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The Cabo Mondego section as a possible Bajocian boundary stratotype

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Abstract. – The Cabo Mondego section situated on the Atlantic coast, 160 km north of Lisbon, presents characteristics of a good boundary stratotype section (G.S.S.P.).

The outcrop is easily accessible and well exposed near the sea where the erosion process is continuous. The section shows a thick succession of clay limestones with a regular sedimentation and belongs to a sedimentary basin whose palaeogeography is already well established.

The variety and abundance of cephalopods provide good correlation between the submediterranean and the subboreal provinces.

This section has already been considered during the discussion on the definition of the boundary stage (Orsay meeting, 1970).

Key words: Aalenian - Bajocian - Boundary stratotype - Ammonites Biozones - Cabo Mondego - Portugal.

Riassunto. *La sezione di Cabo Mondego, possibile stratotipo del limite inferiore del Baiociano.* – La sezione di Cabo Mondego, ubicata sulla costa atlantica, 160 Km a Nord di Lisbona, possiede le caratteristiche tipiche di una potenziale sede di definizione dello stratotipo da limite inferiore (G.S.S.P.) del Baiociano.

L'affioramento è facilmente accessibile e ben esposto lungo la riva del mare dove i processi di erosione sono continui. La sezione è costituita da una spessa successione di calcari e marne con una sedimentazione regolare ed è inserita in un bacino di sedimentazione la cui evoluzione paleogeografica è già ben definita.

La varietà e l'abbondanza di cefalopodi forniscono la possibilità di una buona correlazione tra le provincie submediterranea e subboreale.

Questa sezione è inoltre già stata presa in esame alla data della discussione per la definizione del limite inferiore del Baiociano (meeting di Orsay, 1970).

Parole chiave: Stratigrafia, Baiociano, Stratotipo, Limite inferiore, Ammoniti, Portogallo.

(1) Considering the importance of this section all colleagues particullary concerned with methodologies not yet developed are formally invited to participate in this research project. For that purpose they are asked to contact any of the portuguese co-authors of this paper.

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1. – THE CABO MONDEGO SECTION

The Cabo Mondego section is situated on the Portuguese Atlantic coast 160 km north from Lisbon and 7 km northeastern both from Mondego river mouth and Figueira da Foz (Fig. 1)

It presents the features of a good global boundary stratotype.

The section is easily accessible providing good exposition along cliffs continuously renewed by marine erosion.

It presents a regular alternation of limestones and marls whose sedimentological study was already done. The limestones and marls integrate a continuous series of marine sediments ranging from Upper Toarcian to Middle Callovian with a thickness exceeding 400 m.

These open sea deposits belong to a sedimentary basin with a well established stratigraphy and palaeogeography; a detailed research work in this field is being carried out by Portuguese geologists.

Stratigraphical and paleontological works exclusively concerning Aalenian - Bajocian boundary at the Cabo Mondego section are few and relatively recent. The first general work with a reference to this «classic» section, not including the Aalenian-Bajocian boundary beds, was published by P. CHOFFAT (1880, p. 67). Later the cartography of the

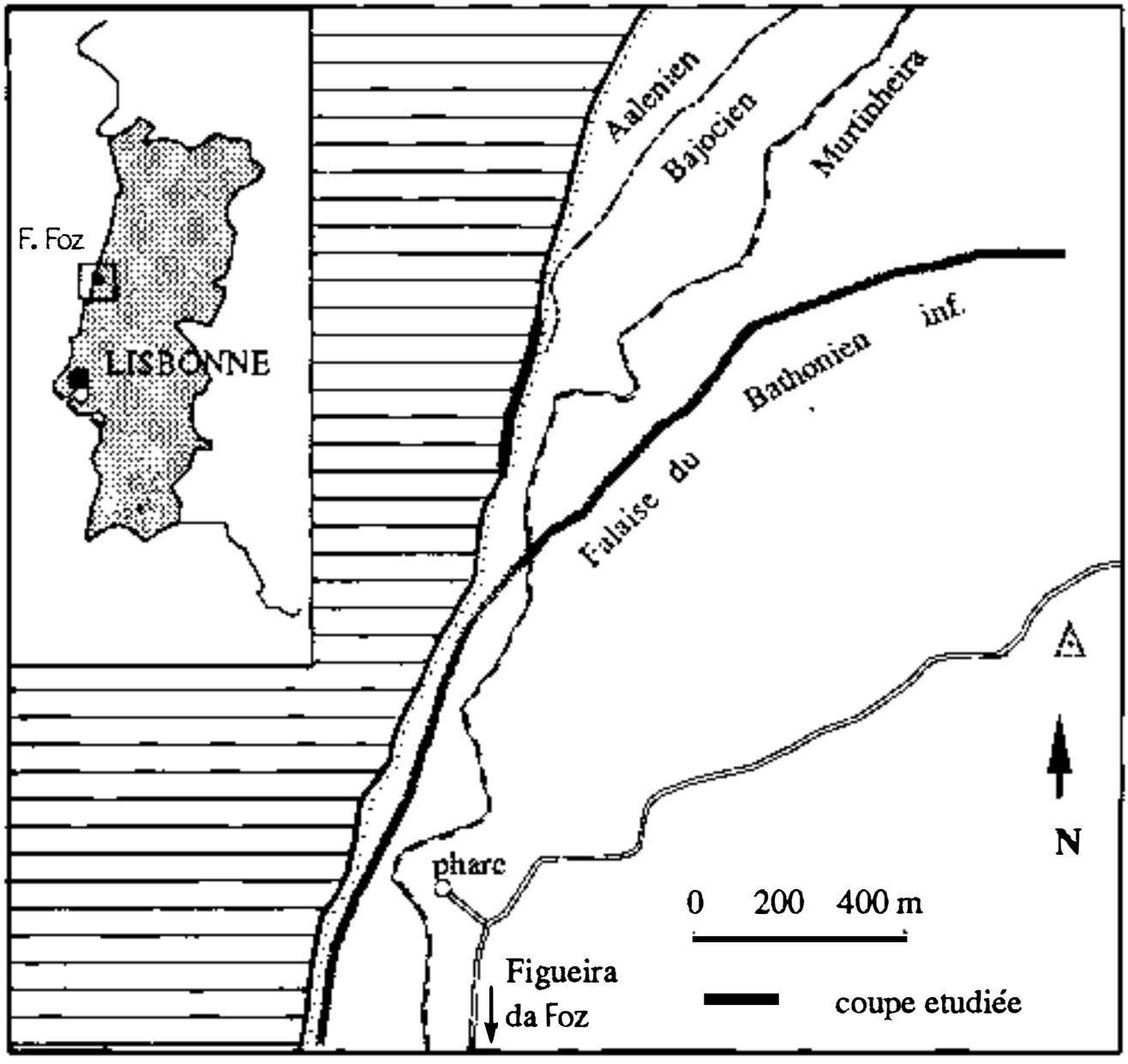

Fig. 1. Localization of Cabo Mondego Section.

boundary for all the Baixo Mondego region is presented by the same author (CHOFFAT, 1927, pl. I).

The first description of Aalenian - Bajocian boudary section at the Cabo Mondego was published thirty years later by C. PERROT & R. MOUTERDE (1957). The location of the boundary is neither discussed in detail nor correctly placed; the 15a, 15b and 15c beds are referred only as «... franchement bajociennes» (*op. cit.*, p. 355). This section is later reconsidered by C. RUGET - PERROT (1961, p. 26) who admits that...«le passage Aalénien-Bajocien se fait au contact de calcaire schisteux à nombreux *Haplopleuroceras* et d'une grosse dalle de calcaire également à faune d'*Haplopleuroceras* et de *Sonninia*(?)»; accordingly the boundary would be placed between beds 13b (1,25m thick) and 14 (0,50m thick) of the previously published work (PERROT & MOUTERDE, 1957, p. 354).

At the 2nd Jurassic Colloquium (Luxembourg), a brief reference to the Cabo Mondego section was made by G. DUBAR *et alli* (1967, p. 404). According to these authors (p. 407) «... la meilleure solution pour les régions étudiées ...» would be to place «... la limite supérieure de l'Aalénien ... au dessous des niveaux à *Toxolioceras* et à *Braunsina*», that is, between beds 12 and 13 mentioned by C. PERROT & MOUTERDE (1957).

The Cabo Mondego section is resumed later by R. MOUTERDE, C. RUGET & B. CALOO (1972) who formally present the Aalenian - Bajocian boundary problem. It is then placed ... «entre la disparition des *Graphoceras* s.s et l'explosion des *Toxolioceras* - *Reynesella*» (*op. cit*, p. 67), that is, between beds AB 4 and AB 10. Considering the section in its global extension the boundary placement in bed AB 8 is suggested although it has been located between beds AB 6 and AB 7 in ammonites distribution table (*op. cit.*, tab. I, p. 64).

D. SADKI (1984) has recently published a systematic study concerning a few Lower Bajocian ammonites of the referred section. Similar works have also been presented during the 2nd International Symposium on Jurassic Stratigraphy in Lisbon (LOPEZ, MOUTERDE & ROCHA, 1988; HENRIQUES, SADKI & MOUTERDE, 1988), as well as a biozonation essay, particulary concerning the Aalenian - Bajocian boundary problem (LOPEZ, HENRIQUES, MOUTERDE, ROCHA & SADKI, 1987), which is then defined by the occurrence of oldest representatives of *Hyperlioceras* - *Toxolioceras* group (bed AB 9).

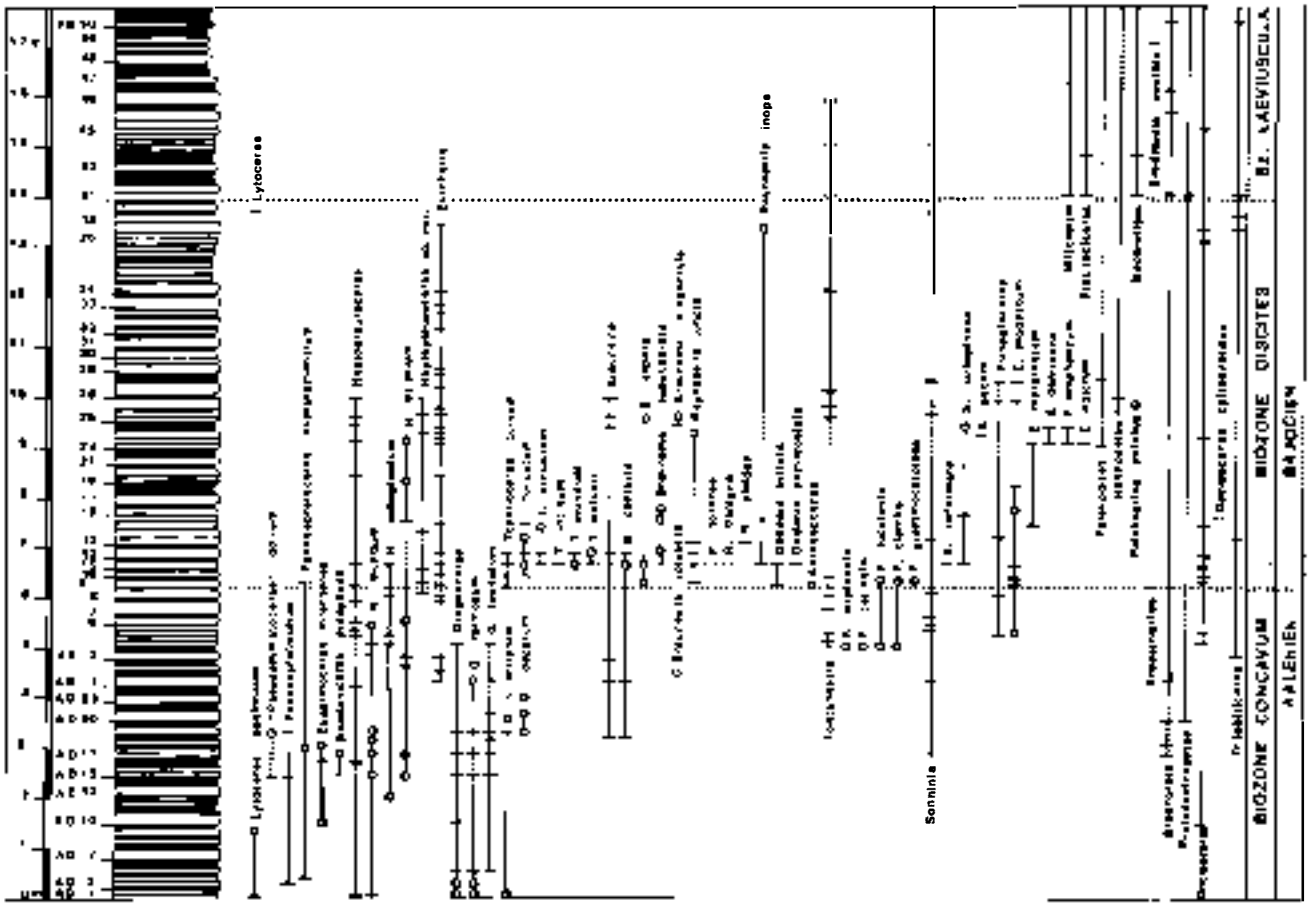

Fig. 2. – Ammonites distribution through Aalenian-Bajocian boundary of Cabo Mondego section.

Until now there is pratically no age indication based on other fossil groups except ammonites.

Two different samples for magnetostratigraphical purposes have been collected, but they have not provided significant results. The study of new samples is in progress.

The Cabo Mondego section supplies an abundant, varied and well preserved cephalopods fauna (Fig. 2). It includes forms with West-European (many Graphoceratids, Sonninids, ...) and Mesogean (Hammatoceratids, *Haplopleuroceras*, *Zurcheria*, *Fontannesia*, *Bradfordia* - *Protoecotraustes*, *Docidoceras* - *Trilobiticeras*, ...) affinities as well as some rare species (*Asthenoceras*, *Praestrigites*,...). A few species referred in South America, such as *Pseudaptetoceras* gr. *klimakomphalum* (VACEK) are also represented. This diversity may provide an easy global correlation.

Last *Graphoceras* s.s. (*G. formosum*, *G. limitatum*) occur up to beds AB 4 and AB 5, whereas the oldest representatives of *Hyperlioceras* (*Toxolioceras*) group occur firstly in AB 9 and AB 10 *H. (T.) curvum* followed by *H. (T.) furcatum*; they are rather abundant in AB 11 providing many species like *H. (T.) arcuatum*, *H. (T.) mundum*, *H. (T.)walkeri*. *H. discitiforme* appears slightly above (at CA 5 = AB 14 and AB 15 levels).

Braunsina representatives occur below and above the limit, together with some microconch forms which may correspond to *Graphoceras* s.s. or *H. (Toxolioceras)*; beds AB 9 and AB 14 contain typical forms of Discites Biozone such as *B. aspera* and *B. subquadrata*, while representatives of *Reynesella* and *Oedania* are only found above bed AB 9.

Taking essentially Graphoceratids into account, Aalenian - Bajocian boundary must be placed below bed AB 9 and above AB 5. Additional work based on the available paleontological and sedimentological data is required to define accurately this boundary position.

Considering the other ammonite families it can be concluded that most of Phymatoceratidae are scarce from 2-3 m below the boundary; their last representatives occur in beds AD 17, 18 and 19; only one variety of *Euaptetoceras klimakomphalum* remains up to bed AB 9 which is considered as belonging to the Discites Biozone.

Of great interest are Erycitidae, in particular *Haplopleuroceras* and *Zurcheria* representatives. *Haplopleuroceras* representatives are known below and above the boundary, but *H. mundum* occurs only in Concavum Biozone. *H. spinatum* persists just up to the basal Discites Biozone; *H. eximium* although more abundant in Discites Biozone are found in both zones. *Zurcheria* s.l. (macroconchs and microcochs) occur together with *Graphoceras limitatum* and *Toxolioceras*.

On the other hand, Sonninids appear already in the last beds of the Concavum Biozone; some doubtful juvenile forms occur in AD 17 and AB 1, while from AB 4 upwards only typical forms occur. Some new species occur in AB 12 as well as in AB 22 where the oldest representatives of *Pelekodites* are represented.

Of particular interest is the presence of the typical cadiconic *Docidoceras* - *Trilobiticeras* (family Otoitidae). It is at least as old as *Graphoceras limitatum* BUCK. and *Pseudaptetoceras* gr. *klimakomphalum* (VACEK).

Fontannesia representatives are relatively frequent among the limit beds. A single specimen of *Asthenoceras* was found.

Bradfordia - *Protoecotraustes* representatives occur already on the upper part of Concavum Biozone, being much more abundant in the Lower Bajocian.

The Cabo Mondego main representatives ammonites are presented in Plates 1, 2 and 3.

Belemmites and brachiopods such as *Z. (Zeilleria) sharpei* (CHOFFAT) are also present. The study of microfauna data is in progress.

There are some complementary sections in the proximity of Cabo Mondego, along Quiaios - Serra da Boa Viagem road, as well as Brenha road and Alhadas de Cima.

2. – CONCLUSIONS

This paper presents the state of knowledge on the Cabo Mondego Aalenian - Bajocian boundary. Although its study is not yet finished, it may be considered as the best known section for the definition of that boundary stratotype (1).

Some complementary studies (paleontological, micropaleontological, paleoecological, stratigraphical, paleomagnetical, sedimentological and others) are being developed to corroborate the arguments for a future definitive proposal to consider the Cabo Mondego section as the Aalenian-Bajocian Global boundary Stratotype Section and Point (GSSP).

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PLATE 1 (All specimens reproduced in natural size. They are from MOUTERDE's Collection).

Fig. 1ab: *Euhoploceras* sp. group *modestum* (BUCKMAN) bed AB 6-9
Fig. 2: *Zurcheria* s.p. bed AB 8-9
Fig. 3: *Euhoploceras* sp. bed AB 8
Fig. 4ab: *Praestrigites* sp. bed AB 9
Fig. 5: *Haplopleuroceras mundum* (BUCKMAN) bed AB 4
Fig. 6: *Fontannesia* aff. *carinata* (BUCKMAN) bed AB 4
Fig. 7: *Fontannesia* aff. *luculenta* (BUCKMAN) bed AB 4
Fig. 8ab: *Asthenoceras* sp. bed AB 9
Fig. 9: *Graphoceras limitatum* (BUCKMAN) bed AB 4
Fig. 10: *Euaptetoceras* aff. *infernense* (ROMAN) bed AD 10
Fig. 11: *Euhoploceras* sp. bed AB 4
Fig. 12: *Bradfordia liomphala* (BUCKMAN) bed AB 19
Fig. 13: *Protoecotraustes* sp.+*Braunsina* or *Graphoceras* microconch sp. juv. bed AD 20
Fig. 14: *Graphoceras limitatum* (BUCKMAN) bed AD 20

PLATE I

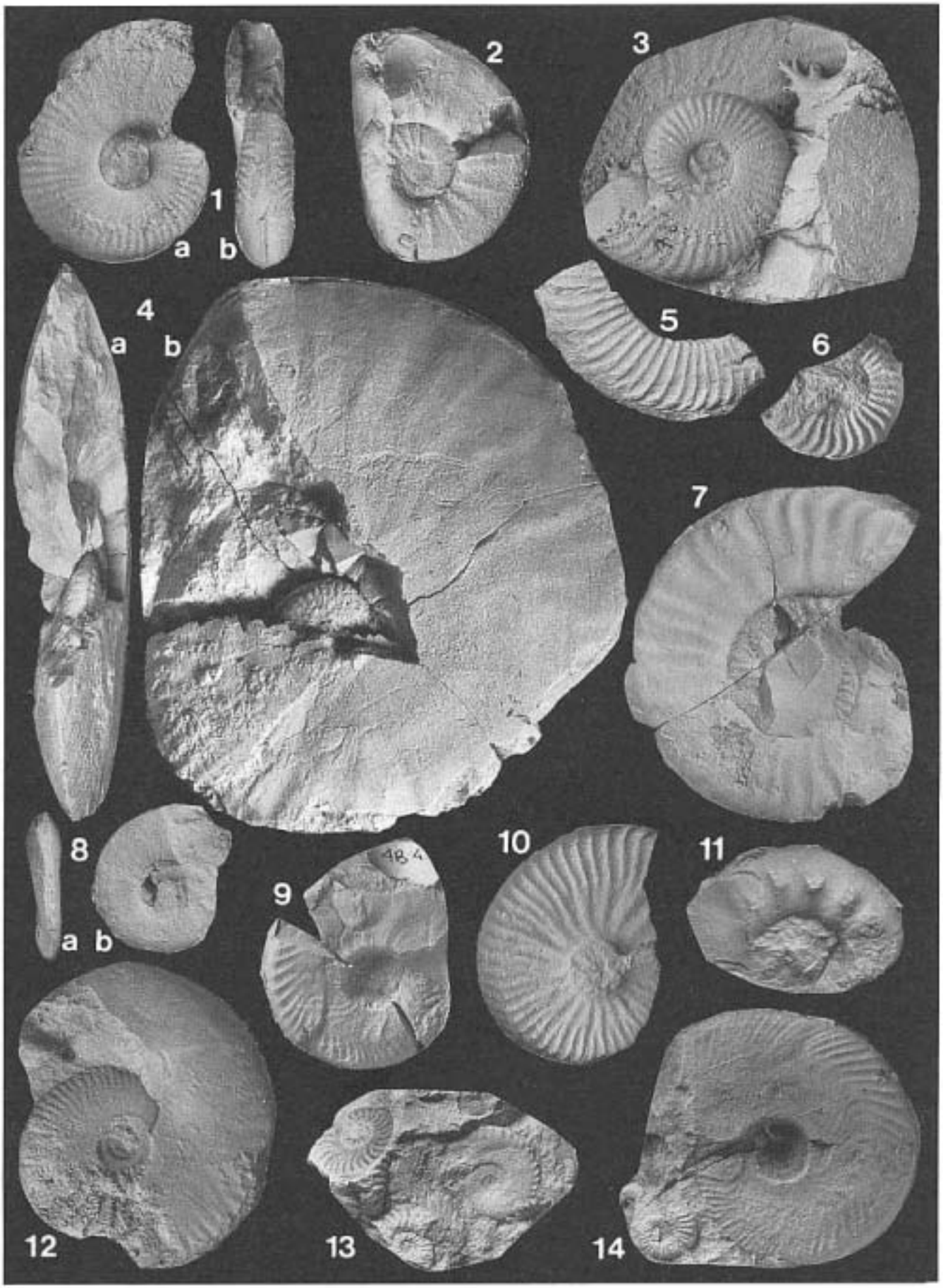

PLATE 2 (All specimens reproduced in natural size. They are from MOUTERDE's Collection).

Fig. 1 : *Hyperlioceras (Toxolioceras)* aff. *curvum* (BUCKMAN) bed AB 14
Fig. 2 : *Euhoploceras marginatum* (BUCKMAN) bed AB 14
Fig. 3 : *Euhoploceras* sp. bed AB 12
Fig. 4 : *Braunsina subquadrata* (BUCKMAN) bed AB 12
Figg. 5, 6ab : *Hyperlioceras (Toxolioceras) curvum* (BUCKMAN) bed AB 12
Fig. 7, 8, 9, 13ab : *Hyperlioceras (Toxolioceras)* cf. *mundum* (BUCKMAN) bed AB 11
Fig. 10, 12 : *Braunsina subquadrata* (BUCKMAN) bed AB 11
Fig. 11 : *Braunsina* ? sp. bed AB 11
Figg. 14, 15, 16 : *Braunsina* sp. gr. *aspera* ? (BUCKMAN) bed AB 10
Fig. 17 : *Hyperlioceras (Toxolioceras)* aff. *curvum* (BUCKMAN) bed AB 9
Fig. 18 : *Euhoploceras* sp. (inner whorls of *E.* (?) *marginatum* (BUCKMAN) bed AB 10
Fig. 19 : *Pseudaptetoceras* cf. *klimakomphalum* (VACEK) (interpreted by WESTERMANN as *Puchenquia*) bed AB 9

PLATE 2

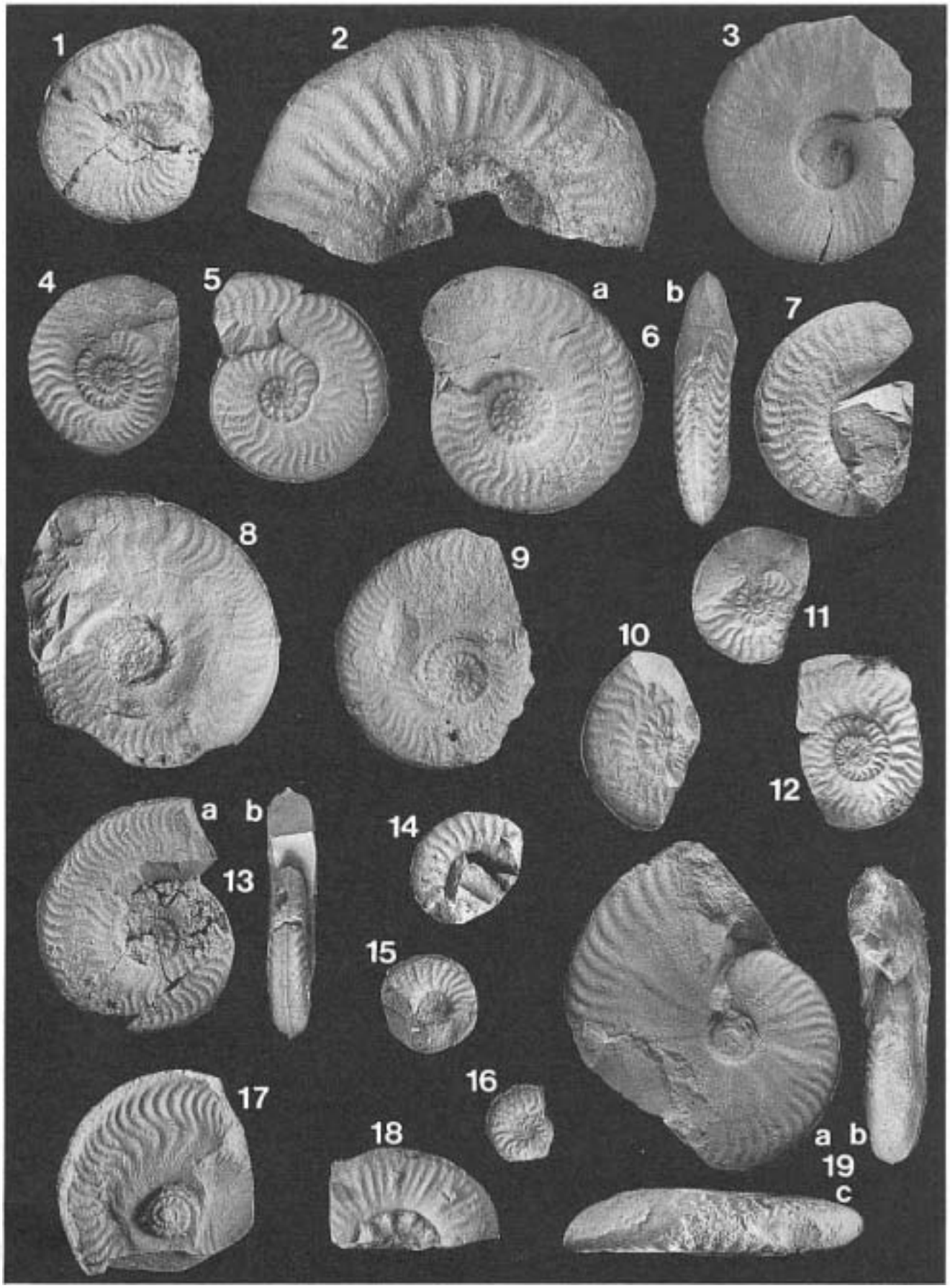

PLATE 3 (All specimens reproduced in natural size. They are from MOUTERDE's Collection).

Fig. 1 ; *Docidoceras* cfr. *perfectum* BUCKMAN (x 0.9). Aalenian, Concavum Zone; locality: Road Quiaios - Boa Viagem (4 km Est of Cabo Mondego) in PERROT et MOUTERDE (1957, p. 357, bed 11). The body chamber is visible along 1/3 whorl. Note the small graphoceratid at the end of the body chamber.

Fig. 2 ; *Docidoceras* sp. (x 0.93). Bajocian, Discites Zone; locality: Cabo Mondego, bed AB 35-38.

Figg. 3-4 ; *Docidoceras* sp. (x 1.9). Bajocian, Discites Zone; locality: Cabo Mondego, bed CA 12.

Fig. 5 : *Docidoceras* sp. *longalvum* (VACEK) (x 0.5). Bajocian Laeviuscula Zone, Ovalis Subzone; locality: Cabo Mondego, bed AB 74 (24m above AB 50).

Figg. 6-7 : *Docidoceras* sp. (x 0.5) remembering *D. zemistephanoides* GÉCZY by its strong ornamentation despite its thinner section. Bajocian, top of the Discites Zone; locality: Porto de Moz (SW of Fatima).

Figg. 8-9 : *Docidoceras* cf. *perfectum* BUCKMAN (x 0.89). Aalenian, Concavum Zone; locality: Miradouro de Cumiera (6 km Est of Cabo Mondego).

Figg. 10-11 : *Eudmetoceras* sp. (gr. *E. eudmetum*) (x 1). Aalenian, Concavum Zone; locality: Cabo Mondego, bed AD 17.

PLATE 3