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The Cenomanian-Turonian transition in West Central Portugal: ammonites and biostratigraphy

Pedro Callapez

Departamento de Ciências da Terra, Universidade de Coimbra, 3000-272 Coimbra, Portugal. callapez@ci.uc.pt.

Abstract

Key-words: Ammonites; biostratigraphy; Cenomanian-Turonian; Portugal.

The Upper Cenomanian and Lower Turonian ammonite assemblages from the onshore sectors of the West Portuguese Margin are reviewed after new studies on the type section of Figueira da Foz, and correlative sections of Baixo Mondego. The faunal succession shows a strong contribution of vascoceratids and other ammonites with North African and Tethyan affinities. *Euomphaloceras septemseriatum* (Cragin, 1893), *Kamerunoceras douvillei* (Pervinquère, 1907), *Fagesia catinus* (Mantell, 1822), *Neoptychites cephalotus* (Courtiller, 1860), and *Thomasites rollandi* (Thomas & Peron, 1889) are for the first time mentioned to Portugal. The Upper Cenomanian is recognised after a set of 3 assemblage zones: *Neolobites vibrayeanus* z., *Euomphaloceras septemseriatum* z., and *Pseudaspidoceras pseudonodosoides* z. The carbonate succession shows an important unconformity across the Cenomanian-Turonian boundary, associated to subaerial exposure, and to the development of a palaeokarst over Upper Cenomanian units. The first Lower Turonian carbonates are yielded a single but diverse ammonite assemblage of middle Lower Turonian age (*Thomasites rollandi* z.). This biozone was previously recognised in Central Tunisia by G. Chancellor *et al.* (1994).

Resumo

Palavras-chave: Amonites; biostratigrafia; Cenomaniano-Turoniano; Portugal.

Procede-se à revisão das associações de amonóides do Cenomaniano Superior e do Turoniano Inferior da Orla Meso-Cenozóica Ocidental de Portugal, com base em novos estudos realizados na secção-tipo da Figueira da Foz e em secções correlativas da região do Baixo Mondego. A sucessão faunística mostra uma forte contribuição em vascoceratideos e outros amonóides com afinidades com o Norte de África e com a Tétis. As espécies *Euomphaloceras septemseriatum* (Cragin, 1893), *Kamerunoceras douvillei* (Pervinquère, 1907), *Fagesia catinus* (Mantell, 1822), *Neoptychites cephalotus* (Courtiller, 1860) e *Thomasites rollandi* (Thomas & Peron, 1889) são descritas pela primeira vez para Portugal. O Cenomaniano Superior é reconhecido através de 3 biozonas de associação: *Neolobites vibrayeanus*, *Euomphaloceras septemseriatum* e *Pseudaspidoceras pseudonodosoides*. A sucessão carbonatada é caracterizada por importante descontinuidade na passagem Cenomaniano-Turoniano, associada a exposição subaérea e ao desenvolvimento de um paleocarso nos calcários do topo do Cenomaniano Superior. Os primeiros níveis do Turoniano Inferior contêm uma associação mais diversificada de amonóides, indicadora da biozona de *Thomasites rollandi*, já anteriormente reconhecida na Tunísia por G. Chancellor *et al.* (1994).

1. Introduction

Within the onshore sectors of the West Portuguese Margin the transition between the Cenomanian and the Turonian stages is recorded through a succession of shallow platform carbonates with abundant faunas of marine invertebrates, including tethyan ammonites, rudists, and hermatypic coral buildups. These carbonate facies are exposed from the region of Lisbon northwards, and overlay a thick and complex succession of Upper Triassic, Jurassic and Lower Cretaceous units related with the sedimentary evolution and depositional events of the West Portuguese Basin (Fig. 1).

Palaeontological evidence suggests that the age of the first carbonated sediments found within this Cretaceous succession, ranges from the Albian (region of Lisbon--Sintra) to the late Middle Cenomanian, and basal Upper Cenomanian (Eastern and Northern sectors of Estremadura

and Beira Litoral). This marked diachrony was the result of a stepped onlap towards North and Northeast, culminating with the installation of a shallow carbonate platform over a system of alluvial and littoral plains with coarse siliciclastic sedimentation (Soares, 1966; Lauverjat, 1982; Berthou, 1984d; Callapez, 1998, 1999b; Diniz, 1999). The carbonate platform was marginal to the western front of the hercynian massif of Iberia, and reached its maximal expansion during the basal Upper Cenomanian.

At the upper part of the sequence, the higher carbonated units that have been recorded match the upper part of the Lower Turonian. These units are restricted to a few areas of the onshore (Leiria-Nazaré, and Figueira da Foz-Montemor-o-Velho), and are overlaid by Middle Turonian marine and alluvial micaceous sandstones.

Ammonites become widespread at the base of the Upper Cenomanian, and occur together with a rich and highly diverse benthic fauna of stenohaline invertebrates. This fossil fauna can be interpreted as a biotic response to the expansion of the carbonate platform, and to the deepening of the sedimentation areas, with introduction of fully marine environments (Callapez, 1998).

The most complete succession of ammonite faunas is found at the exposures of the Baixo Mondego valley, where the stratigraphic sections are more expanded across the Upper Cenomanian and Lower Turonian. The best area for biostratigraphic purposes is situated near the town of Figueira da Foz, not faraway from the Atlantic coast of Beira Litoral. This locality has been recognized, since the XIX century, as an emblematic site for the study of Tethyan ammonite faunas with vascoceratids, *Spathites* and *Pseudaspidoceras* (Choffat, 1898).

The stratigraphic setting of Figueira da Foz and contiguous areas with ammonite facies was first established by Paul Choffat in an extensive monograph concerning the Upper Cretaceous of the West Portuguese Basin (Choffat 1897, 1900). Many of the stratigraphic units recognized by this eminent stratigrapher are still to be used, as well as the original collections of Cenomanian-Turonian invertebrates housed in the National Geological Museum, at Lisbon.

After 1973, the Portuguese ammonite faunas were studied once more by P. Berthou and collaborators, and their importance was emphasised during the Iberian field trips of «Mid Cretaceous Events» (Berthou *et al.*, 1979). The available data and the ammonite and inoceramid zonations proposed by these workers were reviewed by P. Callapez (1998), on the basis of recent developments of the Cenomanian-Turonian ammonite biostratigraphy. The same work also describes a new and large collection of ammonites assembled from the exposures of Figueira da Foz-Coimbra, today housed in the Mineralogical and Geological Museum of the University of Coimbra.

The purpose of this work is a biostratigraphic review of the Cenomanian-Turonian ammonite successions of Figueira da Foz and correlative onshore sections of the West Portuguese Margin, as well as a systematic description of species for the first time recognized in Portugal. A new zonal scheme is proposed, and compared with recent studies of contemporary Tethyan faunas from Tunisia (Chancellor *et al.*, 1994), New Mexico and Texas (Kennedy *et al.*, 1987, 1989; Cobban *et al.*, 1989).

2. Geologic and biostratigraphic settings

The lithological succession observed near Figueira da Foz (Costa d'Arnes Formation, Rocha *et al.*, 1981) is a set of 14 units of limestone and marls, overlaying Lower Cretaceous to Middle Cenomanian coarse sandstones (Figueira da Foz Formation, Diniz, 1999). These units were first described by Paul Choffat (1897, 1900), and named with the capital letters "B" to "O". With the exception of the basal units "B" and "C", the remaining sequence was initially assigned to the Turonian, including the rich vascoceratid assemblages recorded from units "E" to "L" (Fig. 2).

After these early works, more than half century elapsed till the palaeontology and biostratigraphy of the section be reviewed by A. Soares (1966, 1972, 1973, 1980), F. Amédro *et al.* (1980), P. Berthou (1984a, 1984b, 1984c, 1984d), P. Berthou *et al.* (1975, 1985), J. Lauverjat (1978, 1982) and J. Lauverjat & P. Berthou (1973). P. Berthou and J. Lauverjat worked with the main groups of microfossils and essayed the establishment of integrated biostratigraphic zonations, together with the ammonite and inoceramid assemblages. These researches pointed to a Cenomanian age for the oldest *Vascoceras* assemblage recognised (*V. gamai* assemblage from units "E" and "F"). P. Berthou *et*

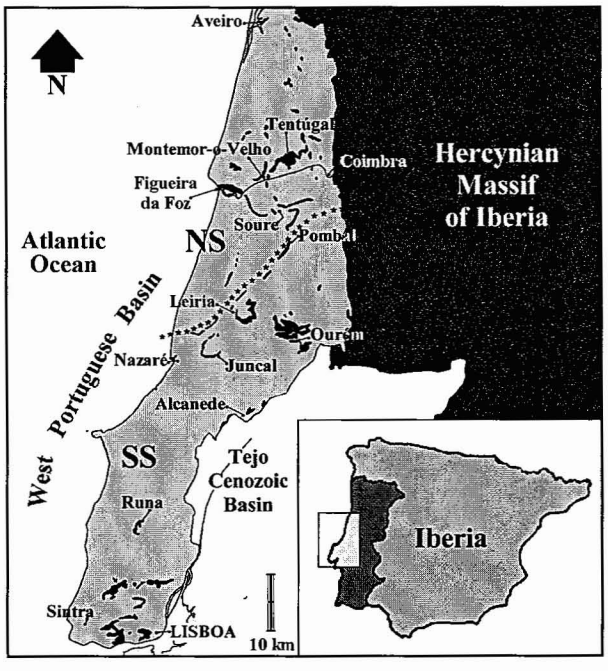

Figure 1 – Location of the West Portuguese Basin, and Cenomanian-Turonian carbonate outcrops and localities mentioned in the text. NS – Northern Sector; SS – Southern Sector; *** boundary between both sectors (Nazaré-Leiria-Pombal fault and associated diapiric structures).

al. (1975, 1985) reviewed also the morphometry and systematics of the Portuguese vascoceratids, and placed the Cenomanian-Turonian boundary on the top of unit "J" (Berthou, 1984a). The last ammonite zonation put forward by Berthou (1984c) was:

Lower Turonian
biozone of *Mammites nodosoides*
(units "L" (top) to "O")
biozone of *Watinoceras coloradoense*
(units "K" and "L")

Upper Cenomanian
biozone of *Neocardioceras juddii*
(units "H" (top) to "J")
Unnamed Zone (Kennedy *et al.*, 1982)
(units "G" and "H")
biozone of *Metoicoceras geslinianum*
(units "E" and "F")
biozone of *Calycoceras naviculare*
(units "C" and "D")

Late Middle Cenomanian
(unit "B")

This zonal scheme was based on the original ammonite collection assembled by P. Choffat, together with a restricted number of new occurrences. It was essentially an attempt to correlate the Portuguese assemblages with the "standard" Western European ammonite zones of J. Kennedy (1984). However, the European index species mentioned by P. Berthou are absent from the Tethyan assemblages of Portugal, with the exception of *Calycoceras naviculare* (Mantell, 1822).

The upper units of the Formation ("M", "N" and "O") are a succession of cross-bedded grainstones with coral and rudist debris, but without any known occurrence of ammonites. After P. Berthou (1984c), the correlation with the *Mammites nodosoides* zone was inferred with the help of palynological data sampled from micaceous sandstones exposed in the region of Coimbra (Moron, 1981).

3. Faunal sequence

The older Cretaceous ammonite assemblage recognised in Figueira da Foz is of Upper Cenomanian age, and occurs in units "C" and "D". The first of these units is a set of nodular marly limestones, very fossiliferous, with a rich benthic fauna of alveolinids, *Pycnodonte*, *Rhynchostreon* and spatangoids. These nodular facies are extensive to the whole sectors of the onshore, and are used as a marker of the basal Upper Cenomanian. *Neolobites vibrayeanus* (d'Orbigny, 1841) is the commonest ammonite, and represents more than 95% of the collected specimens. The remaining species, always very scarce, are *Neolobites bussoni* Collignon, 1965, *Calycoceras (Proeucalycoceras) guerangeri* (Spath, 1926), *C. (C.) naviculare* (Mantell, 1822), *Eucalycoceras pentagonum* (Jukes-Browne, 1896), and *Thomelites hancocki* Juignet & Kennedy, 1976. This fauna indicates the Upper Cenomanian *Calycoceras guerangeri* zone. The index species is known after a single specimen described by P. Choffat (1898, p. 72, pl. 4, fig. 5) as *Acanthoceras* cfr. *rothomagense*, but classified latter on as a probable *C. (P.) guerangeri* (Spath, 1926) (Wright & Kennedy, 1990).

The fauna of unit "D" also correlates with the guerangeri zone. Unit "D" designates a bed of white calcarenitic limestone with scarce ammonite content, but the occurrence of fragments of *Neolobites*, together with *Puzosia (Puzosia)* sp. (Choffat, 1898; Soares, 1980) can be regarded as part of the guerangeri zone assemblages.

The upper limit of unit "D" is a sequence boundary marked by an abrupt shift of lithofacies and faunas. The overlaying units "E", "F" and "G" consist of nodular limestones and marly limestones with the older *Vascoceras* faunas known in the Cretaceous of Portugal. Ammonites form a low diversity assemblage, made of *Euomphaloceras septemseriatum* (Cragin, 1893), *Pseudocalycoceras* sp., and *Vascoceras gamai* Choffat, 1898. This assemblage is dominated by *V. gamai*, which is fairly common in units "E" and "F", and also at the top of "G". A few moulds of *Pseudocalycoceras* are known from units "F" (Amédro *et al.*, 1980) and "G". In the same area, *E. septemseriatum* was collected between units "E" and the top of "G". This species also occurs within the condensed facies of the eastern sectors of Tentúgal-Coimbra (Soares 1966, 1980; Callapez, 1998, 1999b, 2001).

The occurrence of *E. septemseriatum* and *Pseudocalycoceras* over the beds with *Neolobites* is a key to correlate this assemblage with the standard European geslinianum zone. This correspondence is in accord with the opinion of P. Berthou (1984b), but the scheme of this worker does not regard the occurrence of *E. septemseriatum* and restricts the geslinianum zone to units "E" (upper part) and "F". Like in Portugal, *E. septemseriatum* (Cragin, 1893) occurs in North Africa, above the *Neolobites* faunas and bellow the first *Pseudaspidoceras* (Robaszinsky *et al.*, 1990; Chancellor *et al.*, 1994).

P. Berthou (1984b, 1984c, 1984d, 1985) also recognise the "unnamed zone" of J. Kennedy *et al.* (1982), and correlates it with unit "G" and with the lower and middle part of unit "H", without significant palaeontological arguments for that. In fact, the "unnamed zone" is based on a particular *Nigericeras* assemblage found in Southeast England (Wright & Kennedy, 1981), but unknown in Portugal.

Unit "G" is terminated by a discontinuity surface, which is associated to an hardground with dense concentrations of *Thalassinoides* burrows. This surface yielded the youngest *E. semtemseriatum*, many *V. gamai*, and a few moulds assigned to *V. barcoicense* Choffat, 1898 and *V. adonense* Choffat, 1898.

Unit "H" is a set of three beds of white massive limestone with fragments of branched corals and *Thalassinoides* burrows ("H1" to "H3"). The oldest ammonites of this sequence are composite moulds of *Pseudaspidoceras pseudonodosoides* (Choffat, 1898) and vascoceratids, collected near the top of "H1". The

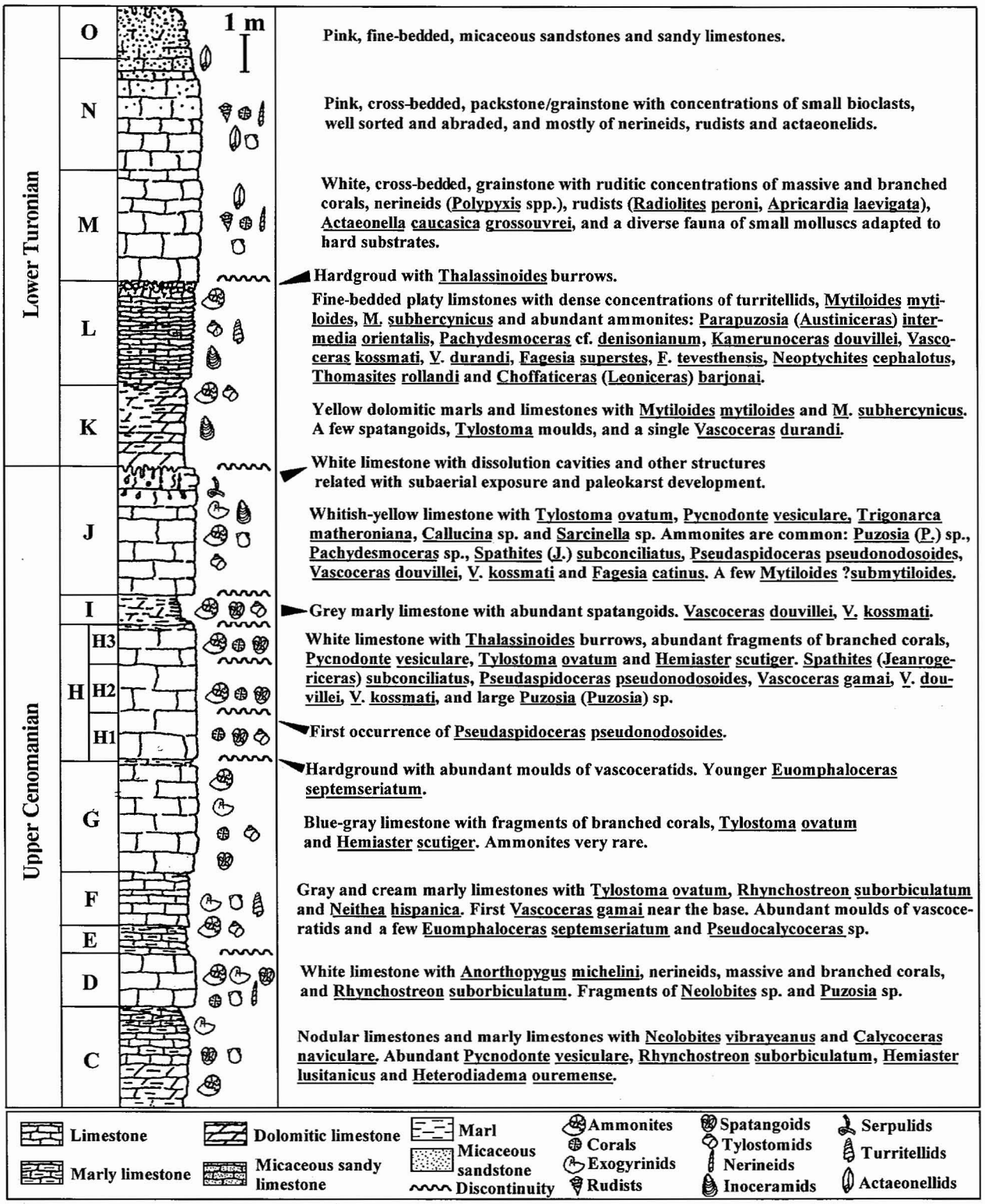

Figure 2 – The Upper Cenomanian and Lower Turonian carbonate succession of Salmanha, Figueira da Foz (below unit "C" there are 20 m of Middle Cenomanian sandy limestones and marls, without known occurrence of ammonites, which are not represented in the figure).

ammonite content increases from "H1" to "H3" and contains the taxa *Puzosia (Puzosia)* sp., *P. pseudonodosoides* (Choffat, 1898), *Spathites (Jeanrogericeras) subconciliatus* Choffat, 1898, *Vascoceras gamai* Choffat, 1898, *V. douvillei* Choffat, 1898, and *V. kossmati* Choffat, 1898.

This assemblage also ranges through units "I" and "J". Unit "I" is a bed of grey marly limestone with abundant spatangoids (*Hemiaster*), and "J" is a whitish-yellow limestone with moulds of *Tylostoma*, serpulids and ammonoids. The acme of *P. pseudonodosoides* and *S. (J.) subconciliatus* occurs at the lower part of this unit. The youngest *P. pseudonodosoides* known was collected 30 cm below the upper limit of the unit, together with *V. kossmati* and large septate fragments of *Puzosia*.

The faunal assemblage of unit "J" also yielded rare *Pachydesmoceras* cf. *deninsonianum* (Stoliczka, 1865), *Fagesia catinus* (Mantell, 1822) and inoceramids close to *Mytiloides sackensis* (Keller, 1982), and *M. submytiloides* (Seitz, 1935) (Callapez, 1998, 1999b, 2001).

The ammonite assemblages of units "H", "I" and "J" have been correlated with the standard zone of *Neocardioceras juddii* (Berthou, 1984c; Berthou *et al.*, 1985). This correspondence was discussed by W. Kennedy (1985, 1986) and W. Kennedy *et al.* (1987, 1989), and based in the extension and common occurrence of *P. pseudonodosoides* in Portugal, New Mexico and Texas. In the last two of these areas, this species is exclusive of the juddii zone, and is found together with the index species (Hook & Cobban, 1981; Cobban *et al.*, 1983, 1989). The occurrence of *S. (J.) subconciliatus* also indicates the juddii zone. The oldest occurrences of this species in Spain belong to this assemblage zone (Wiedmann & Kauffman, 1978), as well as the single specimen known from Southern England, and described by C. Wright & W. Kennedy (1981).

As well as in Tunisia, it is adequate to consider a biozone of *Pseudaspidoceras pseudonodosoides* for the Portuguese assemblages of units "H", "I" and "J". The ammonite content of these units is dominated by Tethyan vascoceratids, and devoided of the most relevant species of the boreal juddii zone. The *P. pseudonodosoides* assemblage zone was first recognised by G. Chancellor *et al.* (1994) in Central Tunisia, where it designates the highest known Cenomanian ammonite fauna. The index species occurs with *Vascoceras* spp. and *Fagesia*.

The youngest ammonite assemblage of Figueira da Foz is found inside a succession of dolomitic and limestone facies (units "K" and "L"). The boundary between "J" and "K" is also an important unconformity, with evidence of subaerial exposure and paleokarst development affecting the Upper Cenomanian limestones of unit "J". This unconformity has been recognised in many sectors of the onshore.

Unit "K" is essentially dolomitic and yielded rare and poorly preserved *Mytiloides mytiloides* (Mantell, 1822), *M. subhercynicus* (Seitz, 1935) and *Vascoceras durandi* (Thomas & Peron, 1889). In stratigraphic continuity with the dolomitic facies there are 4-5 meters of fine-bedded plated limestones with *Tylostoma* and dense concentrations of turritelids (unit "L"). The ammonite and inocermid content of this unit is the most diverse of the whole sequence. The species recorded are *Parapuzosia (Austiniceras) intermedia orientalis* (Matsumoto,1954), *Pachydesmoceras* cf. *denisonianum* (Stoliczka, 1865), *Kamerunoceras douvillei* (Pervinquère, 1907), *Vascoceras kossmati* Choffat, 1898, *V. durandi* (Thomas & Peron, 1889), *Fagesia superstes* (Kossmat, 1897), *F. tevesthensis* (Peron, 1896), *Thomasites rollandi* (Thomas & Peron,1889), *Neoptychites cephalotus* (Courtiller,1860), *Choffaticeras (Leoniceras) barjonai* (Choffat, 1898), *Mytiloides mytiloides* (Mantell, 1822) and *M. subhercynicus* (Seitz, 1935).

K. douvillei, *N. cephalotus* and *T. rollandi* are mentioned for the first time to Portugal. The assemblage indicates the Tethyan *Thomasites rollandi* zone, which was previously defined in the Lower Turonian of Central Tunisia by G. Chancellor *et al.* (1994), and based in faunas first described by L. Pervinquière (1907). The ensemble includes several species of *Kamerunoceras*, *Fagesia* and *Choffaticeras*, together with *Paramammites polymorphus* (Pervinquière, 1907), *Watinoceras coloradoense* (Henderson, 1908), *N. cephalotus* and abundant *V. durandi*. The *Thomasites rollandi* zone correlates with the US Western Interior and Western European zone of *Watinoceras coloradoense* (*sensu* Hancock *et al.*, 1993), and designates faunas with a stratigraphic range below the first occurrences of *Mammites nodosoides* (Chancellor *et al.*, 1994).

Unfortunately, the *M. nodosoides* assemblage zone cannot be directly recognised in Portugal, since the youngest units "M", "N" and "O" of Figueira da Foz are rudist and coral bioclastic limestones, without any known occurrences of ammonites and inoceramids.

4. Cenomanian-Turonian boundary

The ammonite sequence described above suggests that the boundary between the two stages should be placed on the top of unit "J". This location is in agreement with P. Berthou (1984c), P. Berthou *et al.* (1985), and subsequent opinions of W. Kennedy (1985, 1986) and W. Kennedy *et al.* (1987, 1989).

The gap associated to the unconformity "J"/"K" matches both late Upper Cenomanian and basal Lower Turonian times (standard *Nigericeras scotti*, *Watinoceras devonense*, and *Pseudaspidoceras flexuosum* zones of Hancock *et al.*, 1993), and the first Turonian beds observed in Portugal are of middle Lower Turonian age (*Thomasites rollandi* zone).

5. Correlation with other areas

Figure 3 summarises the faunal sequence of Figueira da Foz and correlative ammonite sequences of Northwest Europe, North and West Africa and U.S.A.

a) Spain - The Spanish ammonite sequences were summarised by J. Wiedmann (1964, 1975), J. Wiedmann & E.

Kauffman (1978) and J. Mojica & J. Wiedmann (1977). Despite the geographical proximity, they show significant differences when compared with Portugal. The Upper Cenomanian includes the *Neolobites vibrayeanus* and *Metoicoceras geslinianum* assemblages. *Spathites* are very well represented, and range from the Upper Cenomanian through several zones (Kennedy *et al.*, 1987). *Mammites nodosoides* and *Wrightoceras munieri*, indicate the Lower Turonian biozone of *M. nodosoides*.

b) Central Tunisia - The Cenomanian-Turonian faunal succession of Central Tunisia shows a notorious similarity with Portugal. After F. Robaszinsky *et al.* (1990) and G. Chancellor *et al.* (1994) the *Calycoceras guerangeri*, *Euomphaloceras septemseriatum*, *Pseudaspidoceras pseudonodosoides*, *P. flexuosum*, *Thomasites rollandi* and *Mammites nodosoides* assemblages are well represented. The sequence recognized at Figueira da Foz is comparable, but the *P. flexuosum* and *M. nodosoides* are missing.

c) USA - The Cenomanian-Turonian transition in the US Western Interior is one of the most complete and well studied worldwide. Recent researches on the area have been devoted to the establishment of a GSSP boundary in the section of Pueblo (Colorado) (Kennedy & Cobban, 1991; Bengtson (comp.), 1996). Of special interest for comparison with the Portuguese assemblages are the faunas of Texas and New Mexico described by W. Cobban *et al.* (1983, 1989), W. Kennedy (1988) and W. Kennedy *et al.* (1987). These faunas have a substantial number of Tethyan taxa, including vascoceratids and *Pseudaspidoceras pseudonodosoides* (Choffat, 1898), allowing direct correlations with Portugal.

d) Northwest Europe - The British and correlative faunas of France form a sequence with *Calycoceras*, *Metoicoceras*, *Neocardioceras* and *Watinoceras* assemblages (Wright & Kennedy, 1981; Kennedy, 1984, 1985; Hancock *et al.*, 1993). The first of these assemblages is the only one recognised in Portugal. However, correlation is still possible when based in the common occurrence of *Euomphaloceras septemseriatum*, *Spathites subconciliatus*, *Fagesia catinus* and *Neoptychites cephalotus*.

e) Nigeria - The Cenomanian-Turonian of Northeast Nigeria is exceptionally rich in vascoceratid faunas (Zaborski, 1990, 1995, 1996; Courville, 1992; Meister, 1992; Meister *et al.*, 1994). A full revision of these ammonites was set out by P. Zaborski (1996), together with a comparison with Portugal. Just as in Figueira da Foz, the occurrence of *Pseudaspidoceras pseudonodosoides* (Choffat, 1898) above assemblages of the *Vascoceras cauvini* and *Metoicoceras geslinianum* zones is a marker of the *Neocardioceras juddii* zone.

6. Systematic palaeontology

Repositories of specimens: DCT – Departamento de Ciências da Terra, University of Coimbra; MGN – Museu Geológico Nacional, Lisbon.

Order	AMMONOIDEA Zittel, 1884
Suborder	AMMONITINA Hyatt, 1889
Superfamily	Acanthoceratacеae Grossouvre, 1894
Family	Acanthoceratidae Grossouvre, 1894
Subfamily	Euomphaloceratinae Cooper, 1978
Genus	*Euomphaloceras* Spath, 1923

(Type species: *Ammonites euomphalus* Sharpe, 1855, by original designation)

Western Interior of USA	Figueira da Foz, Portugal	Spain	Central Tunisia	Kallat-es-Senam, Tunisia	Southern England	Touraine, France
Mammites nodosoides	(M/N/O)	*Mammites nodosoides*	*Mammites nodosoides*	*Mammites nodosoides* TrZ	*Mammites nodosoides*	*Mammites nodosoides*
Watinoceras coloradoense	*Thomasites rollandi* (L) (K)		*Thomasites rollandi*	*Choffaticeras* I	Fauna with *Fagesia* and *Pseudaspidoceras*	
Pseudaspidoceras flexuosum		*Paramammites? saenzi*	*Pseudaspidoceras flexuosum*	*Pseusdapidoceras flexuosum* I		
Watinoceras devonense		?			*Watinoceras devonense*	
Nigericeras scotti						
Neocardioceras judii	*Pseudaspidoceras pseudonodosoides* (J) (H/I)	*Spathites (J.) subconciliatus*	*Pseudaspidoceras pseudonodosoides*		*Neocardioceras judii*	
Burroceras clydense	*Euomphaloceras septemseriatum* (G) (E/F)			*Euomphaloceras septemseriatum* I	Fauna with *Nigericeras*	
Sciponoceras gracile		*Metoicoceras geslinianum*			*Metoicoceras geslinianum*	*Metoicoceras geslinianum*
Metoicoceras mosbydense	*Calycoceras guerangeri* (D) (C)	*Metoicoceras muelleri* *Neolobites vibrayeanus*	*Calycoceras guerangeri*	*Eucalycoceras* IZ	*Calycoceras guerangeri*	*Calycoceras guerangeri*
Calycoceras canitaurinum						

Figure 3 – Correlation between the Upper Cenomanian and Lower Turonian ammonite succession of the West Portuguese Basin and the contemporaneous successions of the Western Interior of USA, Southern England and Touraine (after Hancock *et al.*, 1993; Kennedy & Cobban, 1993), Spain (after Mojica & Wiedmann, 1977), Central Tunisia (after Chancellor *et al.*, 1994; Kennedy & Cobban, 1994) and Kalaat-es-Senam in Tunisia (Robaszynski *et al.*, 1990).

Euomphaloceras septemseriatum (Cragin, 1893)
(Pl. 1, figs. 1a-b, 2a-b)

1978 – *Euomphaloceras (Kanabiceras) septem-seriatum* (Cragin, 1893); Cooper, p. 106, figs. 4n-o, 10a-e, 12e-h, 18g-h, 19g-l, 26a-b, 28.
1980 – *Euomphaloceras* cf. *cunningtoni tuberculata* (Pervinquière); Amédro, Berthou & Lauverjat, p. 156, pl. 1, fig. 2a -b.
1981 – *Euomphaloceras septemseriatum* (Cragin, 1893); Wright & Kennedy, p. 64, fig. 10a-j.
1981 – *Euomphaloceras septemseriatum* (Cragin); Kennedy, Juignet & Hancock, p.56, text-fig. 11d-e, pl. 9, figs. 3-5.
1981 – *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy & Juignet, p. 38, fig. 9b-d.
1984 – *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy, Amédro, Badillet, Hancock & Wright, p. 36, fig. 3k-l.
1985 – *Euomphaloceras (Kanabiceras) septemseriatum* (Cragin); Howarth, p. 95, figs. 26-28.
1986 – *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy, Amédro & Colleté, p. 206, figs. 3c-d.
1988 – *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy, p. 53, text-fig. 10e, 11d, pl. 8, figs. 1–6,9, pl. 9, figs. 1-3, 5-7, 9-12; pl. 22, fig. 3.
1989 – *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy, Cobban, Hancock & Hook, p. 64, figs. 10A-J; 11D-I.
1989 – *Euomphaloceras septemseriatum* (Cragin); Cobban, Hook & Kennedy, p. 35, figs. 35, 76Q-T, Z-FF, HH-PP.
1994 – *Euomphaloceras* cf. *septemseriatum* (Cragin, 1893); Kennedy & Juignet, p. 492.

Material: Specimens DCTAM525 (Salmanha, Figueira da Foz, top of unit "G"), DCTAM106 (1.5 km East Salmanha, unit "F") and DCTAM523 (Mala, Coimbra).

Description: DCTAM523 is a fragment of a strongly ornamented fragmocone, with evolute and slightly depressed whorls, and a sub-trapezoidal section, larger than higher. Primary ribs are prominent, prorsiradiate, in number of 10 per half whorl. They arise as umbilical bullae, are straight over the flanks, and link to strong inner ventrolateral and smaller outer ventrolateral tubercles. With two exceptions, the primary ribs are separated by short and weaker intercalar ribs, which arise over the ventral region. Both primary and intercalar ribs almost disappear over the siphonal region. The siphonal clavi are strong and closer, in number of 16 per half whorl. Suture has a broad E/L, a deep and broad, bifid L, and a smaller L/U. DCTAM525 is a septate mould damaged on the flanks, but also bearing a strong ornamentation, with prominent ribs and tubercles. DCTAM106 is a larger fragmocone, with a coiling and whorl section analogous to the previous specimens. However, ribbing is much weaker and the intercalar ribs are less numerous. Tubercles are in number of 8 inner ventrolaterals and 12 outer ventrolaterals and sifonals, in the last half whorl.

Dimensions:

Ref.	D	Wb	Wh	Wb/Wh	U
DCTAM523	50.3	27.3	20.8	1.31	16.3
DCTAM525	64.1	27.0	26.5	1.02	20.2
DCTAM106	71.6	38.7	28.8	1.34	23.3

Discussion: F. Amédro *et al.* (1980) have classified as *Euomphaloceras cunningtoni tuberculata* (Pervinquière, 1907) a small septate fragment collected near Rio Covo (Coimbra), belonging to the collection of Berthou and housed at the University of Paris VI. However, the species of L. Pervinquière is the type of genus *Cunningtoniceras* Collignon, 1937, representing a group of Middle Cenomanian Acanthoceratinae with an high degree of homeomorphism to *Euomphaloceras*. The specimen of F. Amédro *et al.* (op. cit.) shows exactly the same style of ornamentation than our specimens, closely resembling strongly tuberculated fragmocones of *Euomphaloceras septemseriatum* (Cragin, 1893). W. Kennedy & P. Juignet (1981) and W. Cobban, S. Hook & W. Kennedy (1989) have figured several comparative specimens, with similar coiling and ornamentation. The same workers present an exhaustive revision of this species, with a full synonymy.

Occurrence: Upper Cenomanian of Baixo Mondego. Upper Cenomanian *Sciponoceras gracile* zone assemblages of New Mexico, Arizona, Colorado, Kansas, Montana, Utah and California (Kennedy, 1988). Upper Cenomanian of SE England, NW and SE France, Germany, Mexico, Brasil, Angola, Nigeria and Japan (Thomel, 1994; Cobban Hook & W. Kennedy, 1989).

Genus *Kamerunoceras* Reyment, 1954
(Type species: *Acanthoceras eschii* Solger, 1904, by original designation)

Kamerunoceras douvillei (Pervinquière, 1907)
(Pl. 1, figs. 3a-b, 5a-b)

1907 – *Acanthoceras douvillei* Pervinquière, p. 274, pl. 12, figs. 2-3.
1931 – *Prionotropis douvillei* Pervinquière; Basse, p. 44, pl. 6, figs. 6-7.
1979a – *Kamerunoceras douvillei* (Pervinquière); Kennedy & Wright, p.1169.
1994 – *Kamerunoceras douvillei* (Pervinquière); Chancellor, Kennedy & Hancock, p. 28, pl. 6, figs. 1-4; pl. 12, figs.4-5.

Material: Specimens DCTAM152, DCTAM815, from Salmanha, Figueira da Foz, unit "L".

Description: Both specimens are strongly ornamented composite moulds, with a very evolute coiling, a broad umbilicus, and a depressed whorl section. DCTAM815 is slightly deformed and crushed, and presents almost 180° of body chamber. Ribs are strong over the flanks and venter, prorsiradiate, with an estimated number of 14 per half whorl, most of them primaries and arising from

umbilical small bullae. They are straight over the flanks and bear strong conical inner ventrolateral tubercles and weaker outer ventrolateral and siphonal ones. Suture line is relatively indented, with a broad and asymmetrically bifid L, and a prominent but slightly narrow E/L. The second specimen is a fragment with a damaged flank, comprising 160° of body chamber, a depressed whorl section and 12 strong, prorsiradiate, primary ribs. There are also 2 intercalar ribs, weaker and disappearing over the mid flanks. The rows of tubercles are similar to those of the previous specimen.

Dimensions:

Ref.	D	Wb	Wh	Wb/Wh	U
DCTAM152	67.2	27.0	21.7	1.24	42.6
DCTAM815	59.2	26.0	18.7	1.39	37.5

Discussion: The systematic position and phylogeny of *Kamerunoceras* were fully reviewed by W. Kennedy & C. Wright (1979), with emphasis on the European and North African *K. turoniense* (d'Orbigny, 1850). Some related species from the Lower to early Middle Turonian are, among others, *K. calvertense* (Powell, 1963) and *K. puebloense* Cobban & Scott, 1972, from West Texas and Colorado (Kennedy *et al.*, 1987) and *K. douvillei* (Pervinquière, 1907), from North Africa and Madagascar. The last of these species is comparatively smaller than K. turoniense, which has medium sized mature specimens, reaching 200 mm of diameter. The ventral ribs of *K. douvillei* are stronger and bear more prominent rows of inner and outer ventrolateral, and siphonal tubercles. Both Portuguese specimens match well the *K. douvillei* from the Lower Turonian assemblages of Tunisia, recently reviewed by G. Chancellor *et al.* (1994, pl. 12, figs. 4-5; pl. 6, figs. 1-2, 3-4).

Occurrence: *K. douvillei* appears in the Lower Turonian *Thomasites rollandi* zone of Tunisia and Portugal, as well as in Madagascar.

Family Vascoceratidae Douvillé, 1912
Subfamily Vascoceratinae Douvillé, 1912
Genus *Fagesia* Pervinquière, 1907
(Type species: *Olcostephanus superstes* Kossmat, 1897, by original designation)

Fagesia catinus (Mantell, 1822)
(Pl. 2, fig. 1a-b)

1981 – *Fagesia catinus* (Mantell); Wright & Kennedy, p. 88, text-figs. 31-36, pl. 26, fig. 2a-b.
1986 – *Fagesia catinus* (Mantell); Kennedy, pl. 12, figs. 1, 2, 8, 9.
1987 – *Fagesia catinus* (Mantell); Wright & Kennedy, p. 165, text-fig. 7-8.
1987 – *Fagesia catinus* (Mantell); Kennedy, Wright & Hancock, p. 51, text-figs. 2j, k, m, n, 10, pl. 7, figs. 1-13; pl. 8, figs. 1-4, 6-9;
1989 – *Fagesia catinus* (Mantell); Cobban, Hook & Kennedy, p. 50, figs. 50, 92L-KK, 96S-T.
1989 – *Fagesia catinus* (Mantell); Kennedy, Cobban, Hancock & Hook, p. 84.
1991 – *Fagesia catinus* (Mantell); Kennedy & Simmons, p.141, pl. 4C-E.

Material: Specimens DCTAM30 and DCTAM588, from Salmanha, Figueira da Foz, unit "J"; specimen DCTAM589, from Costa d'Arnes, Montemor-o-Velho, unit "J".

Description: DCTAM30 is a globose and evolute septate mould, with a depressed whorl section. On the last half whorl there are 5 prominent umbilical tubercles, from which arise one or two very weak prorsiradiade ribs. DCTAM588 has a shape analogous to the previous specimen, but the number of umbilical tubercles is less than 8 per whorl, and ribs are absent over the ventral region of the septate mould. Sutures are slightly indented, with broad E/L and L/U, and a narrow L. DCTAM589 is a large and slightly distorted mould with nearly half whorl of body chamber preserved. Ribs are absent, but the umbilical tubercles are still prominent and the section is very depressed.

Dimensions:

Ref.	D	Wb	Wh	Wb/Wh	U
DCTAM30	71.3	49.3	27.3	1.81	24.8
DCTAM588	66.7	48.5	22.4	2.17	26.7
DCTAM589	90.2	71.6	38.6	1.85	35.5

Discussion: *Fagesia catinus* was reviewed by C. Wright & J. Kennedy (1981) and W. Kennedy *et al.* (1987) and W. Cobban *et al.* (1989). The first of these works also lists a full synonymy of the species.

The stratigraphic range of *Fagesia* Pervinquière, 1907 is mainly Lower Turonian, being a common genus on the *Pseudaspidoceras flexuosum* assemblages. *F. catinus* is one of these early examples, and many of their known occurrences are of basal Lower Turonian age. However, the Portuguese specimens have been collected together with *P. pseudonodosoides* and other Late Cenomanian species related with the *Neocardioceras juddii* and *Sciponoceras gracile* assemblages (Cobban & Hook, 1983; Cobban *et al.*, 1989; Chancellor *et al.*, 1994). These older occurrences of *F. catinus* are in conformity with the opinions of W. Cobban *et al.* (1989) and G. Chancellor *et al.* (1994), who confirm the existence of *Fagesia* spp. at the Upper Cenomanian, including the other referred species.

Occurrence: *Fagesia catinus* appears at the basal Lower Turonian of Southern England, France, Northern Mexico, California, Montana, Texas, Venezuela and Oman. There are also a few records from the Upper Cenomanian *Neocardioceras juddii* zone of New Mexico (Cobban, Hook & Kennedy, 1989). The Portuguese records are restricted to the Upper Cenomanian *Pseudaspidoceras pseudonodosoides* assemblage of unit "J", from Figueira da Foz and Montemor-o-Velho.

Genus *Neoptychites* Kossmat, 1895
(Type species: *Ammonites telinga* Stoliczka, 1865, by the subsequent designation of F. Solger, 1904)

Neoptychites cephalotus (Courtiller, 1860)
(Pl. 1, fig. 4; pl. 2, fig. 4)

1860 – *Ammonites cephalotus* Courtiller, p. 248, pl. 2, figs. 1-4.
1898 – *Ammonites* sp. ind. aff. *Olcostephanus superstes* Kossmat; Choffat, pl. 14, fig. 4a-b (non p. 69, pl. 10, fig. 4a-b).
1907 – *Neoptychites cephalotus* Courtiller; Pervinquière, p. 393, text-fig. 152, pl. 27, figs. 1-4.
1907 – *Neoptychites xetriformis* Pervinquière, p. 393, text-figs. 153-154, pl. 27, figs. 8-9.
1978 – *Neoptychites (Neoptychites) cephalotus* (Courtiller); Wiedmann & Kauffman, pl. 10, fig. 2.
1979b – *Neoptychites cephalotus* (Courtiller); Kennedy & Wright, p. 670, text-fig. 2, pl. 82, figs. 3-5; pl. 83, figs. 1-3; pl. 84, fig. 4; pl. 85, figs. 1-5; pl. 86, figs. 5-6.
1979b – *Neoptychites xetriformis* Pervinquière, 1907; Kennedy & Wright, p. 679, pl. 84, figs. 1-2; pl. 85, figs. 1-3.
1982 – *Neoptychites cephalotus* (Courtiller); Robaszynsky *et al.*, pl. 2, fig. 1.
1982 – *Neoptychites xetriformis* Pervinquière; Robaszynsky *et al.*, pl. 2, fig. 2.
1983a – *Neoptychites cephalotus* (Courtiller); Cobban & Hook, p. 44, text-fig. 9, pl. 3, figs. 9-11; pls. 9-12.
1985 – *Neoptychites cephalotus* (Courtiller, 1860); Amédro & Hancock, p. 17, fig. 7c-d.
1987 – *Neoptychites cephalotus* (Courtiller); Zaborsky, p. 43, figs. 31-32.
1989 – *Neoptychites* cf. *cephalotus* (Courtiller); Kennedy, Cobban, Hancock & Hook, p. 84.
1990 – *Neoptychites cephalotus* (Courtiller); Robaszynsky *et al.*, p. 266, pl. 20, figs. 2-3; pl. 21, fig. 3.
1994 – *Neoptychites cephalotus* (Courtiller); Chancellor, Kennedy & Hancock, p. 70, pl. 16, figs. 1-4; pl. 17, figs 1-5; pl. 18, figs. 1-3; pl. 26, figs. 2-4.
1996 – *Neoptychites* gr. *cephalotus* (Courtiller); Meister & Abdallah, p. 11, text-fig. 5f-g, pl. 3, fig. 2; pl. 5, fig. 3; pl. 6, fig. 1.

Material: Specimen nº 840 of collection Choffat (MGN), from Amieira, Figueira da Foz, unit "L" (Choffat, 1898, pl. 14, fig. 4a-b); DCTAM52, from Salmanha, Figueira da Foz, unit "L".

Description: Both specimens are moulds of juvenile *Neoptychites*, closely resembling the earliest to middle ontogenic stages described by W. Kennedy & C. Wright (1979b), with numerous low and broad ribs visible over the ventral region. DCTAM52 is a specimen with compressed and very involute whorls, where the last 120° of coiling belong to the body chamber. Ornament consists in round, broad, prorsiradiate ribs, stronger over the venter and gradually weakened across the flanks. These ribs are in number of 17 on the last half whorl. Suture line is moderately incised. The specimen figured by P. Choffat (1898) is a small composite mould, with 90° of body chamber preserved, and the whorl section and ribbing analogous to the specimen previously described.

Dimensions:

Ref.	D	Wb	Wh	Wb/Wh	U
DCTAM52	52.7	21.7	27.3	0.79	5.5

Discussion: The variability of *N. cephalotus* was analysed by W. Kennedy & C. Wright (1979) and G. Chancellor *et al.* (1994), with full synonymy. Adult specimens are easily identified because of their very involute shape, compressed whorls, and subtrigonal whorl section. These typical shells are unknown from the Lower Turonian of Portugal. The specimen figured by P. Choffat (1898) as an indeterminate mould close to *Fagesia superstes* (Kossmat, 1895), belongs to the middle ontogenic stages of juvenile *Neoptychites*, when numerous fold-like ribs emerge from the flanks and cross the ventral region of shells. Both Portuguese specimens match well with some of the juveniles figured in previous works.

Occurrence: *Neoptychites cephalotus* first appears in the middle part of the Lower Turonian and persists into the middle Turonian (Chancellor *et al.*, 1994), showing a wide geographic record. The species was previously recorded on South and Central America, U.S.A. (Colorado, Novo Mexico and Texas), France, Spain, Morocco, Algeria, Israel, Syria, Nigeria, South India and Madagascar. Both Portuguese specimens belong to the middle Lower Turonian *Thomasites rollandi* ammonite assemblage of unit "L".

Family Pseudotissotiidae Hyatt, 1903
Subfamily Pseudotissotiinae Hyatt, 1903
Genus *Thomasites* Pervinquière, 1907
(Type species: *Pachydiscus rollandi* Peron, 1889, by subsequent designation of C. Diener, 1925)

Thomasites rollandi (Thomas & Peron, 1889)
(Pl. 2, figs. 2a-b, 3a-b)

1889 – *Pachydiscus Rollandi* Thomas & Peron, p. 25, pl. 17, figs. 1-3.
1907 – *Thomasites Rollandi* Thomas & Peron et variétés; Pervinquière, p. 341, text-figs.127-130, pl. 22, figs. 1-7.
1907 – *Thomasites Meslei* Pervinquière, p. 345, text-fig. 131, pl. 22, figs. 8a-b, 9a-b.
1907 – *Thomasites Jordani* Pervinquière, p. 341, figs. texto 132-133, pl. 22, figs. 10a-b, 11a-b, 12a-b (var. *costata*), 13a-b (var. *laevis*).
1981 – *Thomasites* cf. *rollandi* (Peron); Wright & Kennedy, pl. 22, fig. 1.

1990 – *Thomasites rollandi* (Peron); Robaszynsky *et al.*, p. 267, pl. 22, figs. 1-4.

1990 – *Thomasites jordani* Pervinquière, 1907; Robaszynsky *et al.*, p. 286, pl. 22, fig. 3.

1994 – *Thomasites rollandi* (Thomas & Peron); Chancellor, Kennedy & Hancock, p. 75, text-fig. 14A-F, pl. 19, figs. 1-2; pl. 20, figs. 1-12; pl. 21, figs. 1-9; pl. 22, figs. 1-6; pl. 23, figs. 1-6.

1996 – *Thomasites rollandi* (Thomas & Peron) s.s., 1889; Meister & Abdallah, p. 12, text-fig. 5h-I, k, pl. 7, figs. 1-2; pl. 11, fig. 2; pl. 14, fig. 1.

1996 – *Thomasites rollandi* forme *jordani* Pervinquière, 1907; Meister & Abdallah, p. 12, text-fig. 5j, pl. 6, fig. 2.

1996 – *Thomasites rollandi* forme *meslei* Pervinquière, 1907; Meister & Abdallah, p. 13, text-fig. 6a-d, pl. 8, figs. 1-3; pl. 9, fig. 2; pl. 10, fig. 2.

Material: Specimens DCTAM47 and DCTAM442 from Salmanha, Figueira da Foz, unit "L"; DCTAM49 from Fontela, Figueira da Foz, unit "L".

Description: DCTAM442 is a fragment with the fragmocone and the beginning of the body chamber, involute and moderately globose. The last whorl is fully ornamented with 24 rectiradiate ribs, more prominent over the convex venter. They arise from 6 umbilical tubercles, small and gradually weaker. The ventral region of the fragmocone shows three rows of weak and regular, outer ventrolateral and siphonal tubercles. Suture is slightly indented with a broad and deep, bifid L. DCTAM49 is a septate fragment with 90° of body chamber, ornamented with weak, broad, retroverse ribs. The rows of ventrolateral and siphonal tubercles are slightly perceptible and the umbilical ones are absent. DCTAM47 is a septate and involute mould, with depressed whorl section and convex venter. Ribs are in number of 13 per half whorl, and give rise to 3 rows of small, equal and regular, ventrolateral and siphonal tubercles. The umbilical tubercles are stronger, in number of 6 or 7 per whorl. Suture line is similar to those of previous specimens, with a broad, bifid, L.

Dimensions:

Ref.	D	Wb	Wh	Wb/Wh	U
DCTAM442	66.2	31.8	29.5	1.08	12.5
DCTAM049	77.0	33.4	37.5	0.89	18.1
DCTAM047	67.3	31.4	38.0	0.83	11.2

Discussion: G. Chancellor *et al.* (1994) have reviewed the North African *Thomasites*, with full synonymy. *T. rollandi* is a very variable species, with an involute and moderately compressed to globose shell, and a convex venter. Some of these variations, corresponding to different shapes of *T. rollandi*, are related with the taxa *T. meslei* and *T. jordani* of L. Pervinquière (1907). The Portuguese specimens are globose and slightly less involute than the comparative specimens of Tunisia, figured by L. Pervinquière (1907) and G. Chancellor *et al.* (1994).

Occurrence: *Thomasites rollandi* appears in the Lower Turonian of North Africa (Tunisia, Egypt and Israel), SE France, Spain and Portugal (Figueira da Foz, unit "L").

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References

Amédro, F.; Berthou, P. & Lauverjat, J. (1980) - Nouvelles preuves de l'apparition au Cénomanien supérieur des premiers Vascoceras dans la série type de la basse vallée du Rio Mondego (Beira Litoral, Portugal). *Bol. Soc. Geol. Portugal*, 22: 153-162.

Amédro, F. & Hancock, J. (1985) - Les Ammonites de l'autoroute "l'Aquitaine", France (Turonien et Santonien). *Cret. Research*, 6: 15-32.

Basse, E. (1931) - Monographie paléontologique de Crétacé de la province de Maintirano. *Mém. Géol. Serv. Min. Madagascar*, 86 p.

Bengtson, P. (comp.) (1996) - The Turonian stage and substrage boundaries. *In* Rawson, P., Dhondt, A., Hancock, J. & Kennedy, W. eds. - Proceedings of the Second International Symposium on Cretaceous Stage Boundaries. *Bull. Inst. Royal Sci. Nat. Belgique*, 66, appendix: 69-80.

Berthou, P. (1984a) - Albian-Turonian stage boundaries and subdivisions in the Western Portuguese Basin, with special emphasis on the Cenomanian-Turonian boundary in the Ammonite Facies and Rudist Facies. *Bull. Geol. Soc. Denmark*, 33: 41-45.

Berthou, P. Y. (1984b) - Répartition stratigraphique actualisée des principaux foraminifères benthiques du Crétacé moyen et supérieur du Bassin Occidental Portugais. *Benthos*, 83: 45-54.

Berthou, P. (1984c) - Zonation par les Ammonites du Cenomanien supérieur et du Turonien inferieur du Bassin Occidental Portugais. *Actas I° Congresso Español de Geologia*, 1: 13-26.

Berthou, P. (1984d) - Résumé synthétique de la stratigraphie et de la paléogéographie du Crétacé moyen et supérieur du bassin occidental portugais. *Geonovas*, 7: 99-120.

Berthou, P., Brower, J. & Reyment, R. (1975) - Morphometrical study of Choffat's Vascoceratids from Portugal. *Bull. Geol. Inst. Univ. Uppsala*, 6: 73-83.

Berthou, P., Chancellor, G. & Lauverjat, J. (1985) - Revision of the Cenomanian-Turonian Ammonite Vascoceras Choffat, 1898, from Portugal. *Comun. Serv. Geol. Portugal*, 71: 55-79.

Berthou, P. & Lauverjat, J. (1975) - Le Cénomano-Turonien à Vascocératidés dans sa région type (embouchure du Rio Mondego, Beira Litoral, Portugal). *Newsl. Stratigr.*, 4: 96-118.

Berthou, P., Soares, A. & Lauvervat, J. (1979) - Portugal. *In:* Mid Cretaceous Events Iberian field Conference 77, guide, I partie, *Cuadernos Geologia Ibérica*, 5: 31-124.

Callapez, P. (1998) - *Estratigrafia e Paleobiologia do Cenomaniano-Turoniano. O significado do eixo da Nazaré-Leiria-Pombal.* Unpubl. D. Phil. Thesis, Coimbra University, 491 p.

Callapez, P. (1999a) - The marine Lower Turonian of West Central Portugal. *EPA Workshop,* Lisbon: 83-87.

Callapez, P. (1999b) - The Cenomanian-Turonian of the western Portuguese Basin: Stratigraphy and Palaeobiology of the Central and Northern sectors. *EPA Workshop,* Lisbon, field trip 2, 45 p.

Callapez, P. (2001) - Upper Cenomanian and Lower Turonian Ammonite Biostratigraphy of West-Central Portugal. *Bull. Soc. d'Étude Sci. Nat. d'Elbeuf, Spec. Num. "Colloque sur le Cénomanien"*: 23-26.

Chancellor, G., Kennedy, W. & Hancock, J. (1994) - Turonian ammonite faunas from central Tunisia. *Spec. Papers Palaeont.*, 50, 118 p.

Choffat, P. (1987) - Sur le Crétacique de la région du Mondego. *C.R. Acad. Sc. Paris*, 124: 422-424.

Choffat, P. (1898) - Recueil d'études paléontologiques sur la Faune Crétacique du Portugal 2, Les Ammonées du Bellasien, des Couches à *Neolobites vibrayeanus*, du Turonien et du Senonien. *Section des. Travaux. Géologiques du Portugal*, Lisbonne, 45 p.

Choffat, P. (1900) - Recueil de monographies stratigraphiques sur le Système Crétacique du Portugal - Deuxième étude - Le Crétacé supérieur au Nord du Tage. *Direction Services Géologiques Portugal*, Lisbonne, 287 p.

Cobban, W. & Hook, S. (1983) - *Pseudaspidoceras pseudonodosoides* (Choffat) - common Upper Cretaceous guide fossil in southwest New Mexico. *Ann. Rep. New Mexico Bur. Mines Min. Res.*, 1981-82: 37-40.

Cobban, W.; Hook, S. & Kennedy, W. (1989) - Upper Cretaceous rocks and ammonite faunas of southwestern New Mexico. *Mem. New Mex. Bur. Mines Min. Res.*, 45, 137 p.

Cooper, M. (1978) - Uppermost Cenomanian-Basal Turonian Ammonites from Salinas, Angola. *Ann. South African Museum*, 75: 51-152.

Courtiller, M. (1860) - Description de trois nouvelles espèces d'ammonites du terrain crétacé. *Mém. Soc. Impér. Agric. Sci. Arts Angers*, 3: 246-252.

Diniz, J. (1999) - *Estratigrafia e Sedimentologia da Formação da Figueira da Foz – Aptiano a Cenomaniano do sector Norte da Bacia Lusitânica.* Unpublished D. Phil. Thesis, Coimbra University, 381p.

Hook, S. & Cobban, W, (1981) - Late Greenhorn (mid-Cretaceous) discontinuity surfaces, southwest New Mexico. *New Mexico Bur. Mines Miner. Res. Circ.*, 180: 5-21.

Hancock, J.; Kennedy, W. & Cobban, W. (1993) - A correlation of the Upper Albian to basal Coniacian sequences of Northwest Europe, Texas and the United States Western Interior. *In* Caldwell, W. & Kauffman, E. eds. - The evolution of the Western Interior Basin. *Geol.Assoc. Canada, spec. paper*, 39: 453-476.

Howarth, M. (1985) - Cenomanian and Turonian ammonites from the Novo Redondo area Angola. *Bull. British. Museum (Nat. Hist.)*, Geol. Series, 39: 73-105.

Kennedy, W. (1984) - Ammonite faunas and the "standard zones" of the Cenomanian to the Maastrichtian stages in their type areas, with some proposals for the definition of stage boundaries by ammonites. *Bull. Geol. Soc. Denmark*, 33: 147-161.

Kennedy, W. (1985) - Integrated macrobiostratigraphy of the Albian to basal Santonian. *Publ. Palaeont. Inst. Univ. Upsala*, spec. 5: 91-108.

Kennedy, W. (1986) - Ammonite biostratigraphy of the Albian to Basal Santonian (Appendix 1). *In* Reyment, R. & Bengtson, P. eds. - *Events of the Mid-Cretaceous*, Pergamon Press, Oxford: 129-143.

Kennedy, W. (1988) - Late Cenomanian and Turonian Ammonite faunas from North-East and Central Texas. *Spec. Pap. Palaeont.*, 39, 131 p.

Kennedy, W.; Amédro, F.; Badillet, F.; Hancock, J. & Wright, C. (1984) - Notes on late Cenomanian and Turonian ammonites from Touraine, Western France. *Cret. Research*, 5: 29-45.

Kennedy, W.; Amédro, F. & Collete, C. (1986) - Late Cenomanian and Turonian ammonites from Ardennes, Aube and Yonne, Eastern Paris Basin (France). *N. Jb. Geol. Palaeont. Abh.*, 172: 193-217.

Kennedy, W. & Cobban, W. (1991) - Stratigraphy and interregional correlation of the Cenomanian-Turonian transition in the Western Interior of the United States near Pueblo, Colorado, a potential boundary stratotype for the base of the Turonian stage. *Newsl. Stratigr.*, 24: 1-33.

Kennedy, W.; Cobban, W.; Hancock, J. & Hook, S. (1989) - Biostratigraphy of the Chispa Summit Formation at is type locality: a Cenomanian through Turonian reference section for Trans-Pecos Texas. *Bull.Geol. Inst. Univ. Uppsala*, 15: 39-119.

Kennedy, W. & Juignet, P. (1981) - Upper Cenomanian Ammonites from the environs of Saumur, and the provenance of the types of Ammonites vibrayeanus and Ammon. geslinianus. *Cret. Research*, 2: 19-49.

Kennedy, W.; Juignet, P. & Hancock, J. (1981) - Upper Cenomanian ammonites from the Anjou and the Vendée, Western France. *Palaeont.*, 24: 25-84.

Kennedy, W. & Simmons, D. (1991) - Mid-Cretaceous ammonites and associated microfossils from the Central Oman Mountains. *Newsl. Stratigr.*, 25: 127-154.

Kennedy, W. & Wright, C. (1979a) - On *Kamerunoceras* Reyment, 1954 (Cretaceous: Ammonoidea). *Journ. Paleontology*, 53: 1165-1178.

Kennedy, W. & Wright, C. (1979b) - Vascoceratid ammonites from the type Turonian. *Palaeont.*, 22: 665-683.

Kennedy, W.; Wright, C., & Hancock, J. (1982) - Ammonite zonation and correlation of the uppermost Cenomanian and Turonian of Southern England and the type areas of Sarthe and Touraine in France. *Mém. Mus. Nat. Hist. Naturelle.*, 49: 175-181.

Kennedy, W.; Wright, C. & Hancock, J. (1987) - Basal Turonian ammonites from west Texas. *Palaeont.*, 30: 27-74.

Lauverjat, J. (1978) - Le Cénomanien de la Valée du Mondego (Portugal). Limite avec le Turonien. Evolution Ouest-Est, implications paléogéographiques. *Géol. Mediterranéenne*, 5: 109- 114.

Lauverjat, J. (1982) - *Le Crétacé Supérieur dans le Nord du Bassin Occidental Portugais*. Univ. Pierre et Marie Curie, Th. Doct. D'État, Paris.

Lauverjat, J. & Berthou, P. (1973) - Le Cénomano-Turonien de l'embouchure du Rio Mondego, Beira Litoral, Portugal. *Comun. Serv. Geol. Portugal*, 57: 266-301.

Meister, C. & Abdallah, H. (1996) - Les ammonites du Cenomanien Supérieur et du Turonien Inférieur de la region de Gafsa-Chotts, Tunisie du Centre-Sud. *Geobios*, 29(5), appendix, 22 p.

Meister, C.; Aizouma, K.; Lang., J. & Mathey, B. (1992) - Les ammonites du Niger (Afrique occidentale) et la transgression transsaharienne au cours du Cenomanien-Turonien. *Geobios*, 25(1): 55-100.

Meister, C.; Aizouma, K.; Lang., J.; Mathey, B. & Pascal., A. (1994) - Nouvelles données sur les Amonites du Niger oriental (Tenere, Afrique occidentale) dans le cadre de la transgression du Cenomanien-Turonien. *Geobios*, 27: 189-219.

Mojica, J. & Wiedmann, J. (1977) - Kreide-Entwicklung und Cenomanien/Turonien Grenze der mittleren Keltiberischen Ketten bei Nuevalos (Prov. Zaragoza, Spanien). *Ecl. Geol. Helv.*, 70: 739-759.

Moron, J. (1981) - *Etude Paléobotanique et Palynologique du Crétacé supérieur du Bassin Occidental Portugais au Nord de l'accident de Nazaré (Portugal)*. Thèse 3ème cycle, Paris, 287 p.

Peron, A. (1889-93) - *Description des Mollusques fossiles des terrains Crêtacés de la région du Sud des hauts-plateaux de la Tunisie, recueillis en 1885 et 1886 par M. Philippe Thomas*. Imprim. Nationale, Paris, 405 p.

Pervinquière, L. (1907) - Études de Paléontologie Tunisienee. 1. Céphalopodes des terrains secondaires. *Carte Géologique de la Tunisie, De Rudeval*, Paris, 438 p.

Rawson, P., Dhondt, A., Hancock, J. & Kennedy, W. (eds.) (1997) - Proceedings of the Second International Symposium on Cretaceous Stage Boundaries. *Bull. Inst. Royal Sci. Nat. Belgique*, 66, appendix: 69-80.

Robaszynski, F.; Alcayde, G.; Amedro, F.; Badillet, G.; Damotte, R.; Foucher, J.; Jardine, S.; Legoux, O.; Manivit, H.; Monciardini, C. & Sornay, J. (1982) - Le Turonien dans sa region-type «de Saumur a Montrichard»: Biostratigraphie, Sedimentologie, Coupures. *Mem. Mus. Nat. Hist. Nat.*, Paris, C, 49: 15-28.

Robaszynski, F.; Caron, M.; Duouis, C.; Amédro, F.; Donoso, J.-M.; Linares, D.; Hardenbol, J.: Gartner, S.; Calandra, F. & Deloffre, R. (1990) - A tentative integrated stratigraphy in the Turonian of Central Tunisia: formations, zones and sequential stratigraphy in the Kalaat Senan area. *Bull. Centre Rech. Explor.-Prod. ELF-Aquitaine*, 14: 213-284.

Soares, A. (1966) - Estudo das formações pós-jurássicas das regiões de entre Sargento-Mor e Montemor-o-Velho (margem direita do Rio Mondego). *Memórias Notícias*, Coimbra, 62, 343 p.

Soares, A. (1972) - Contribuição para o estudo do Cretácico em Portugal (o Cretácico superior da Costa de Arnes). *Memórias Notícias*, Coimbra, 74: 1-56.

Soares, A. (1980) - A «Formação Carbonatada» na região do Baixo-Mondego. *Comun. Serv. Geol. Portugal*, 66: 99-109.

Soares, A. & Marques, A. (1973) - Os equinídeos cretácicos da região do Rio Mondego (estudo sistemático). *Memórias Notícias*, Coimbra, 75: 1-45.

Wiedmann, J. (1964) - Le Crétacé supérieur de l'Espagne et du Portugal et ses Céphalopodes. *Estud. Geol.*, 20: 107-148.

Wiedmann, J. (1975) - Subdivisiones et precisiones bioestratigraficas en el Cretacico Superior de las Cadenas Celtibericas. *Actes 1er Symp. Cret. Cord. Iberica*: 135-153.

Wiedmann, J. & Kauffman, E. (1978) - Mid-Cretaceous biostratigraphy of Northern Spain. *Ann. Mus. Hist. Natur. Nice*, 4: 1-33.

Wright, C. & Kennedy, W. (1981) - The Ammonoidea of the Plenus Marls and Middle Chalk. *Mon. Palaeont. Soc.*, 134, 148 p.

Wright, C. & Kennedy, W. (1987) - The Ammonoidea of the Lower Chalk. *Mon. Palaeont. Soc.*, 139: 127-218.

Zaborski, P. (1990) - The Cenomanian and Turonian (mid.Cretaceous) ammonite biostratigraphy of north-eastern Nigeria. *Bull. British Museum (Nat. Hist)*, ser. Geology, 46: 1-18.

Zaborski, P. (1995) - The Upper Cretaceous ammonite *Pseudaspidoceras* Hyatt, 1903, in north-eastern Nigeria. *Bull. Nat. Hist. Mus. London*, ser. Geology, 51: 53-72.

Zaborski, P. (1996) - The Upper Cretaceous ammonite *Vascoceras* Choffat, 1898 in north-eastern Nigeria. *Bull. Nat. Hist. Mus. London*, ser. Geology, 52: 61-89.

Plate 1

Fig. 1a-b – *Euomphaloceras septemseriatum* (Cragin, 1893). Specimen DCTAM523, from Mala, NW Coimbra, Upper Cenomanian (x1).

Fig. 2a-b – *Euomphaloceras septemseriatum* (Cragin, 1893). Specimen DCTAM106, from Salmanha, Figueira da Foz, unit "E", Upper Cenomanian (x1).

Fig. 3a-b – *Kamerunoceras douvillei* (Pervinquière, 1907). Specimen DCTAM152, from Salmanha, Figueira da Foz, unit "L", Lower Turonian (x1).

Fig. 4 – *Neoptychites cephalotus* (Courtiller, 1860). Specimen DCTAM56, from Salmanha, Figueira da Foz, unit "L", Lower Turonian (x1).

Fig. 5a-b – *Kamerunoceras douvillei* (Pervinquière, 1907). Specimen CTAM815, from Salmanha, Figueira da Foz, unit "L", Lower Turonian (x1).

PLATE 1

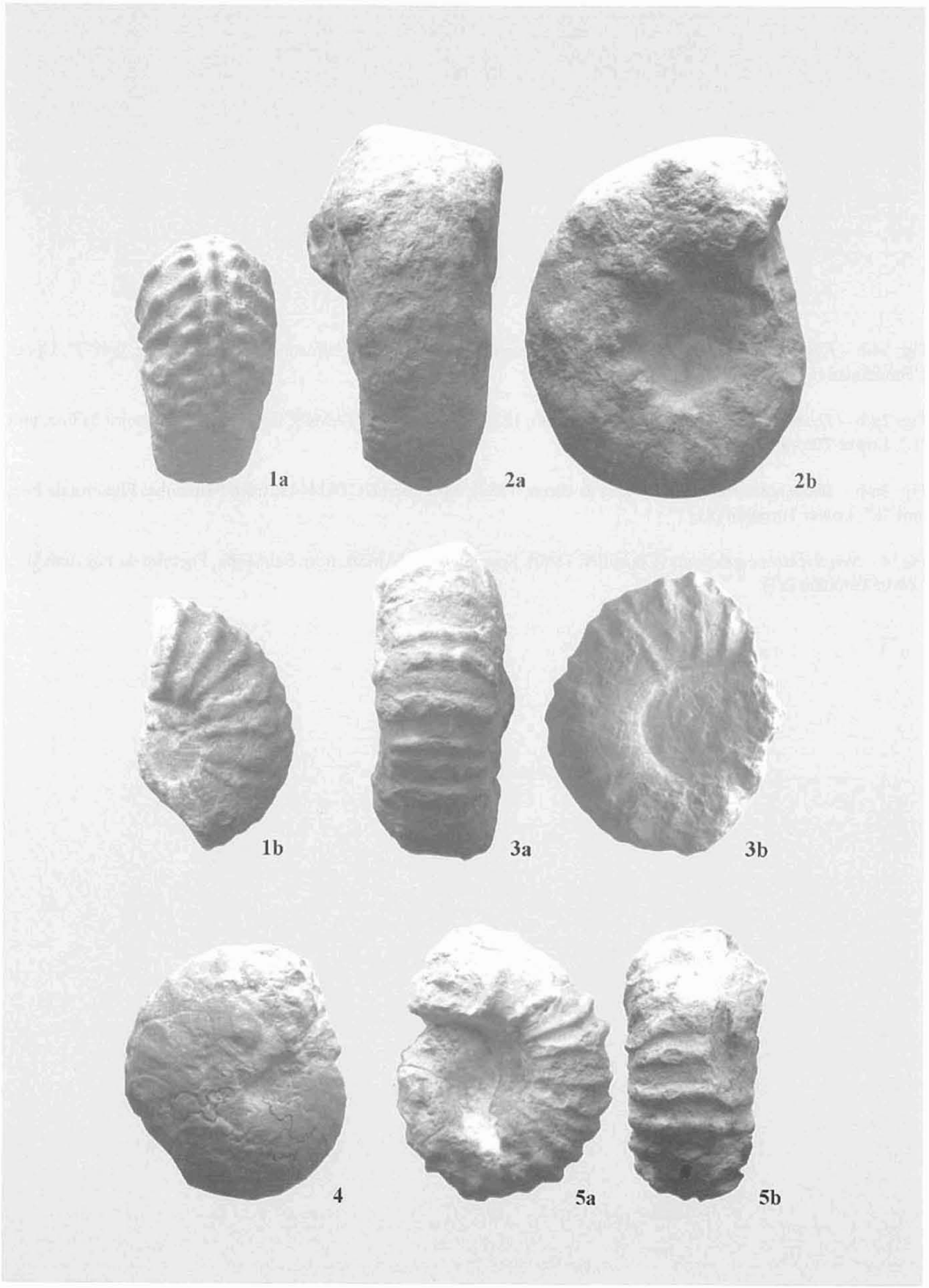

Plate 2

Fig. 1a-b – *Fagesia catinus* (Mantell, 1822). Specimen DCTAM30, from Salmanha, Figueira da Foz, unit "J", Upper Cenomanian (x1).

Fig. 2a-b – *Thomasites rollandi* (Thomas & Peron, 1889). Specimen DCTAM49, from Fontela, Figueira da Foz, unit "L", Lower Turonian (x1).

Fig. 3a-b – *Thomasites rollandi* (Thomas & Peron, 1889). Specimen DCTAM442, from Salmanha, Figueira da Foz, unit "L", Lower Turonian (x1).

Fig. 4 – *Neoptychites cephalotus* (Courtiller, 1860). Specimen DCTAM56, from Salmanha, Figueira da Foz, unit "L", Lower Turonian (x1).

PLATE 2