Pliensbachian/Toarcian boundary: the proposed GSSP of Peniche (Portugal)

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ABSTRACT: The Peniche section (Portugal) is cosidered as a potential stratotype (GSSP) for the Pliensbachian-Toarcian boundary and it is analysed on the background of the available data on the ammonite successions from other Tethyan and NW European areas.

INTRODUCTION

It will be useful to remind that the definition of a GSSP must be based on a marker bed choosen in a well documented and easily accessible locality. During Jurassic times, the ammonite assemblages are the best tool presently available to establish correct correlations. A single palaeontologic event, as first (FO) or last occurrences (LO) of a species, cannot be taken in account because the dating of such FO or LO can be improved by new discoveries. If we attach a too great importance to such events, it must be admitted that every locality where a new FO/LO datum will be discovered would become a new but highly unstable GSSP. The problem is of semantic nature: changing data (or opinions) would provoke changing limits. That is neither convenient nor coherent because stability of the chronostratigraphic vocabulary is an absolute necessity. We need to find and define good markers in a single good locality. We must use faunal assemblages (unitarian associations or others) to establish a good scenario of the different appearances. The knowledge of the faunal turnover can (must!) be always improved but our litho-stratigraphic reference (as a bed in a precise locality) must remain stable, at least during a long period between largely accepted revisons. Such a work is progressing now to establish GSSP. Thus, we can be coherent on the differences between chrono and biostratigraphy. For instance, the FO of the so called *Dactylioceras (Eodactylites)* can be earlier than the GSSPs. This is an important fact but it does not mean that we must change the GSSP. It must be stressed, following F. Macchioni (2002, and many other previous authors) that the base of the Toarcian Stage is uneasy to correlate between the NW European domain (not to be confused with the true Boreal domain) and the Tethys.

This is known since the first clear definition of the "*Eodactylites*" fauna both by A. Fucini

(1936) and H. Termier (1936; "*D. athleticum*", see Colo 1962), respectively in Sicily (Taormina) and in the Moroccan Middle Atlas. In these areas, these beds have been included initially within the "Domerian" formations. In Peniche (Portugal), R. Mouterde (1955) has classified all the *Couches de passage* (or "Transition beds") into the Domerian in his preliminary paper. However, the Mirabilis beds have been placed by G. Dubar (1942, 1952, see Colo 1962) in the Toarcian. He was the first author to individualize a "Mirabilis horizon" as the "niveau à *Dactylioceras mirabile* Fucini") (for more details: see Guex 1973; Elmi *et al*. 1974). This definition must be retained in agreement not only with the priority rule but also with the general use. A large agreement has followed (see Arkell 1956; Guex 1973). From this date, it was generally admitted that the "Mirabilis horizon" is older than the Semicostatum level of NW Europe. This fact has been clearly established in Portugal (Mouterde 1967). This datum has been stated by several authors but the problem is the correlation of the Tenuicostatum Subzone. It must be emphasized that this question, depending on palaeontological and zonal difficulties, must be separated from the GSSP definition. Similarily, the necessary palaeontological and nomenclatural works on ammonites need to be actively continued.

The correlation problem has been always present. For instance, B. Ouahhabi (1994) stated: *le passage Domérien-Toarcien a fait l'objet de discussions souvent très vives*. For this colleague, "the faunal renewal is not so sharp at the Domerian-Toarcian passage than admitted". In the *Taurومeniceras* levels, clearly Domerian, very rare *Eodactylites* announce the Toarcian fauna (Pinna & Levi-Setti 1971; Jimenez & Rivas 1981; Mouterde & Ruget 1984; Goy *et al*. 1987). We are far from a general agreement as supposed by F. Macchioni (2002).

A first step in the definition of the marker GSSP for the Pliensbachian/Toarcian boundary was reached during the 1996 meeting in Spain and Germany and the 1993 field workshop in Italy. I have organized a first informal pool on the following proposal: "The type locality (GSSP) must be choosen in the Western Tethyan realm". The participation to the pool has been relatively poor but a unanimous consensus was reached on this proposal. This choice has been made because no NW European section seems to be as complete as their Tethyan (or "preatlantic") equivalents. An agreement has been also reached on the biostratigraphic point of view (see below).

It must be underlined that to place the limit under the main *Eodactylites* bed is in agreement with the biologic crisis known to have occurred during these times but its effects are not comparable among the diverse palaeontologic groups. The ammonite fauna sustained a strong change (see Macchioni & Cecca 2002, for a recent revision). The main Domerian markers *(Emaciaticeras, Taurومeniceras, Neolioceratoides,* amaltheids) disappear or diminish strongly *(Lioceratoides)*. *Paltarpites* pass through the limit and *Protogrammoceras (Paltarpites) paltum* Buck. seems to appear slightly before the main *Eodactylites* beds in some localities (Moroccan High-Atlas, Sadki, 1996; personal new data from Mellala, Algeria). The change for the foraminifers, the ostracods, the nannofossils and the brachiopods occurs later, especially at the boundary between the Tenuicostatum-Polymorphum Zone and the Serpentinus-Levisoni Zone (Baloge 1981; Mouterde & Ruget 1984; Boudchiche *et al*. 1987; Alméras *et al*. 1989; Boudchiche & Ruget 1993; Boutakiout & Elmi 1996). Concerning the foraminifers, it is now established (Sebane *et al*. 2006) that the extinction was preceded by a decreasing of the biodiversity and next by a stage of specialization (survival stage) of the fauna. The main extinction occurred during the late Tenuicostatum-Polymorphum and the early Serpentinum-Levisoni zones. However, the impact of the anoxic-hypoxic event must be more precisely investigated.

SOME HISTORICAL CONSIDERATIONS

The Thouars stratotype of the stage bas been extensively worked and protected. The succession of the ammonite biohorizons is very well established, perhaps better than elsewhere. This section is conveniently protected inside a fenced land which is the property of the official local authorities. But the passage Pliensbachian-Toarcian is marked by a strong unconformity and it remains a big question: What is missing at the base of the Toarcian (or at the top of the Pliensbachian)? This long known problem has prevented easy correlations since the beginning of the use of the Toarcian Stage. The lower limit must be selected elsewhere. The recent discovery of *Eodactylites* in the *P. (P.) paltum* bed of Vendée (Bécaud 2006) supports the hypothesis that the Paltum Subzone is roughly equivalent to the Mirabile Subzone.

Similar problems have been encountered in many other classic NW European localities: Anse Saint Nicolas (Vendée, Central Western France) (described by Gabilly 1964, 1976), La Verpillière (Saint Quentin – Fallavier, East of Lyons, South Eastern France) (known since Dumortier, revised by Rulleau *et al*. 2001), Yorkshire (Howarth 1992; see Macchioni 2002, for a formal revision). However, some rare places seem to expose a more continuous record of the transition between the two stages. Some examples will be quoted below.

Anse Saint Nicolas (Bécaud 2006 and unpublished data). A representative of the subgenus *Eodactylites* has been found in the lower bed together with *Protogrammoceras (Paltarpites) paltum*, but the outcrop is rarely exposed during low tides. In the temporary quarries of the nearby locality of Le Bernard, the lowermost Toarcian beds (n° 1-6; Bécaud 2006) contain *P. (P.) paltum* and *Lioceratoides*(?) aff. *serotinus* (Bettoni) and, above, the classic succession of the *Dactylioceras (Orthodactylites)* has been recorded (Bécaud 2006): *crosbeyi*, *tenuicostatum* and *semicelatum* as established in Yorkshire by M. K. Howarth (1973). These data are not sufficient to provide a good GSSP point but they confirm the correlation between the Paltum Subzone of North West Europe and the Mirabile Subzone of the Tethys.

Dotternhausen in South West Germany. The palaeontologic record is poor but this profile is of great value because it shows the succession of *P. (Paltarpites)* aff. *paltum* associated with *D. (Eodactylites)* cf. *polymorphum* (Fucini) above *Pleuroceras* gr. *hawskerense* (Buckman) (Schlatter 1985). The association of *D. (E.)* cf. *simplex* (Fucini) and *Pleuroceras yeovilense* Howarth remains unclear as only one *Eodactylites* has been found in a small temporary excavation inside the quarry that was visited during the 1996 field meeting of the Toarcian and Aalenian Working Groups.

In the French **Causses** (Aveyron department, South France), **Quercy** (South West France) and South East Basin (Elmi 1967; Cubaynes 1986; Morard 2004) the passage is troublesome with non sedimentation and/or erosion gaps. Recent papers (Guex *et al*. 2001; Morard *et al*. 2003) have underlined the importance of these gaps which are widespread in NW Europe but, also, on the seamounts, shoals and basin borders of the Western Tethys (including the Tethyan or Mediterranean Seuil). These gaps followed the neat cooling of the Late Domerian that has been evidenced since a long time (see for instance Lucas 1942, 1952) according to the southward migration of the amaltheids as far as the northern borders of the Sahara craton.

La Almunia de Doña Godina section in the Iberic Range (Comas Rengifo *et al*. 1999) is also important because the first *Eodactylites* bed is well exposed. But the underlying levels are not so well documented. It can be used as a good auxiliary section. Tethyan ammonites occur in this area, which is largely of northwestern European influence. In the same region, the **Almonacid de La Cuba** section has been exhaustively studied by the Madrid team (Goy and coll.) and it gives valuable informations on the palaeomagnetism record. This cooling is now interpreted as linked to a glacial event.

THE TETHYAN DATA

This is not a general review of all the available data but some examples can help to expose the particularities of the Tethyan faunal and sedimentary features.

The now classic profiles of the **Umbria – Marche** in Central Italy generally illustrate a clear cut transition between the limestones of the *Corniola* facies (including the *Corniola nodulare*) and the more marly overlaying deposits (Monte Serrone or Sentino Formations; *Umbro-marchiggiano rosso ammonitico*). But, as at La Almunia and in numerous Tethyan localities, the transition between the Domerian and the Toarcian (the latest marked by the *Eodactylites* "explosion") occurs within the limestones, the faunal limit being indicated by the change from a "Domerian" dominated fauna *(Emaciaticeras, Tauromeniceras)* to a dactylioceratid dominated fauna. However, there are also several remaining problems and the interpretation of the boundary by P. Faraoni *et al*. (1994) must be discussed. The first *Eodactylites* recorded at Colle d'Orlando can be older than the subgenus "explosion".

More information are needed for the Dinarids where M. Gakovic (1986) has individualized a Late

Domerian Schopeni Zone, tentatively correlated with the Hawskerense Zone of NW Europe but it includes an Upper Polymorphum Subzone according to the lithologic criterion.

Morocco is the best historical country to define the limit especially in the Middle Atlas where Dubar has established his initial definition. In this region, the best section presently known is the **Ahermoumou (=Ribat Al Khayr)** profile (Guex 1973; Benshili 1989) but the lower part of the profile is often covered. Talghemt (Central High Atlas) is one of the the best Moroccan examples. The last bed of the Ouchbis Formation (alternating marls-marly limestones) as described by D. Sadki (1996, n°TdB30) contains *Eodactylites, Paltarpites* and a questionable *Hildaites*. Under this bed, the classic "Tethyan" fauna of the Late Domerian occurs. The following formation (Tagoudite Fm.) begins by thick silty marls with resedimented oolite supplies. It is poorly fossiliferous and, upwards, ammonites become relatively frequent only in the Bifrons and Gradata zones (calciturbidites and laminites). These perturbations and the magmatism of the area are unfavourable for the selection as a reference point. Other good sections exist but they are situated in remote regions like the Eastern High Atlas (**Al Hallouf Çghir**, North of Jebel Bou Dahar; **Boulbourhal**, West of Jebel Bou Arouss, for instance). In all these localities, the *Eodactylites* bed is situated at the top of the calcareour Ouchbis Fm. and under the marls of the Tagoudite Fm. However, there are numerous outcrops exposing the Pliensbachian-Toarcian transition in Morocco.

Out of the Atlas Domain, a good profile has been described by B. Ouahhabi (1994, p. 234) at Beni Hammad, in the Beni Snassen Mountains (North Eastern Morocco). It can be a valuable replacement solution.

Mellala in North Western Algeria (Traras Mountains). The section described by M. Ameur (1999) is an exceptional outcrop exposing the limit within an homogenous succession of alternating hemipelagic marls and marly limestones (Benia Formation). The section is located in a small (kilometric) but strongly subsident basin ("umbilicus" *sensu* Elmi; see Elmi *et al*. 1998). It has been newly studied by an international team (Tchenar and Sebane, Oran; Marok, Tlemcen; Bodergat, Elmi and Mattioli, Lyon) and some results are summarized in an abstract of the 7th International Congress on the Jurassic System (Elmi *et al*. 2006a, b).

Djebel Nador (Benia) section in the transition zone between the Tlemcenian and Atlasic domains (see Elmi *et al*. 1974; Baloge 1981 and Sapunov 1974 in Rakus 1995, for a rapid description) is a very good locality but it has not been recently accessible. Sections in the Ksour Mountains (Saharian Atlas in the eastern continuation of the High Atlas) are of interest for the *Eodactylites* fauna but the faunal turnover is not very well documented (Bassoullet 1973; Elmi *et al*. 1974; Mekahli 1998).

SOME PROBLEMS AND COMMENTS

This short account summarizes several difficulties presented by the definition of the Pliensbachian/Toarcian boundary. We can presume that the differences between NW Europe and Tethys are multicausal and due to palaeobiogeographic segregation, dynamics (tectonic evolution of palaeoreliefs) and eustatic changes of sea level (glacioeustatism and tectonoeustatism).

1. Transgressive events following the Late Pliensbachian regression or shallowing. These events are not coeval with the proposed boundary and their worldwide synchronism is not proved.
2. Tectonic decoupling between subsiding basins and uplifting shoals.
3. Praeaccretionnal rifting preceding the Atlantic oceanic opening.
4. Possible influence of the late Karroo volcanism as supposed by J. Pálfi and P. Smith (2000). The supposed role of forest fires has also been evoked.
5. Faunal biogeographic segregation in the ammonite distribution, even if it has been less global than supposed.
6. Difficulty to place the precise apparition of many species of dactylioceratids and harpoceratids.
7. Some authors (for instance Venturi, personal communication) underline the importance of the hypoxic/anoxic event (Jenkyns 1988). It is a dynamic and climatic phenomenon of tremendous importance but it cannot be considered as a reliable chronologic marker. Its diachronism (or the diachronism of its recording) is possible. Some authors suppose

the existence of several anoxic levels during the Levisoni Zone (Jimenez *et al.* 1996). Indeed, this important event cannot be taken in account for the designation of the GSSP because it has occurred neatly earlier than the debated limit.

8. Possible glacial consequences of the cooling: inlandsis? altitude glacier?
9. Many examples of the early appearance of *Eodactylites* (including *pseudocommune, simplex, mirabile, pseudocrassulosum…*) have been established but often in unclear conditions (condensation, section more or less well sampled). The latest occurrences of Tethyan Domerian groups are also unclear. These problems, compound with sedimentary unconformities, have led P. Choffat (1880), then R. Mouterde (1955), to use the expression *Couches de passage* ("passage beds"). In Peniche, the proposed GSSP bed (n°15e, see below) contains *Neolioceratoides ballinense* (Haas), *Tiltoniceras capillatum* [Denckmann (= *T.* aff. *antiquum*?)], *Protogrammoceras (Paltarpites)* cf. *paltum* (Buckman) associated with *D. (Eodactylites) simplex* (Fucini), *D. (E.) pseudocommune* (Fucini), and *D. (E.) polymorphum* (Fucini) (Choffat 1880; Mouterde 1955; Elmi *et al.* 1996). Mouterde (1955) has even quoted "*Tauromenia* sp."

A main contribution in the reconstruction of the faunal succession and turnover has been given by M. Rakus (1995) who has discovered the coexistence of *D. (E.) simplex* and *D. (E.) pseudocommune* with *Pleuroceras hawskerense* in the Western Carpathians. His conclusion (p.169) is noteworthy: "the first *Dactylioceras* appear in the Upper Domerian… (but) …their mass occurrence should, however, be identified with the Lower Toarcian Tenuicostatum Zone". I agree with this remark. But we can also present the question in an other way: did the first *Eodactylites* appear in the Late Domerian or did the latest *Pleuroceras*, *Emaciaticeras*, *Tauromeniceras* keep up to the beginning of the Toarcian?!

These problems are linked to the evolution of the biologic associations and to the tectono-sedimentary dynamics of the basins. We need a good, even arbitrary, reference marker to accurately appreciate these evolutions. A GSSP is one kind of these markers and it must be documented by a faunal association (assemblages or "fauna" of some French authors; see Elmi *et al.* 1974, for the Algerian Toarcian).

It is also difficult to recognize the Late Pliensbachian (Domerian) even in NW Europe because the Hawskerense Subzone (probable equivalent of the Tethyan Elisa Subzone) is often badly documented. This time-interval corresponds to a largely widespread gap (Guex *et al.* 2001, for a recent review). In transitional domains (Portugal, Moroccan Middle and High Atlas, also in Western Algeria), *Pleuroceras solare* (Young & Bird) is often quoted below the Emaciatum-Elisa fauna. But the last species, *Pleuroceras hawskerense* (Philips) seems to be absent at the exception of the Slovakian specimen cited by M. Rakus (1995) on the northern rim of the Tethys. In my opinion, the Elisa and Hawskerense Subzones are roughly contemporaneous, but their boundaries can be slightly diachronous. This correlation problem will remain whatever the GSSP selection.

We must also take in account the sequence stratigraphy data. The main Toarcian sequence (3rd or 2nd order) of the Lusitanian basin begins apparently after the *Eodactylites* bed (between Duarte's MD and MSTP 1; Duarte, 1995). In several localities (in Portugal as well as in North Africa), the "Couches de passage" or their equivalents can be interpreted as a condensed level. The deepening and the transgressive trends seem to have often begun during the Emaciatum Zone in the Tethyan realm.

THE PENICHE SECTION: A RAPID SURVEY

The Peniche outcrops are situated along cliffs bordering the Atlantic coast in the southern part of the North Lusitanian basin. The succession is illustrated in Fig. 1. The so-called "Domerian sequence" (Lemede Formation) crops at the top of a cliff. Its upper part is made of the *Couches de passage* (n°15) that are a condensed interval indicating the sedimentary crisis of the Late Pliensbachian. They have yielded a continuous and diversified fossil material, which has been strongly collected. Shells are often accumulated and gathered, forming irregular heaps. Some belemnite accumulations have been interpreted as coprolites remnants. *Plicatula* and serpulids are fixed on ammonite shells or casts.

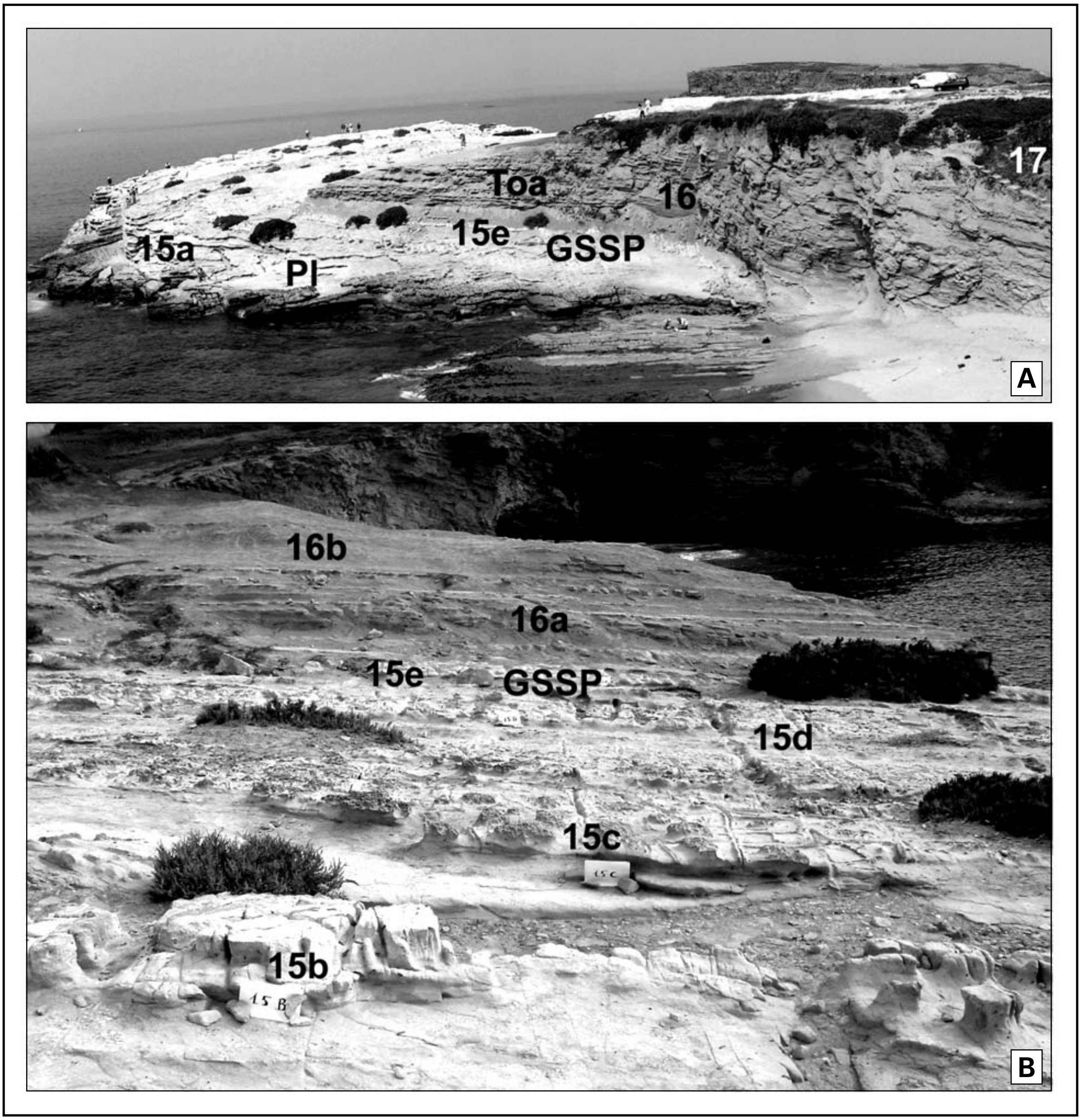

Fig. 1. A – General view of the section of Ponta do Trovão, Peniche (Portugal). Pl – Pliensbachian; Toa – Toarcian; GSSP – proposed Global Stratotype Section and Point for the Toarcian; 15a-e – *Couches de passage* (Transition beds, Lemede Formation); 16 – base of Carbo Carvoeiro Fm., Semicelatum Subzone (St1 3rd order sequence, Duarte 2004); 17 – base of Levisoni Zone (beginning of St2).
B – Detail of the *Couches de passage*: 15b – *Plicatula* marly limestones, 15c-d – *Tauromeniceras* beds, 15e – *Eodactylites* bed, 16a – marls with *Dactylioceras (Orthodactylites) crosbeyi* (Simpson), 16b – first occurrence of *D. (O.) semicelatum* (Simpson).

The *Couches de passage* indicate a low sedimentation rate and they are capped by a hard ground (top surface of level 15e; D5; DT1, Duarte 1995, 1997, 2003). The last bed (15e) has yielded a characteristic association of dactylioceratids that is classically interpreted as marking the beginning of the Toarcian. In consequence, the chronostrati-graphic boundary differs from the lithologic one, the latter being situated between the *Couches de passage* (levels 15, topmost of Lemede Formation) and the base of the Cabo Carvoeiro Formation (level 16, base of Cabo Carvoeiro, 1st member; =*Couches à Leptaena*).

The biostratigraphic boundary is located within a succession showing a progressive sedimentary evolution, without noticeable interruption. The time recording can be considered good enough to give an international reference.

Bed 15a. *Canavaria* bed, slightly nodular and heavily bioturbed. *Canavaria zancleana* (Fucini), *Emaciaticeras* and *Lioceratoides*. Emaciatum Subzone.

Bed 15b. *Plicatula* rich marly micrites.

Beds 15c-d. *Tauromeniceras* bed. *Tauromeniceras* associated with *Lioceratoides*, *Tiltoniceras* and *Protogrammoceras (Paltarpites)*. Fossil accumulation, bioturbation and a possible firm ground at the top. On the contrary, the boundaries between 15a, b and c are more gradual.

Bed 15e. *Eodactylites* bed. First local occurrence of these dactylioceratids associated with *Paltarpites* but (Fig. 2) also with *Tiltoniceras* and *Lioceratoides*. This bed marks the beginning of the Polymorphum Zone (Mirabilis horizon or Simplex Subzone) of the Tethys. It can be roughly correlated with the Paltum Subzone of NW Europe. The association of *D. (E.) pseudocommune* and *P. (P.) paltum* is also known in Yorkshire (Howarth 1973, 1992).

An important feature of the Peniche profile is that the superposed marls and shales (base of Cabo Carvoeiro Fm.; beds 16) yield several pyritous ammonite assemblages. The first is the *D. (Orthodactylites) crosbeyi-clevelandicum* one (bed 16a), indicating that the *Eodactylites* have existed before the main arrival of the *Orthodactylites* and that their apparent geographic segregation is not only the result of a palaeobiogeographic differentiation. Similar observations have been realized in the Algerian section of Mellala (Elmi *et al*. 2006a, b). In the meter overlying the Crosbey level, rare specimens can be temptatively compared with *D. (O.) tenuicostatum* (Young & Bird). *D. (O.) semicelatum* (Simpson) occur in situ above. The levels equivalent to the upper part of the Polymorphum Zone (above the Mirabile horizon) were classified as Semicelatum Subzone by early authors equivalent to the Madagascariense Subzone of J. Guex (1973).

In Peniche, the beds 16 finish under the appearance of coarse quartz supplies dated to the earliest Serpentinus/Levisoni Zone (beds 17).

PRELIMINARY CONCLUSIONS

The following agreements have been reached during the preliminary meetings:

1. The *Eodactylites* main horizon must be the marker fauna [*D. (E.) polymorphum* group, including simplex]. It must be nderlined that it is not the FO of the dactylioceratids.
2. The marker bed must be defined within the Tethyan realm.
3. Peniche is the best section presently available.

Below, a summary of interesting and important results achieved during the Peniche session both in the field and during the discussion is given

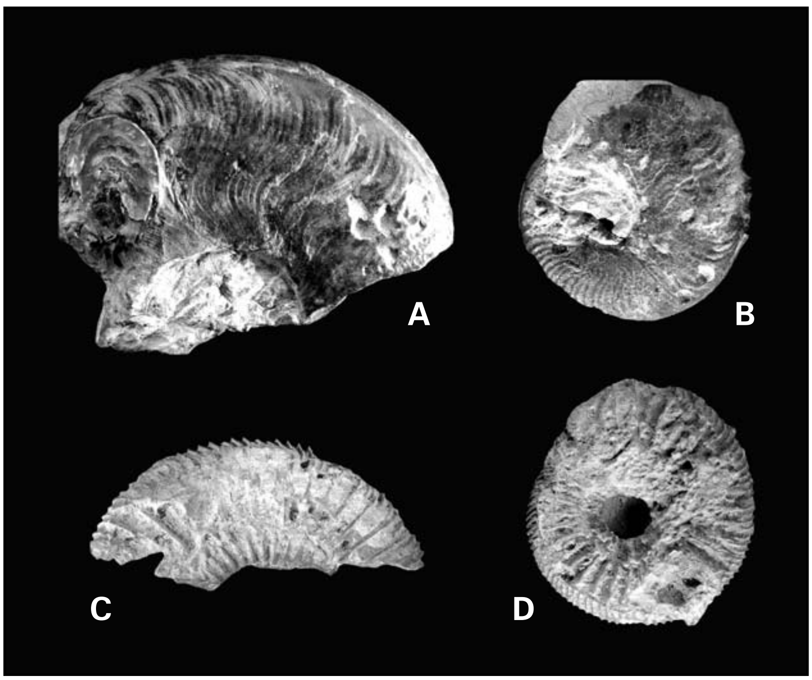

Fig. 2. A-B – *Protogrammoceras (Paltarpites)* cf. *paltum* (Buckman); C-D – *Dactylioceras (Eodactylites) polymorphum* (Fucini). Peniche, bed 15e. Natural size. Photographs by S. Mailliot, S. Elmi and Muséum d'Histoire naturelle de Lyon.

(cf. References of the papers included in the Peniche volume).

1. Agreement on the position of the PLIensbachian/TOArcian boundary that will be placed under the bed 15e, last bed of the *Couches de passage* ("Transition beds"). This bed marks the massive appearance of the *Dactylioceras (Eodactylites)* associated with *Paltarpites*. The unitarian association methods (Besson 1998) confirm that the *Eodactylites* assemblage is a reproductible unit badly represented in NW Europe but neatly distinct of the following *Orthodactylites* assemblages.
2. Agreement on the proposal of the Peniche section (Ponta do Trovão) as GSSP candidate.
3. The participants in the field-meeting have collected in situ the main components of the macrofauna. New sampling for micro- and nannopalaeontology and for geochemical analysis has also been made.
4. The succession of a basal level with *Eodactylites* (15e) and of a succeeding level with *Dact. (Orthodactylites) crosbeyi* has been confirmed. The palaeontological study is however delicate owing to the small size of the pyritous casts. These forms have been attributed to *Coeloceras* sp. aff. *dayi* (Reynès) by Mouterde (1955, p. 25). New data from sections in Vendée (Western France on the border of the Armorican Massif near Thouars; Bécaud, in press) confirm this observation. Similar results have been obtained at Mellala (NW Algeria, Traras Mountains). The individualization of a Crosbeyi horizon can be useful; it corresponds roughly to the Clevelandicum Subzone of Yorkshire. *D. (O.) crosbeyi* is used here as an informal index to avoid any confusion with the NW European standard. It must be underlined that the use of the Tenuicostatum horizon (or Subzone) is difficult and, even, unrealistic in the Tethys because the index-species is rare or absent.
5. The field measurements given by the successive authors have been checked (comparison and correlations between the thicknesses numberings given by Mouterde 1955, Duarte 1995, 2003, Wilson, Elmi *et al*. 1996. The Mouterde's numeration will be retained but it must be considered that the thickness of the upper part of 16 has been exaggerated (6m instead of 9m for the levels 16c/d (Mouterde 1955 = 16 E/G, Elmi *et al*. 1996). This correction has no consequence for the GSSP position. The new and precise observations will be reported in indicating their position above the base of 16a (Mailliot, Mattioli, Pittet, Suan in progress).
6. Belemnite rostrums are abundant in the "Transition beds" (=*Couches de passage*) (15a-15e). A geochemical study of Sr is in progress across the boundary (Hesselbo, Jenkyns, Oliveira).
7. Palaeomagnetism measurements have been disappointing (Duarte). The Almonacid de la Cuba section in the Iberic Ranges has been proposed as complementary reference (Goy and the Madrid team). The biostratigraphic correlation with Peniche is good.
8. Ammonites coming from levels 15 and 16 (across the boundary) have been figured in the guide-book (Elmi, Mouterde, Rocha; Mouterde's collection). This figuration will be extended in the definitive report.
9. The general data on ammonite faunas have been synthetized. The results obtained in Western France (Vendée) and in Western Algeria (Mellala) allow to have a better comprehension of the correlations between the Tethyan and the NW European faunas and succession. Frequent absence of *Eodactylites* in the NW European province has often been credited to provincialism. In fact, it is often due to stratigraphic gaps that are known for a long time (studies of Buckman, Howarth, Gabilly and others). A palaeobiogeographic gradient existed. The relative abundance of *Eodactylites* is feebler in the North but there is no true segregation. Moreover, the apparent differences are emphasized by a general fall of the biodiversity, especially for the ammonites, near the PLI/TOA boundary. The thickest sections (Peniche, Mellala and several sections in Morocco) indicate also that the paltus group (*Paltarpites* or *Protogrammoceras*) has appeared before the mass development of *Eodactylites*. The *Eodactylites* marker is of primordial importance because it is known in Chile and North America. The citation of the group in Siberia must be confirmed.
10. Nannofossils (Mailliot, Mattioli, Oliveira, Perilli) and ostracods (Bodergat, Cabral, Pinto), indicate that the choosen PLI/TOA boundary

does not correspond with a special event in the history of these groups, a remark already made for the foraminifera (Mouterde & Ruget 1984). The foraminifera are dominated by "Domerian" species until the end of the Crosbeyi horizon. Nannoplankton is in a diversification phase starting during the Late Domerian and ending in the Early Toarcian. A new approach for the Foraminifera will be made by Hart.

11. The "anoxic" (or hypoxic) event occurred later than the boundary. The duration of the separating interval is that of an ammonite zone. It took place at the beginning of the Serpentinum/Levisoni Zone. It is coeval with an important change or turnover of the microfauna and microflora. They cannot be used to determine the GSSP. Obviously, the hypoxic maximum (TOC maximum, Duarte) occurred after the specialization phase known in the brachiopods (small specimens of the "*Koninckella*" fauna = classic "*Leptaena* fauna"). This brachiopod-event happened generaly at the beginning of the Semicelatum Subzone (Crosbeyi horizon). However, it began earlier (Elisa Subzone) in some North African basins (Elmi *et al*. 2006a, b).
12. The "Transition beds" can be interpreted as a condensed interval, following the general faunal impoverishment during the Solare Subzone. The major lithological change (= first Toarcian flooding of Duarte and coll.) is found at the base ot the overlying marls (16a; base of the Crosbeyi horizon). Cyclic interpretation of the Peniche section is in progress (Pittet and coll.).
13. The organization of the meeting was perfectly assured by the Universidade Nova de Lisboa (CIGA) and by the Universidade de Coimbra (GC/UC) thanks to Prof. Rocha and Doct. Duarte. 30 specialists from 5 countries have participated. This work has been supported by the project Bioscales (POCTI/36438/PAL/2000).
14. Protection of the site will be secured in good conditions. The town of Peniche is highly interested in the GSSP project. We thank the town council for its help and for the very friendly reception.

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