Importance of the Mellala section (Traras Mountains, northwestern Algeria) for the correlation of the Pliensbachian-Toarcian boundary

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ABSTRACT: In the Mellala profile, located in the Traras Mountains (Tlemcen Domain, NW Algeria), the hemipelagic Bayada Fm. includes the transition from the Pliensbachian to the Toarcian within a continuous succession of alternating marls and marly limestones, whose thickness reaches approximatively 50 m.

The Bayada Fm. begins in the Upper Domerian. The Solare Subzone of the Emaciatum Zone is proved by the occurence of several *Pleuroceras solare* (Phillips) in the lower part, associated with *Emaciaticeras* upwards. The Elisa Subzone is characterized by *Tauromeniceras elisa* (Fucini), *Canavaria finitima* (Fucini), *Paltarpites bettonii* (Fucini) associated with numerous *Phymatothyris kerkyreae* (Renz) and rare *Lobothyris punctata* (Sowerby). *Leioceratoides* gr. *serotinus* (Bettoni) has been found in the upper part of the subzone.

The base of the lowermost Toarcian (Mirabile Horizon, Paltus Subzone) is marked by a decimetric bed (no. 38) with *Paltarpites paltus* (Buckman) but which has not yielded *Eodactylites* in the present state of the research. The following calcareous bed (no. 40) has yielded several *Dactylioceras* (*Eodactylites*) *polymorphum* (Fucini), *D.* (*E.*) *mirabile* (Fucini) and *D.* (*E.*) *pseudocommune* (Fucini). Upwards, *Eodactylites* is abundant over 10 to12 m, especially in Bed no. 44. At 3.50 m below the top, a marker-bed corresponds to a lenticular level of bioclastic quartz-rich limestones that marks the limit between the two members of the formation. The overlying 15 m are attributed to the Semicelatum Subzone (Tethyan nomenclature). At the base a level with *D.* (*Orthodactylites*) *crosbeyi* (Simpson) allows a good correlation with the Clevelandicum Subzone (or Horizon) of Northwestern Europe. The topmost 5 m of the outcrop are dated to the Levisoni Zone with *Eleganticeras* sp. The anoxic event of the beginning of this Zone is indicated only by an abnormal variability of the foraminifera. The presence of *Lenticulina obonensis* Ruget indicates stressing conditions.

The occurrence, from the Upper Domerian to the Polymorphum Zone, of a fauna comprising the brachiopod *Koninckella* is important because it confirms that the environment was restricted within a deep, strongly subsiding basin (the "umbilicus").

INTRODUCTION

The aim of Global Stratotype Section and Points is to stabilize the nomenclature of geological stages. These "points" must give a good definition of the stages by way of the choice and illustration of their bases. For the Toarcian, a candidate section has been chosen in Portugal (Peniche section) where a continuous and perennial profile is exposed along marine cliffs (see Elmi 2006 a, b). The bed choosen to mark the beginning of the Toarcian Stage is characterized by the *Eodactylites* (ammonite) assemblage. It occurs at the top of the "*Couches de passage*", at the summit of a calcareous unit. This proposal has received large international agreement. It is however important to illustrate complementary sections in order to facilitate correlations between the different palaeobiogeographic provinces (between NW Europe and Western Tethys, among others) but also to appreciate the influence of palaeophysiographic and palaeostructural factors. In this paper, we present a description of the Mellala section located in the Traras Mountains (Beni Menir sector) in northwestern Algeria near the border with Morocco. It is one of the very few examples of continuous and monotonous sedimentation through the Pliensbachian-Toarcian boundary. After the initial observations of Guardia (1975), the first detailed description was given by Ameur (1999, section Mellala no. 2, p. 92-95). Field study has been resumed recently, after the amelioration of the security situation, by an international team (A. Sebane and M. Ben-

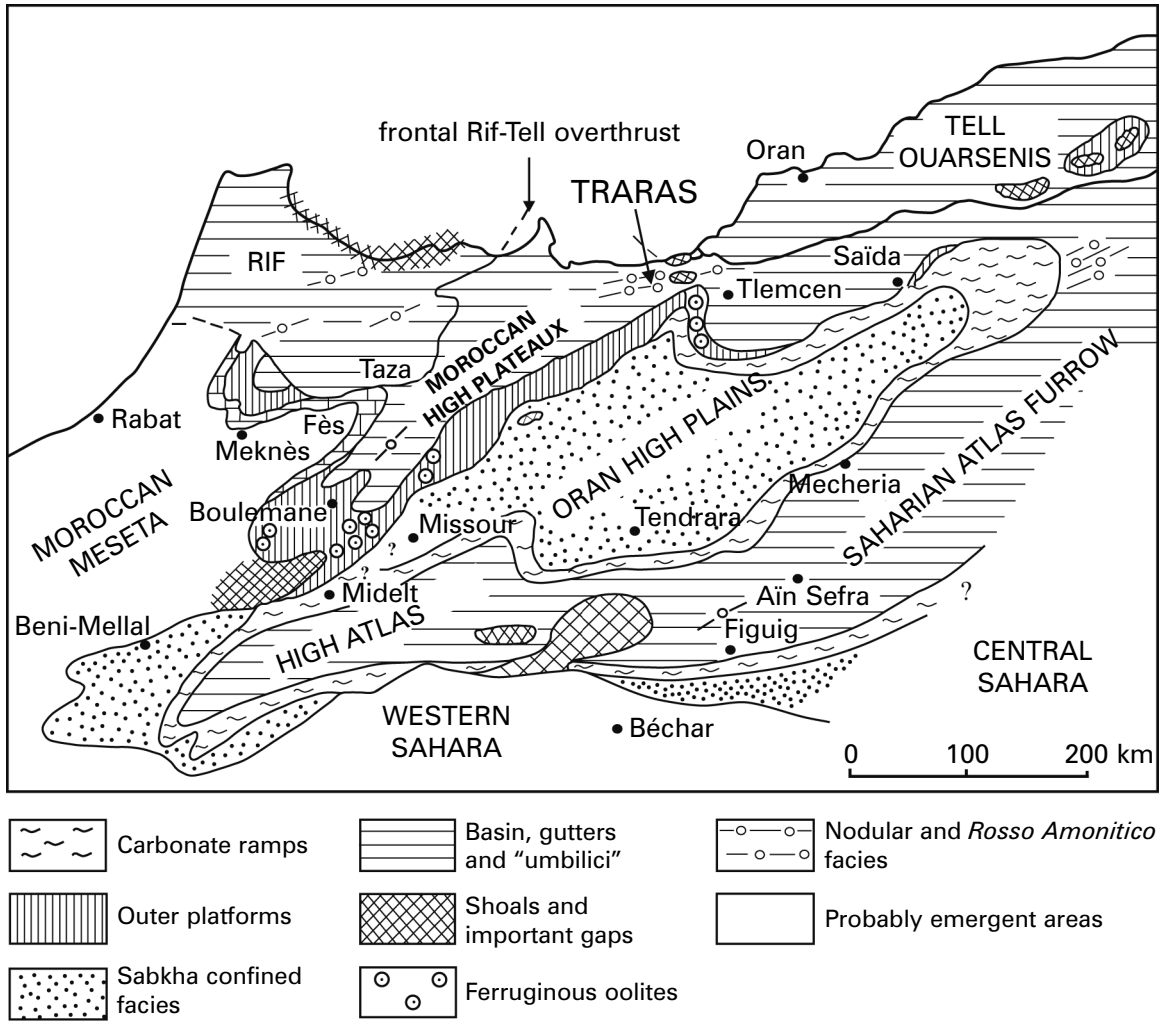


Fig. 1. Place of the Traras Mountains on a palaeogeographical map of western Algeria and Morocco during the Toarcian (redrawn from Elmi, Benshili 1987).

hamou, Oran; A. Marok and S. Tchenar, Tlemcen; Y. Alméras, A. M. Bodergat, S. Elmi, S. Mailliot and E. Mattioli, Lyon). The present communication is principally devoted to the ammonite, brachiopod and foraminifera successions.

In large parts of Europe, but also in numerous areas within Tethys Domain, eustatic and tectonic events occurring near the Pliensbachian/Toarcian boundary prevent good preservation of the transitional beds (see Guex *et al*. 2001, for a recent review; Howarth 1973, 1992, for the British Isles; Gabilly 1976, for western France amongst others). In western Algeria and in Morocco, the boundary is often located near (or at) a major lithostratigraphic change, as evidenced in the classic Talghemt section of the Moroccan High-Atlas, with the passage of the Ouchbis limestone dominated Fm. into the Tagoudite marly Fm. (Dubar 1952; Sadki 1996; El Kamar *et al*. 1998). The Pliensbachian/Toarcian boundary occurs under the last beds of the Ouchbis Fm., within a sedimentary unit. This situation is widespread in Tethys and is similar to the succession in Peniche where the proposed GSSP is located at the top of the "*Couches de passage*".

The Mellala section has the big advantage of exposing a continuous transition located within a monotonous succession of alternating marls and marly limestones forming the hemipelagic Bayada Fm. (Ameur 1999). No sedimentary event perturbs the chronological and faunal record.

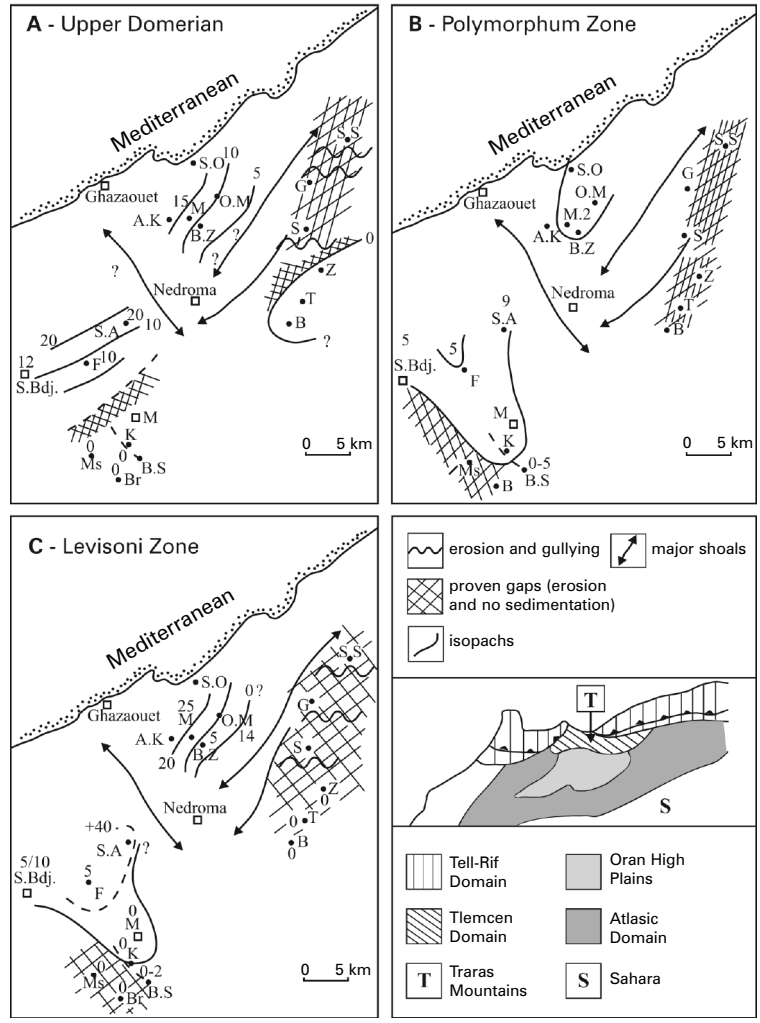


Fig. 2. Sketches of the evolution of the Traras Mountains during the Late Domerian and the Early Toarcian (reinterpreted after Ameur 1999): A.K – Aïn Killoun; B – Bayada; Br – Bendjeddour; B.S – Ben Seria; B.Z – Benzerka; F – Fenakech; G – Gorine; K – Kébir; M – Mellala; Ms – M'sama; O.M – Ouled Malek; S – Sekika; S.A – Sof Ahmed; S.Bdj – Sidi Boudjenane; S.O – Sidna Oucha; S.S – Sidi Sofiane; T – Taouia; Z – Zaïlou.

GEOLOGIC AND PALAEOGEOGRAPHIC SETTINGS

During Pliensbachian and Toarcian times, the Saharian Craton constituted the NW edge of the Gondwana continent and was only encroached by pellicular and sabkhaic transgressions in the Lower Sahara. It was limited to the north by evolving and intervening marine basins forming the southern margin of the Western (or Maghrebian) Tethys. These regions constituted the "Atlas Domain" (future Atlas ranges or Berberids). From south to north, in western Algeria, the mosaic of regional basins and shoals can be grouped in three main palaeogeographic and palaeostructural units, illustrated on the schematic maps (Fig. 1):

– to the south, the Saharian Atlas Furrow, passing into the High-Atlas westward (Morocco);
– in the median part, the Oran High Plains constituting a large platform (=Oran Meseta of some authors); to the west they were prolonged by the Moroccan High Plateaus and limited by the subsiding Middle Atlas to the west;
– to the north, the Tlemcen Domain (Fig. 2), is constituted of a mosaic of elementary basins and shoals, passing into the Middle Atlas to the west.

During the Toarcian, the partition into a mosaic of subsiding and deepening "umbilici" separated by a structural network of shoals and ridges had been exaggerated. A first deepening episode occurred during the Early Toarcian, but the uplift of some large blocks (Oran High Plains) and ridges indicates that tectonic controls were important. Sabkhas isolated by oolitic barriers developed on the Oran High Plains. Elsewhere, thick marly sediments accumulated in the "umbilici" and narrow subbasins. The slopes were characterized by mass-flows, calciturbidites and siliciclastics. In consequence, the tectonism counteracts strongly the effect of eustatism and must have enhanced the effect of local and general climatic changes. The real transgression onto the continental margins was limited.

Inside the Tlemcen Domain, the Traras Mountains are divided into at least three hectokilometric subbasins (or "umbilici") that have become progressively more distinct during the Early Jurassic. This evolution is illustrated in Fig. 2 for the Late Domerian-Early Toarcian period (Emaciatum, Polymorphum and Levisoni zones). The transitions between the shoals and the "umbilici" bottoms were steep and rapid (often within less than 1 km). In the most subsiding areas (Mellala in the Beni Menir), subsidence remained active through the Pliensbachian/Toarcian boundary, which is preserved without any break in the sedimentation.

SUCCESSION OF THE BAYADA FORMATION AT MELLALA

Observations have been made bed by bed in a large outcrop, extending down the village of Mellala in the western part (Beni Ménir) of the northern Traras (x=93.8 to 93.2; y=206.4 to 205.8). The dip is nearly vertical. A preliminary revision of the Ameur's results has been recently published (Elmi *et al*. 2006 a, b).

The first levels of the Bayada Fm. overly limestones (Tisseddoûra Fm., 9 m) showing an outer platform facies (biomicrites containing brachiopods and belemnites), dated to the Early Domerian. At Mellala, the presence of *Tetrarhynchia dumbletonensis* (Davidson) indicates the Algovianum Zone. The Bayada Fm has an overall thickness of nearly 50 m. It shows a hemipelagic facies and yields *Zoophycos* and *Steinmania* shells and "filaments". It is divided into two unnamed members (lower: 22-23 m; upper: *circa* 25 m) separated by one or two erosive lenticular beds of allodapic biomicrite rich in ossicles and in millimetric quartz grains (beds 48-49). This level disappears rapidly laterally. The sequence shows deepening upward trend towards the top of the formation that is sharp discontinuity surface (now hidden by trenchs and field works). Laterally (Aïn Killoun and Benzerka, sections distant of less than 1 km), the Bifrons Zone is well represented and thick (20 m at least).

The major biostratigraphic data are given on Fig. 3. The zonal scheme used is the Tethyan one which corresponds roughly to the NW European units: Emaciatum Zone = Spinatum Zone; Polymorphum Zone = Tenuicostatum Zone; Levisoni Zone = Serpentinum Zone.

The Bayada Fm. begins in the Upper Domerian. The Emaciatum Zone is divided in two parts. The presence of the lower (Solare Subzone) is documented by the occurence of several *Pleuroceras solare* (Phillips) occurring alone in the lower part of the subzone (Pl. 1: 3a-b), but associated with *Emaciaticeras* upwards. Brachiopods include: *Phymatothyris kerkyreae* (Renz) and *Quadratirhynchia quadrata* Buckman. The upper part (Elisa Subzone) is characterized by *Tauromeniceras elisa* (Fucini) and *Canavaria finitima* (Fucini) associated with numerous *P. kerkyreae* (Renz) and rare *Lobothyris punctata* (Sowerby). In addition the main part of the brachiopod assemblage consists of small sized species: *Nannirhynchia pygmoea* (Davidson), *Koninckella liasina* (Davidson) and *Cadomella* cf. *moorei* (Davidson). This is the *Koninckella* fauna (previously named *Leptaena* fauna). *Leioceratoides* gr. *serotinus* (Bettoni) has been found in the upper part of the Elisa Subzone.

The base of the lowermost Toarcian (Mirabile Subzone) is marked by two decimetric beds (no. 38, 39) with *Paltarpites paltus* (Buckman) (Pl. 1: 1, 2) but without *Eodactylites* at the present state of the research. The next well marked calcareous beds (no. 40) have yielded several *Dactylioceras* (*Eodactylites*) *polymorphum* (Fucini), *D.* (*E.*) *mirabile* (Fucini) (Pl. 1: 4) and *D.* (*E.*) *pseudocommune* (Fucini) (="first *Eodactylites*"; Fig. 3 and 4). The brachiopods are represented by *Liospiriferina subquadrata* (Seguenza), *Lobothyris* sp. and the *Koninckella* fauna: *C. moorei*, *N. pygmoea* and *K. liasina*. Upwards, *Eodactylites* becomes abundant, especially in Bed no. 44. It persists up to the top

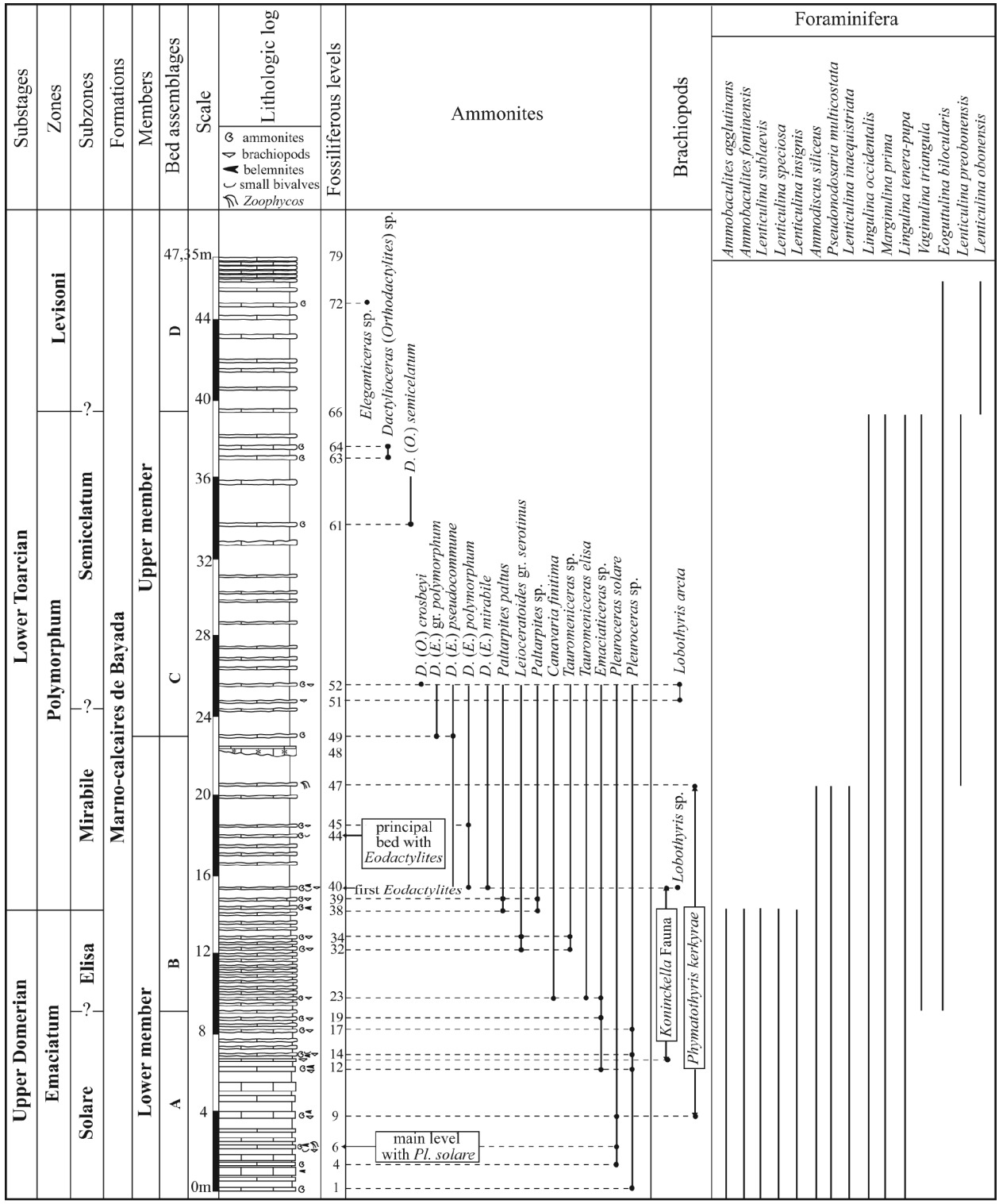


Fig. 3. Succession of the main faunas (ammonites, brachiopods, foraminifera) in the Mellala no. 2 section; Beni Menir sector of the Traras Mountains (Tlemcen, Algeria).

Fig. 4. *Dactylioceras (Eodactylites) pseudocommune* (Fucini). Mellala no. 2 section. Bed 40, *in situ* view. Natural size.

of assemblage B (marker beds 48-49) and at the base of assemblage C. The presence of the foraminifer species *Lenticulina preobonensis* Boudchiche in Nicollin and Ruget (1988) is significant because its geographic distribution is restricted to more or less isolated small basins (Lusitanian Basin and Tlemcen Domain: Mellala and the bordering Beni Snassen; Boudchiche 1986,1994). From the environment point of view, its presence marks the late normal phase of the foraminiferal development (Sebane *et al*. 2007), that immediately preceeded the crisis relating to the anoxic event that occurred during the early Levisoni-Serpentinus Chron.

The overlying 15 m are attributed to the Semicelatum Subzone (Tethyan nomenclature). The base of the subzone is indicated by a level (no. 52) with *D*. (*Orthodactylites*) *crosbeyi* (Simpson) associated with *Lobothyris arcta* (Dubar) which allows a good correlation with the Clevelandicum Subzone (or Horizon) of northwestern Europe. Bed 61 has yielded *D*. (*O*.) *semicelatum* (Simpson). Near the top of the section, *Eleganticeras* sp. in Bed 72 indicates the Levisoni Zone, which may begin slightly lower, as suggested by the occurence of *Lenticulina obonensis* Ruget in Bed 66. The anoxic event at the beginning of this Zone is indicated by abnormal variability in the foraminifera and by the dominance of *L. obonensis* Ruget indicating stressing conditions.

CONCLUSIONS

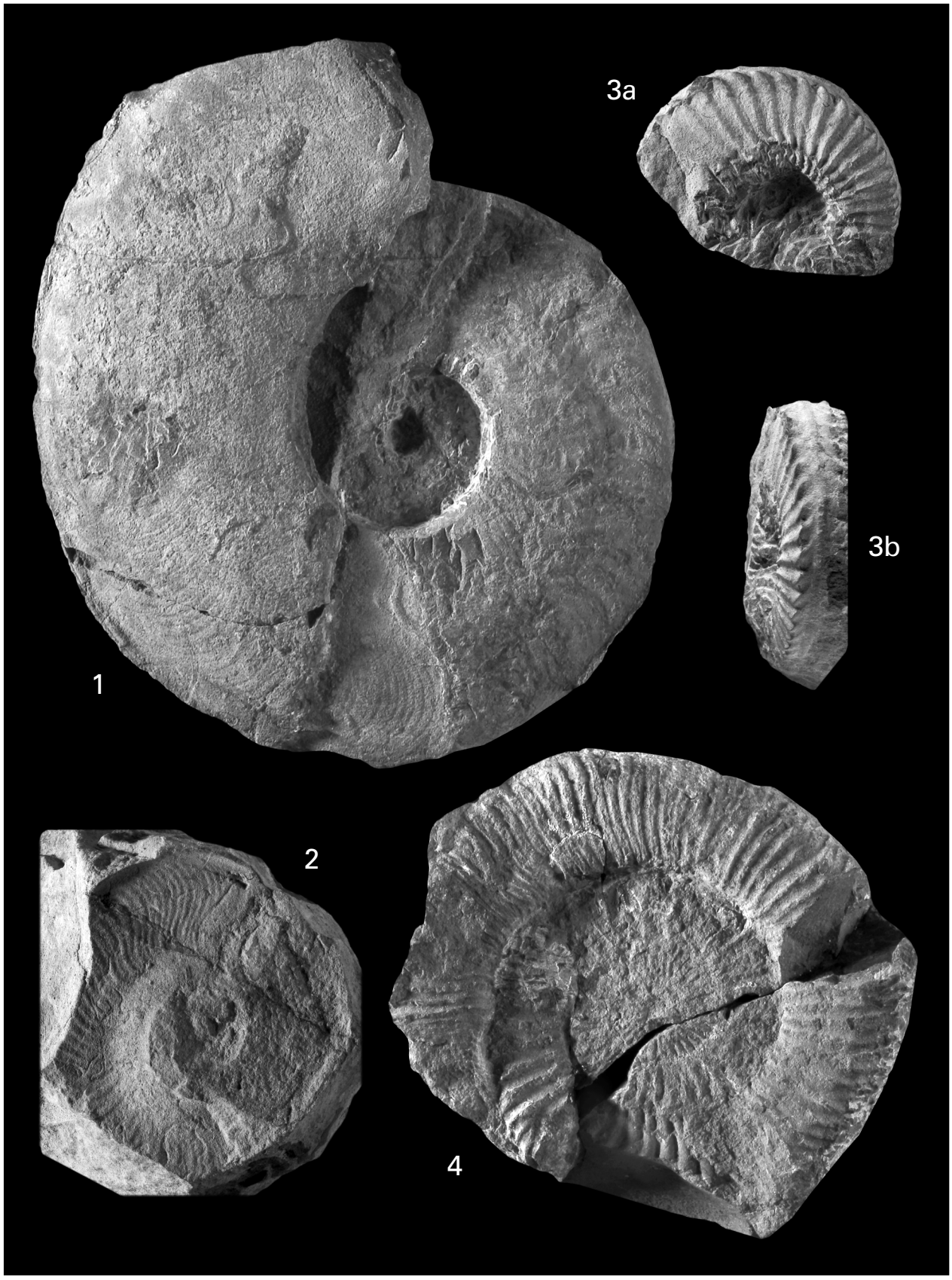
The Mellala section provides several important results concerning the biostratigraphy, the environment evolution and the biogeography of the area during the latest Pliensbachian and the Early Toarcian.

Concerning the ammonites, *Pleuroceras solare* is abundant in the lower part of the Emaciatum Zone, and it exists before the appearance of *Emaciaticeras*. The presence of amaltheids within the Tethyan Realm is not exceptional. It is linked rather to palaeophysiographic conditions such as the vicinity of a shallow "epicontinental" platform as proposed by Lucas as early as 1942 and 1952. Badly preserved *Pleuroceras* sp. occurs up to the end of the subzone. On the contrary, *Pleuroceras hawskerense* is absent at the end of the Domerian in the Elisa Subzone and the precise correlation with the NW European Hawskerense Subzone remains uncertain.

Paltarpites paltus appeared locally before *Eodactylites*. The bed concerned (no. 38) has been tentatively attributed to the Toarcian. *D*. (*O*.) *crosbeyi* is present above the last *Eodactylites*. This datum confirms that the Paltus Subzone and the Mirabile Horizon of the Mediterranean Province begin before the appearance of the *Orthodactylites*. The frequent lack of *Eodactylites* in the NW European Province is not due to palaeogeographic segregation but to the widespread (but not total) sedimentary gap known during these times (Guex *et al*. 2001) added to the effect of its variable distribution. One more time period, the equivalent of the Tenuicostatum Horizon (or Subzone) cannot be established, perhaps because of the lack of ammonites in the corresponding beds.

For the brachiopods, one important result is the early appearance of the *Koninckella* fauna which

Plate 1
1 – *Paltarpites paltus* (Buckman), bed 38; 2 – *Paltarpites* gr. *paltus* (Buckman), bed 39; 3a-b – *Pleuroceras* aff. *solare* (Phillips), bed 6; 4 – *Dactylioceras (Eodactylites) mirabile* (Fucini), bed 40. All specimens from Mellala no. 2 section near Nedroma (Tlemcen prov., Algeria): natural size. Authors' collection.


3a
3b
1
2
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happened near the boundary between the Solare and the Elisa subzones. Elsewhere, the known age of this ubiquitous fauna is restricted to the Polymorphum-Tenuicostatum Zone. The *Koninckella* fauna has been observed on the north-western European platforms (Somerset and Gloucester in England, Normandy in France), on the northern margin (Pic Saint Loup, south of the French Massif Central; North Lusitanian Basin; Sicily; Southern Alps; Bavaria) and on the southern margin of the Western Tethys (Beni Snassen in Morocco; Traras and Nador-Tiaret Mountains in Algeria). These data underline the strong relationship that existed between the existence of this small fauna and an environment of small, relatively deep and strongly subsiding basins ("umbilici"). The existence of *Phymatoceras kerkyreae* is also significant. The presence of this species, defined in the Ionian Islands (Corfu), appears also to be tied to special environmental conditions. This kind of situation in "limited umbilicus" is also illustrated by the rarity of *Quadratirhynchia* and *Lobothyris*, by the presence of the spiriferinids and by the special foraminifera fauna.

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REFERENCES

Ameur M. 1999. Histoire d'une plate-forme carbonatée de la marge sud-téthysienne: l'autochtone des Traras (Algérie occidentale) du Trias supérieur jusqu'au Bathonien moyen. *Documents des Laboratoires de Géologie de Lyon*, **150**: 1-339.

Boudchiche L. 1986. Etude micropaléontologique du Domérien, Toarcien et Bajocien des Beni Snassen orientaux. Unpublished thesis, Lyon 1 University, 1-190.

Boudchiche L. 1994. Le Lias-Dogger des Beni Snassen orientaux (Maroc nord-oriental): Succession stratigraphique, évolution tectonosédimentaire et micropalaéontologie. Unpublished PhD thesis, Oujda University, 1-253.

Dubar G. 1952. Livret-guide de l'excursion A34, Haut-Atlas central. *19*éme *Congres géologique international, Alger, série Maroc*, **4**: 1-74.

Elmi S. 2006a. Toarcian Working Group. Progress Report: Peniche field meeting (Portugal). June 2005. *In*: N. Morton and P. Bown (*Eds*): *International Subcommission on Jurassic Stratigraphy Newsletter*, **33**: 14-16.

El Kamar A., Boutakiout M., Elmi S., Sadki D. and Ruget C. 1998. Foraminiferes et ostracodes du Lias supérieur et du Bajocien de la Ride de Talghemt (Haut-Atlas central, Maroc). *Bulletin de l'Institut Scientifique*, *Rabat*, **21**: 31-41.

Elmi S. 2006b. Pliensbachian-Toarcian boundary: the proposed GSSP of Peniche (Portugal). *7th International Congress on the Jurassic System, 6-18 September 2006, Kraków, Poland. Volumina Jurassica*, **4**: 5-16.

Elmi S. and Benshili K. 1987. Relations entre la structuration tectonique, la composition des peuplements et l'évolution; exemple du Toarcien du Moyen-Atlas méridional (Maroc). *Bolletino della Societá Paleontologica Italiana*, **26**, 1/2: 46-62.

Elmi S., Marok A., Sebane A. and Alméras Y. 2006a. Intéret de la coupe de Mellala (Monts des Traras, Algérie occidentale pour les corrélations de la limite Pliensbachien-Toarcien. *12*éme *Séminaire national des Sciences de la Terre, Oran, Mars 2006*: 29-30.

Elmi S., Marok A., Sebane A. and Alméras Y. 2006b. Importance of the Mellala section (Traras Mountains, north-western Algeria) for the correlations of the Pliensbachian-Toarcian boundary. *7th International Congress on the Jurassic System, 6-18 September 2006, Kraków, Poland. Volumina Jurassica,* **4**: 158-160.

Gabilly J. 1976. Le Toarcien à Thouars et dans le Centre-Ouest de la France. *Publications du Comité Francais de Stratigraphie, Editions du Centre National de la Recherche Scientifique*, **3**: 1-217.

Guardia P. 1975. Géodynamique de la marge alpine du continent africain d'apres l'étude de l'Oranie nord-occidentale. Unpublished PhD thesis, Nice University, 1-286.

Guex J., Morard A., Bartolini A. and Morettini E. 2001. Découverte d'une importante lacune stratigraphique à la limite Domérien-Toarcien: implications paléo- océanographiques. *Bulletin de la Société Vaudoise des Sciences Naturelles*, **345**: 277-284.

Howarth M. K. 1973. The stratigraphy and ammonite fauna of the Upper Liassic grey shales of the Yorkshire coast. *Bulletin of the British Museum (Natural History), Geology,* **24**, 4: 237-277.

Howarth M. K. 1992. The ammonite family Hildoceratidae in the Lower Jurassic of Britain. *Monograph of the Palaeontographical Society*, **145** (586): 1-106.

Lucas G. 1942. Description géologique et pétrographique des Monts de Ghar Rouban et de Sidi el Abed. *Bulletin du Service Géologique de l'Algérie*, 2, **42**: 1-539.

Lucas G. 1952. Bordure nord des Hautes Plaines dans l'Algérie occidentale. *19*éme *Congres géologique international*, *Alger*, *Monographies régionales*, 1, **21**: 1-139.

Nicollin J. P. and Ruget C. 1988. Microfaune du Toarcien inférieur (zones a Tenuicostatum et Serpentinum). *Benthos' 86. Revue de Paléobiologie*, *spec. vol.*, **2**: 183-189.

Sadki D. 1996. Le Haut-Atlas central (Maroc). Stratigraphie et paléontologie du Lias supérieur et du Dogger inférieur. Dynamique du bassin et des peuplements. *Documents des Laboratoires de Géologie de Lyon*, **142**: 1-245.

Sebane A., Marok A. and Elmi S. 2007. Evolution des peuplements de foraminiféres pendant la crise toarcienne à l'exemple des données des monts des Ksour (Atlas saharien occidental, Algérie). *Comptes Rendus de l'Académie des Sciences, Palevol*, **6**: 189-196.