The External Domain of Maghrebides Belt on the North–East of Algeria, Souk Ahras Segment: Definition of Structural Units, Block Structure and Timing of Thrusts Setting

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Abstract

The detailed geological mapping supported by micropaleontological, tectonic and structural data of Souk Ahras region (North–East of Algeria) made it possible to define the main structural units of the external domain of the Maghrebides belt in the North–East of Algeria. The study area shows a block structure illustrating an allochthonous domain (Numidian unit, the northern Tellian unit and the southern Tellian) thrusting a folded para-autochthonous domain (the scaly unit of the Sellaoua type and the Dj. Graout unit). The current structure is edified into three phases at least: post Langhian phase, Tortonian phase and Pliocene phase.

Keywords

External domain • Allochthonous domain
Tellian nappes • Sellaoua unit • Souk Ahras
Algeria

1 Introduction

In the last century, the Maghrebides chain has commonly been divided into three distinctive domains, from north to south: the internal domain, the Flyschs domain and the external domain [1]. These domains have collided following the convergence of the African and European plates. This collision led to the scaling of the internal domain, the closing of the Flyschs and Tellian basin, and the thrusting of the series far to the south above the formations of the northern African plate margin [2].

The Souk Ahras zone is part of the external domain of the Maghrebides belt [3]. It offers an excellent structure built in the Neogene. Geological mapping, micropaleontological, tectonic and structural data allowed us to characterize the structural units and to suggest a scenario of units in the region's setting.

2 Materials and Methods

The study area is situated in the northeast of Algeria (Souk Ahras) which is spread into two domains:

A. Allochthonous domain: Dj Boubakhouch-M'Cid (BB-MC) Numidian nappe, Ouled Driss-Dj Boukebch (OD-BK) Tellian nappes),
B. Para-autochthonous domain: Dj Boubakhouch–Dj Bouallegue (BB-BL) of Sellaoua unit and Dj Graout–Merahna (GT-MR) unit.

This study is based on geological mapping supported by geological sections, using micropaleontological, tectonic and structure data. Over one hundred samples of marl, taken from different sections, have been dated. The sections are spread over four sectors of the region, from south to north: Graout–Merahna (GT-MR) sector (A-A' section), Boukebch (BK) sector (B-B section), Dj. Boubakhouch (BB) sector (C-C' section) and Ouled Driss (OD) sector (D-D' section). In this study, we will focus only on samples collected from different discontinuities contacts.

3 Results

3.1. Oued Medjerda–Lakhdara Section (A-A' Section) was investigated in the para- autochthonous of (GT-MR) sector (Fig. 1). It shows an NNE-SSW anticline structure

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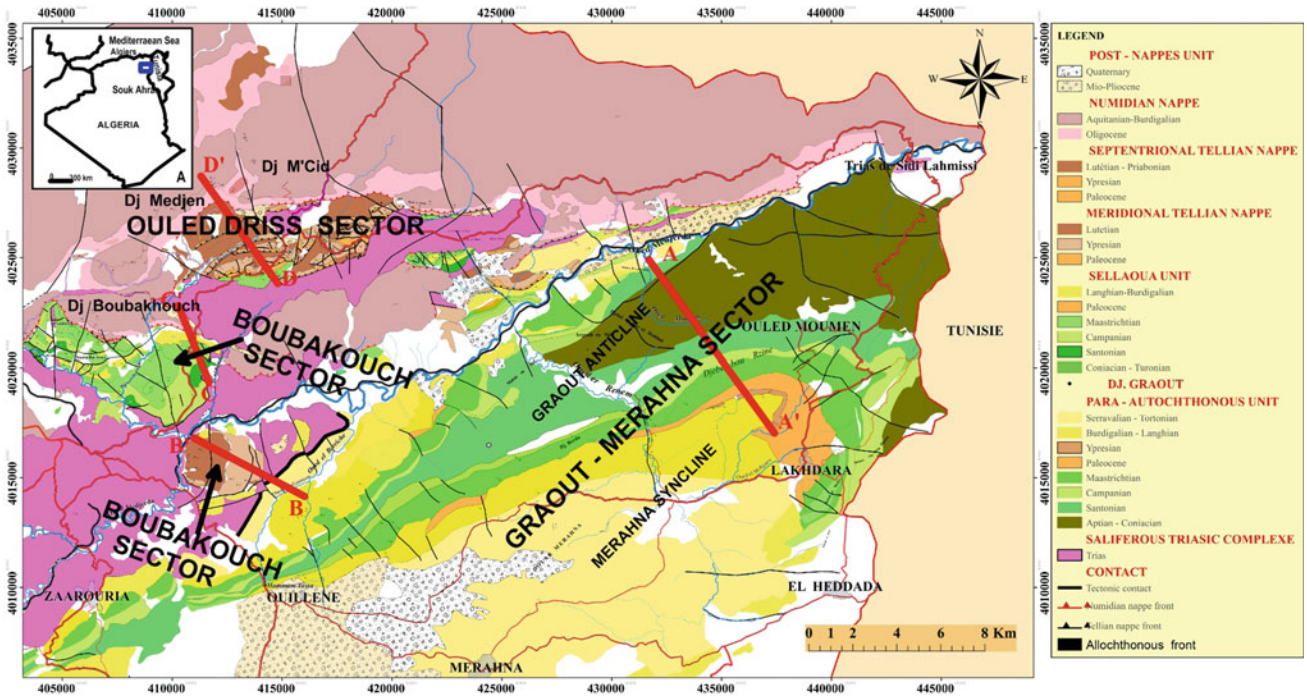

Fig. 1 Geological simplified map of the studied area and location of cross-sections

centered at GT succeeded by MR syncline. From North to South we can distinguish (Fig. 2a):

(a) Aptian–Coniacian: black marls, limestone and grey sandstone, (b) Santonian: grey marl and marl-limestone, (c) Campanian: a 160 m thick alternation of marl and limestone—marl with white limestone bar with a 100 m thick layer above, (d) Maastrichtian: 80 m of thick alternating grey marl with chalky limestone, and a bar of chalky limestones 100 m thick above. This Cretaceous series is overlaid by an alternating limestone and grey marl (120 m thick). Samples (S1–S3) which are collected from this level yielded *Globotruncanita falsostuarti, Rosita contusa, Gansserina gansseri* indicate the upper Maastrichtian.

However, Paleogene deposits are represented by (e) 260 m of thick schistose black marls rich in organic matter. The samples (S4–S7) which are collected from this level yielded *Morozovella trinidanensis, M. pseudobulloides and Globigerina triloculinoides,* (f) Ypresian–Lower Lutetian deposits are represented by a Nummulitic limestone bar 45 m in thickness. (g) Miocene is characterized by Glauconitic marls and sandstones, which overlay the previous term through an erosional surface marked by bioturbation. Samples S8–S10 and geological map [4] indicate Burdigalian–Tortonian age.

3. 2. Dj. Boukebch Section (B-B' Section): from SE to NO shows (Fig. 2b):

A. **Miocene** cover of (**GT-MR**) **unit**, thick series of brown marl and glauconitic sandstone. Samples (S11–S12) which are collected from the upper level are Serravallian age.
B. **Triassic salt complex**; clay-gypsum, dolomite, cargneule and anhydrite formations.
C. **The southern Tellian unit of BK**: to the south, this unit overlaps the Miocene (Serravallian) of O. El Berriche cover of the para-autochthonous domain. From bottom to top this unit is formed by: (a) **Paleocene**: approximately 5 m thick layer of black marl, (S13) is rich in benthic foraminifera with *Tritaxia midwayensis, Ammodiscus glabrata, Trochammina abrupta,* (b) **Ypresian**: 140 m thick, Nummulitic and lumachellic limestones. This level is overlaid by chalky limestones with *irregularis Nummulites, N. subirregularis, N. globulus, N. atacicus, N. subatacicus, N. gizehensis* [4] (c) **Lutetian deposits**; 200 m thick of alternating marls, brown clays and limestones. The marls yielded *Turritella carinifera,* and *Morozovella inaequispera, Globigerinatheka subconglobata* and Ostracodes (*Loculocyteretta*) (S14–S16). The series end with glauconitic sandstone.

3. 3. Dj. Bouallegue Section (C-C' Section) from the NW to the SE displayed in (Fig. 2c) shows:

(A) **The Sellaoua type unit of (BL)**: overlays the Triassic complex through a tectonic contact. This unit is made of: Santonian–Maastrichtian marly, marly-limestone

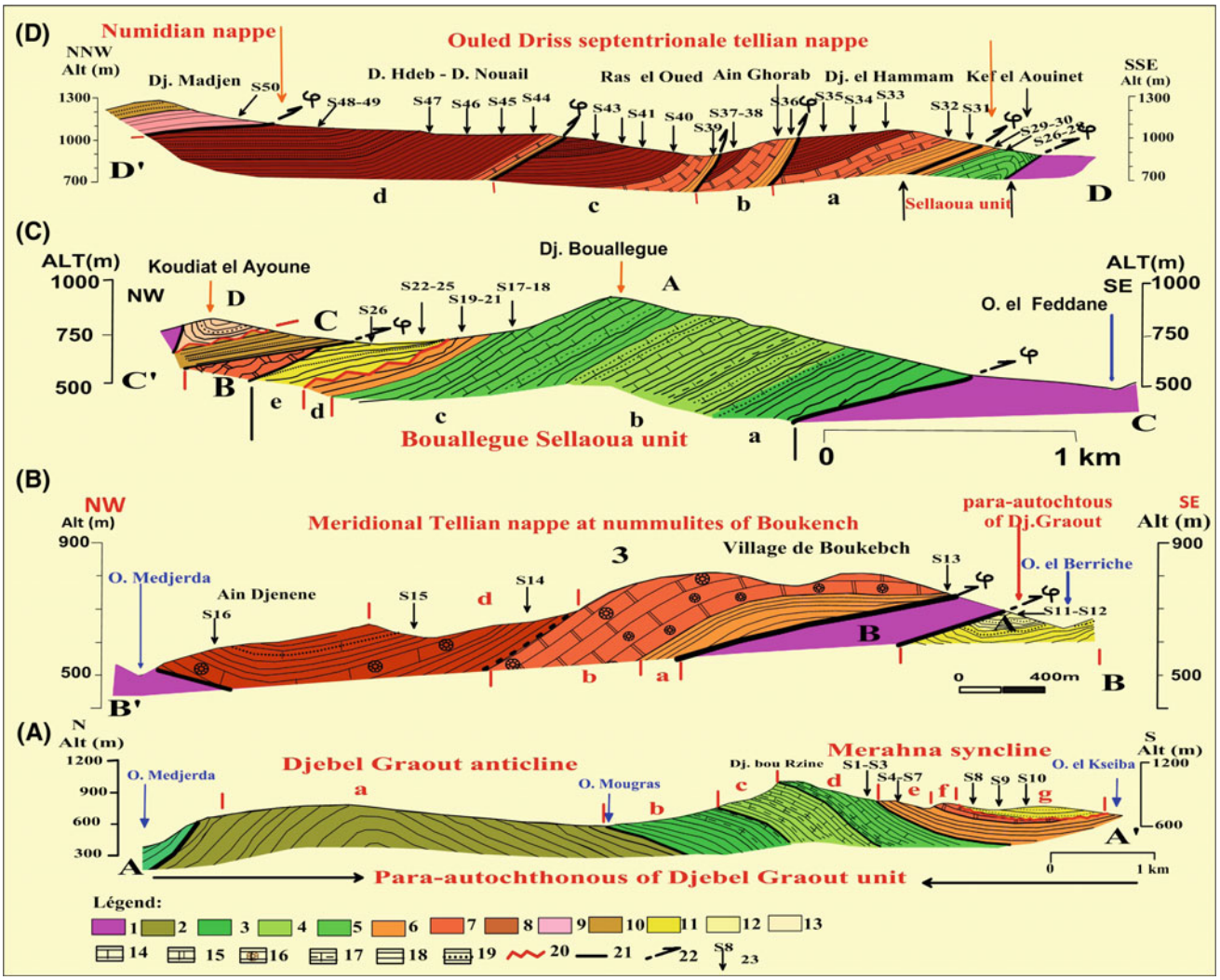

Fig. 2 Interpretative cross-sections: (1) Trias, (2) Aptian–Coniacian, (3) Santonian, (4) Campanian, (5) Maastrichtian, (6) Paleocene, (7) Ypresian, (8) Lutetian-Priabonian, (9) Oligocene, (10) Aquitanian, (11) Burdigalian–Langhian, (12) Serravalian–Tortonian, (13) Plio-Quaternary, (14) chalky limestone, (15) black limestone at silex, (16) Nummulites Limestone, (17) Marly–limestone, (18) Mudstone, (29) Sandstone, (20) Erosional surface, (21) Tectonic contact, (22) Thrust front, (23) Sample and its number

and chalky limestone 420 m thick (a, b, c). Samples (S17–18) collected from the uppermost part contains *Globotruncana stuartiformis, G. subspinosa, G. gansseri, G. Falsostuarti, G. havanensis*. (d) Paleocene, dark marl (nearly 20 m thick), samples (S19–S21) yielded Globigerina *triloculinoides, Planorotalites*. (e) Miocene: Glauconitic marls and sandstone with 70 m thick. Samples (S22–S26) collected from the uppermost part of these series provide *Praeorbulina glomerosa, P. transistoria, Globigerinoides trilobus, G. primorduis, G. altiapartura, G. bisphericus,* dating lower Langhian. The Miocene overlays Paleocene and Maastrichtian series, through an erosional surface.

(B) **BL Tellian unit**: shows black marl and dark limestones globigerina of Paleocene–Ypresian age.

(C) **BB Numidian unit** (Koudiet Ras El Ayoune): it is composed of marls and sandstone with 1000 m thick thrusting Tellian and Sellaoua units. It starts with a

green clay 140-m-thick surmounted by sandstone layers separated by 100–150 m thick mudstone. We can attribute the Oligocene to lower Miocene this series [5–7].

(D) **Koudiet Ras el Ayoune post-nappe unit**: represented by polygenic conglomerates, sands, and red clays, of Mio-Pliocene. It is a continental molasse, folded to NW-SE syncline. This series is gulled by a Triassic formation overlapping the previous unit through sub-vertical tectonic contact.

3.4. Ouled Driss Section (D-D Section): from the SSE-NNW, it is represented by (Fig. 2d):

A. In the South, the Sellaoua type unit (OD scale) which is tectonically in contact on the Trias. The series starts with alternation of grey limestone and grey marl. Sample (S26–S28) collected from marls, yielded *Globotrucanita aegyptiaca, Gansserina gansseri and Rosita contusa* dating upper Maastrichtian. The series overlaid by 80-m-thick of black marls (S29-S30) including *Globigerina triloculinoides* which indicates lower Paleocene.
B. Farther north, the OD northern Tellian unit thrusts Sellaoua type unit. This unit contains four (04) thrusts, separated by SSW-NNE reverse faults; Dj. el Hammam thrust (a), Ain Ghorab thrust (b), Chaabet Ras el Oued thrust (c) and Douar Hdeb-Douar Nouail thrust (d). This unit consists of globigerina and flint carbonate material featuring a circalittoral deposit. Every thrust reveals upper Paleocene (P5) to Lutetian–Priabonian age [8].
C. **Dj. M'Cid Numidian unit:** is represented by 140-m-thick Oligocene green clay "sub-Numidian clays", surmounted by 900 m-thick, Oligocene–Burdigalien sandstone series, admitting clay levels.

3.1 Structure

The interpretative section (Fig. 3) shows a complex structure characterized by the stacking of thrusts allochthonous units on a folded para-autochthonous domain, organized in three blocks separated by major tectonic contacts involving the ductile formations of the Triassic. From south to north:

(a) **GT-MR block "Block A"**: represents a folded structure with the succession of the Merahna syncline to the south and the Dj Graout anticline to the north. This block characterizes platform sedimentation of Cretaceous age and shallow Paleocene–Ypresian sedimentation. These series are overlaid by unconformable marl, sandstone and glauconitic sandstone clays, of Burdigalian–Tortonian age, with an erosional surface at the base. This block represents a para-autochthonous structure.
(b) **BB–BL–BK block "Block B"**: the series of this block overlap the Miocene (Serravallian) of **"Block A"** through a major tectonic contact involving Triassic material. From bottom to top this block is formed by: BB–BL Sellaoua type unit, which presents a scaled structure implying Miocene series and overlapping by Northern Tellian unit with globigerina of Koudiet Ras el Ayoune from the North. After these units comes the BB Numidian unit that overlaps Tellian and Sellaoua units with a sub-horizontal tectonic contact. The block ends with Koudiet Ras el Ayoune post-nappe unit (Pliocene) which surmounts the Numidian nappe by a sedimentary contact.
(c) **MC–OD block "Block C"**: overlaps **"Block B"** by a major tectonic contact leading to the plastic formations of the Triassic which lead the folding of the Pliocene formations of the "block B". It is made of Sellaoua unit of OD which is thrusting by OD northern Tellian unit. The OD Tellian unit is characterized by a duplex structure of four thrusts (Upper Paleocene to late Priabonian). The delamination occurred in the Upper Paleocene marl. This block ends by MC Numidian unit.

4 Discussion and Conclusion

Calendar and setting of structural units: The superposition of units illustrated in (Fig. 3) allows us to distinguish 3 stages of emplacement of the structural units during Neogene.

(a) **1**st **Phase** (The setting of Tellian and Numidia units): the geological map, sections (Figs. 1 and 2) and the interpretative section (Fig. 3) show that Tellian and Numidian units overlap the Burdigalien–Langhien series which covers the BB-BL Sellaoua units. On the one hand, the Numidian unit supports Pliocene deposits at of Koudiet Ras el Ayoune (D-D' Fig. 2). These arguments are in favor of laying nappes in Sellaoua basin, later to Langhian inferior and prior to Pliocene.
b) **2**nd **Phase** the "C and D blocks" overlap the Burdigalian–Tortonian series cover of GT-MR block at O. el Berriche. The structure is in favor a compressional deformation which induced the setting "C and D blocks" in common motion. This displacement caused the scaling of Sellaoua unit (Dj. BB–BL unit) in the Langhian and moving the entire block to the south on

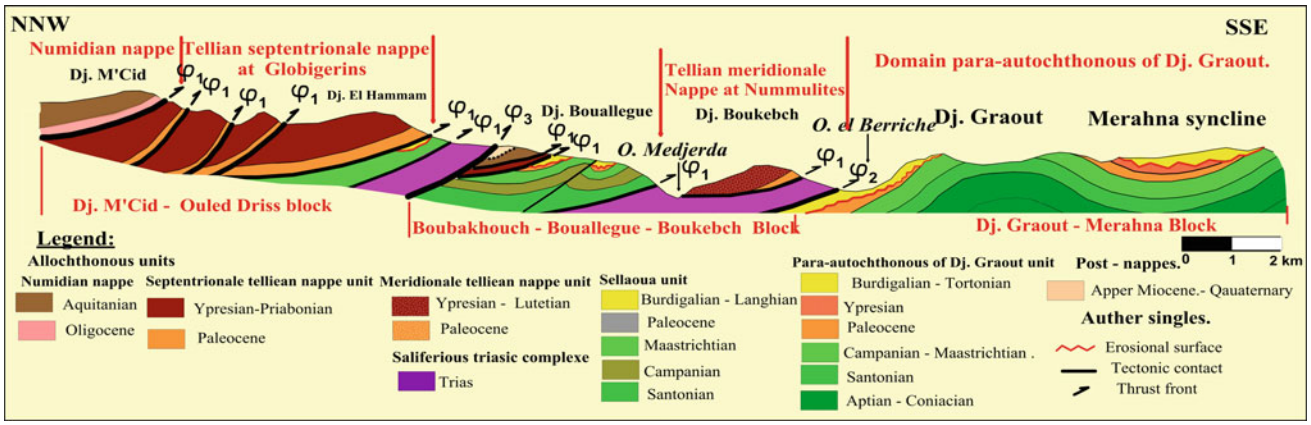

Fig. 3 Simplified interpretative cross-section of Souk Ahras structure

the para-autochthonous domain of GT-MR in the Upper Miocene. This level of delamination is major, leading the Triassic formations that should have been outcropped by the diapirism phenomenon before the late Miocene period.

(c) **3rd Phase** (The setting of MC–OD block): the present structure shows that the united block (MC–OD and BB–BL–BK) flaking into two blocks separated by a plastic level consisting of Triassic formations (Fig. 3). The newly separated block (MC–OD) overlaps BB–BL–BK block to the south, inducing the folding of the Pliocene of Koudiet Ras el Ayoune unit. These facts are in favor of post-Pliocene displacement and illustrate a post- Pliocene compressional deformation.

This thrusting calendar is in line with that proposed to the west of investigated area by [6] in the region of Sidi Afif, Sedrata (near 40 km NW of study area) and that of [9] in the region of Hodna Mounts, central Algeria (near 500 km West of study area).

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