38]. The next major phase in the area was

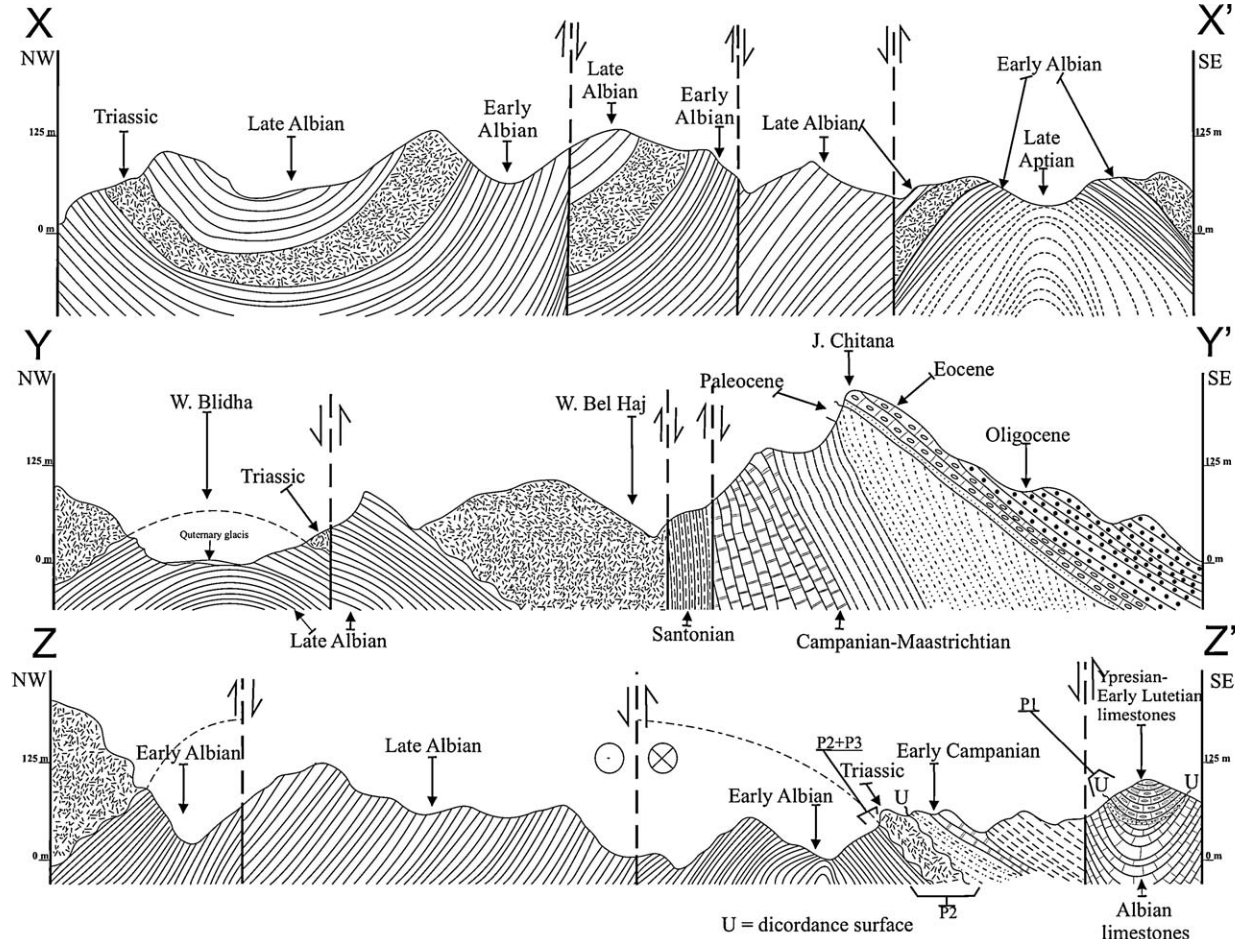

Fig. 4. Geological cross-sections in the W. bou Kralfa, J. Chitana and W. El Begi.

Fig. 4. Coupes géologiques dans l'oued bou Kralfa, J. Chitana et oued. El Begi.

dated to the end of the Santonian time [32] marked by the transgressive cycle of Early Campanian marls bearing *G. elevata*, *G.ventricosa*, *G. stuatiformis*, on numerous substratums as observed on the Triassic sheet of W. Bou Kralfa (Fig. 3 P3). We considered the incipient of the positive tectonic inversion approximately at the transition between the Lower and Upper Senonian [40]: beginning of the true graben inversion. In fact, these structures were complicated by the Tertiary folding.

The salt structure born in the graben basin has been subjected to asymmetric thrusting, possibly enhanced by gravitational gliding due to: (1) the slight, Late Eocene compression phase; (2) the latest salt stock coming from the mother salt probably belonging to the Oligocene episode. This later characterized by many extensive features in outcrops (grainstones, septarias etc.); (3) the orientation of the major inherited normal faults opposed to the direction of the principal oblique compression (NW–SE) (for example, Fig. 3 and Plate 1 of ref. [16]).

6. Interpretation

These updated biostratigraphic and observations data confirm the hypotheses of an interbeded Triassic material as previously announced on field [8,28,39,42,66] and in subsurface study [4,5,36,61]. Within the southern part of the studied area, the evaporitic Triassic and red beds form a melange with only Early Albian limestone dipping under the Triassic mass (Fig. 4). In addition, the evidence of Paleocene exiguous scarps as well as the unconformity of Lower Eocene deposits on Albian strata attest the bottom instability during deposition.

The most spectacular discordance of the described Lower Eocene limestone is that of W. Bou Kralfa where a gentil angle (about 20°) with the adjacent Albian series is observed (Fig. 4 Z-Z', Fig. 5V, and Fig. 5 P1).

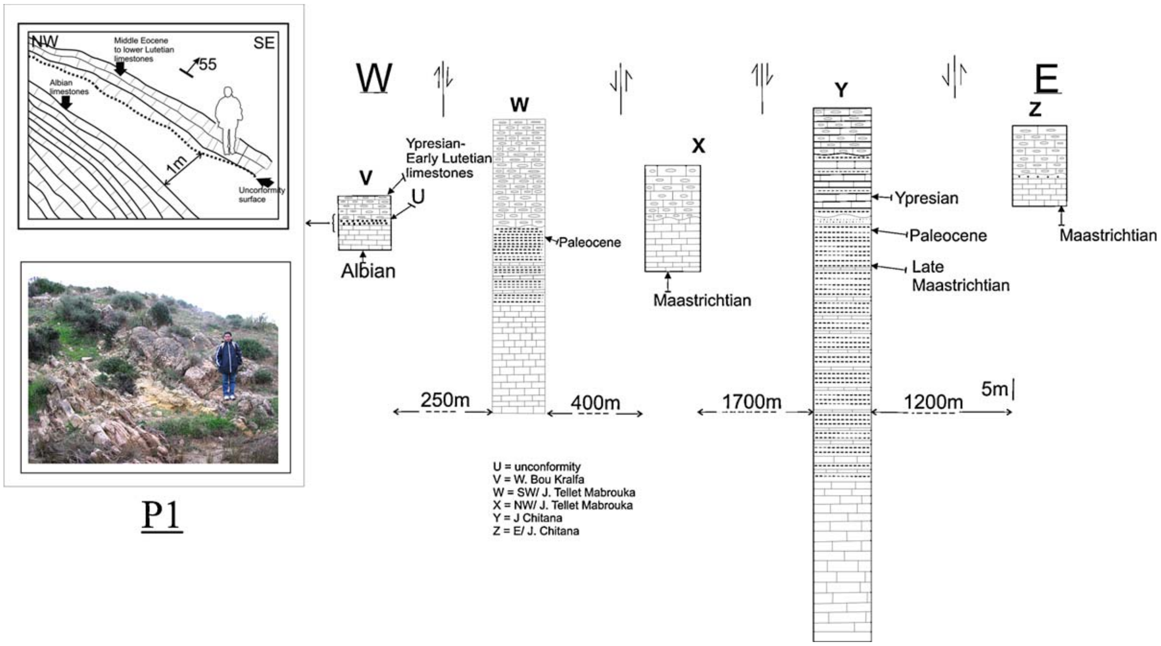

Fig. 5. West–east correlation panel across the area showing the Middle Eocene–Early Lutetian deposits discordance on various substratums.

Fig. 5. Le panneau de corrélation oust–est à travers le secteur montrant la discordance de l'Éocène moyen–Lutétien inférieur sur divers substratums.

This unconformity fossilizes the beginning of the Late Eocene folding followed by a regressive-transgressive cycle.

The collected data on regional scale as well as the North-African literature confirm these observations [17,27,37,39,44,66,68]. The extracted data from field study are included in the North Africa's margin framework evolution [12,15,27,32,61].

The updated data presented in this paper support an interstratified Triassic salt in Albian time. Besides, the Oligocene unconformity on the salt rocks does not correspond to erosional activity that affected the Triassic in its original position, to the Early Mesozoic bottom. After straightening the two Tertiary foldings, the Oligocene units do not allow one to find ''an intrusive Triassic structure'' rather than a ''horizontal'' emplacement of salt mass.

Furthermore, the unconformity of Eocene deposits on subjacent series excludes the thrust position of the Triassic complex. In addition, according to the structural restoration of the Tertiary folding, we showed the Middle Eocene–Early Lutetian limestone deposed with a gentle angle (20°) on the substratum of the Triassic mass (Fig. 5 P1). These observations confirm the salt ''glacier'' hypothesis rather than an intruded structure. During folding, salt rocks may therefore be remobilized from extensional fracturing of the overburden rather than from overall lateral compression.

In fact, the Triassic salt rocks emplaced in Albian times over a previously marine slope, within a hot rifted setting, following a scenario similar to those of the Kebbouche, Ben Gasseur and Fej el Adoum salt ''glacier'' (N. Tunisia) [1,4,5,14,18,29,62,66,67] as well as a submarine salt ''glacier'' of Golf Coast of Mexico and Northern America [20,34,58,59].

7. Conclusion

The studied area, as for the neighbouring region, has undergone a moderate ante-Oligocene compression, the initiation of the Eocene phase [45].

The lower erosion contact Triassic/Albian and the Triassic variegated debris reworked by Albian limestone indicate that the lateral extrusion of the Triassic material took place during the Albian in a shallow marine environment on a gentle slope.

Our study suggests that the Chitana-J. Sene Ed Jemel area is a submarine composite salt «glacier» extruded during Lower Albian and then laterally expanded rapidly till the Uppermost Albian (Vraconian) and the J. ed Djebs was considered as a simple salt «glacier» installed during Early Albian or an detached open toe of sheet during overthrust episodes (Fig. 6).

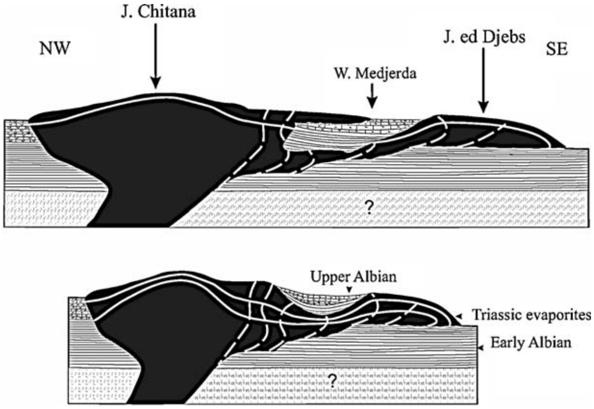

Fig. 6. Hypothetical restoration of mechanism evolution of Triassic mass during Albian time, inspired from Talbot [59], Hudec and Jackson [33].

Fig. 6. Restauration hypothétique de l'évolution de la masse triasique pendant l'Albien, inspirée de Talbot [59], de Hudec et de Jackson [33].

We considered the paroxysm of the Late Mesozoic tectonic inversion has begun in the Middle Eocene–Early Lutetian. This setting is attested by many recent publications in neighbouring areas as well as Africa's northern margin [3,15,27,37,39,44,61].

As summary, the results attest the existence of a widespread salt province and the coexistence of all types of salt structures in Africa's margin as well as the generalization of the Eocene compressive episode throughout the Moghrebian margin.

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