

Ammonite stratigraphy of the Valanginian to Barremian for the Mediterranean region

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Since the 2nd Workshop of the Lower Cretaceous Cephalopod Team in Mula, Spain (Hoedemaeker et al., 1993), several ammonite zones and ammonite horizons have been introduced that still have not been inserted in the standard zonation of the Mediterranean area. In the present survey (1) the different results of various independent specialists are compared, (2) an attempt is made to correlate their resulting zonation schemes, and (3) recommendations are given for the use of the newly introduced zones and horizons in the Mediterranean region.

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Introduction

Since the 2nd workshop of the International Lower Cretaceous Cephalopod team in Mula (Spain) in 1992 (Hoedemaeker et al., 1993), several new ammonite zones and biohorizons for the Mediterranean region have been introduced and defined. Some of them were already introduced before the 3rd workshop of this team in Piobbico (Italy) in 1994 (Hoedemaeker et al., 1995), but the team preferred not to change the standard zonation because too many changes in too short a time would affect the credibility of the team. Also during the 4th workshop in London in 1997 (Rawson et al., this volume) the team again decided not to change the zonation, because many newly proposed biostratigraphic units were still invalid, controversial, or difficult to calibrate. The team hopes to be able to perform the necessary changes in 2000, when there will be a 5th workshop. This paper gives an outline of the ammonite zones and biohorizons that have been proposed since 1992 for the Mediterranean region and discusses their validity and usefulness for a future standard zonation.

At first we discuss the ammonite zones and horizons that were introduced since 1992 by two independent groups of lower Cretaceous ammonite specialists, one from

Grenoble (mainly the authors Bulot and Thieuloy) and the other from Lyon (mainly the authors Atrops and Reboulet). They published many papers on the Valanginian and Hauterivian strata in southeast France. The newly proposed ammonite zones and horizons are here compared, the zonal schemes as far as possible correlated, and recommendations are given as to the validity and workability of the newly proposed biostratigraphic units as standard biostratigraphic units for the Mediterranean region.

Secondly we discuss the new zones and horizons proposed for the upper Hauterivian and Barremian. For the upper Hauterivian no spectacular changes have been proposed. For the Barremian, however, several new biostratigraphic units have been introduced mainly by two groups of specialists: one from Granada (Spain) and one from Nice (France). Company, Sandoval & Tavera (1995) from Granada propose for this stage a zonal scheme that is slightly different from that of the Mula scheme. Their scheme is based on the analysis of the stratigraphic distribution of over 4000 ammonites collected in different sections of the Betic Cordillera (Spain).

The knowledge of the ammonite stratigraphy in the Barremian stratotype is recently considerably augmented as a result of the work of the authors Delanoy and Vermeulen from Nice. The stratotype, therefore, can now very well be used as a reference for correlation. Vermeulen (1996a, 1997a, 1998b) proposed a heterophyletic biozonation for this stage based on the ammonite family Pulchelliidae, a result of his investigations in SE France and Spain and his study of this family. Delanoy (1997, 1998) proposed some new horizons for the Upper Barremian Substage, which has since long been the subject of his research.

Also the work in Spain of Company et al. (1995), Hoedemaeker (1995) and Hoedemaeker & Leereveld (1995) has considerably contributed to a more detailed correlation and a better knowledge of the upper Hauterivian and Barremian stratigraphy of the Mediterranean region.

Valanginian and lower Hauterivian zonation (Fig. 1)

Grenoble proposals

Horizon of *Kilianella thieuloyi* (upper part of the Otopeta Subzone)

Bulot & Thieuloy (1995) indicate that this horizon spans the biostratigraphic interval between the first appearance of *Kilianella thieuloyi* nom. nud. (unpublished thesis of Bulot, 1995) and that of *Tirnovella pertransiens* (Sayn, 1907), without giving a formal definition.

The ammonite association of this horizon is nearly equal to that of the lower part of the Otopeta Subzone. All this hinders the use this biohorizon in a Mediterranean context.

Zone of *Olcostephanus (Olcostephanus) stephanophorus*

This zone was defined by Bulot & Thieuloy (1995) as the biostratigraphic interval between the first appearance of *O. (O.) stephanophorus* (Matheron, 1878) and that of *Karakaschiceras inostranzewi* (Karakasch, 1889). *O. (O.) stephanophorus* was carefully described by Bulot & Autran (1989). It appears to be well distinguishable from other species of *Olcostephanus*.

stage	Bulot & Thieuloy, 1992-1995		Atrops & Reboulet, 1992-1995	
	Zone	Horizons	Zones	Horizons
HAUTERIVIAN	<i>L. nodosoplicatum</i>	<i>L. collignoni</i>	<i>L. nodosoplicatum</i>	<i>L. bargemense</i>
		<i>O. variegatus</i>		<i>L. nodosoplicatum</i>
	<i>C. loryi</i>	<i>O. (J.) jeannoti</i>	<i>C. loryi</i>	<i>O. (J.) jeannoti</i>
		<i>C. loryi</i>		<i>C. loryi</i>
<i>A. radiatus</i>	<i>L. buxtorfi</i>	<i>A. radiatus</i>		
	<i>B. castellanense</i>			
VALANGINIAN	<i>T. callidiscus</i>		<i>T. callidiscus</i>	
		<i>T. callidiscus</i>		<i>T. callidiscus</i>
	<i>H. trinodosum</i>	<i>C. furcillata</i>	<i>H. trinodosum</i>	<i>C. subheterocostata</i>
		<i>O. nicklesi</i>		<i>C. furcillata</i>
				<i>K. companyi</i>
	<i>S. verrucosum</i>	<i>V. perigrinus</i>	<i>S. verrucosum</i>	<i>V. perigrinus</i>
		<i>K. pronecostatum</i>		<i>K. pronecostatum</i>
		<i>S. verrucosum</i>		<i>N. neocomiensis</i>
				<i>S. verrucosum</i>
	<i>K. inostranzewi</i>		<i>B. campylotoxus</i>	<i>N. (E.) platycostatus</i>
				<i>K. biassalense</i>
	<i>O. stephanophorus</i>	<i>B. campylotoxus</i>		<i>S. fuhri</i>
		<i>B. subcampylotoxus</i>		<i>K. quadristrangulatum</i>
		<i>B. hirsutus</i>		<i>B. hirsutus</i>
<i>T. pertransiens</i>		<i>T. pertransiens</i>		
<i>K. otopeta</i>	<i>K. thieuloyi</i>			
	<i>K. otopeta</i>			

Fig. 1. Newly proposed Valanginian and lower Hauterivian zones and horizons.

The distribution is almost global: France, Switzerland (?), Spain, South Africa (?) according to Bulot & Autran (1989) and Pakistan according to Fatmi & Rawson (1993). The ammonite association is quite different from that of the Pertransiens Zone, for simultaneously with the name-giving species appear according to Bulot & Thieuloy (1995): *Busnardoites roberti* (Bulot, 1995) nom. nud., *Baronnites hirsutus* (Fallot & Termier, 1923), *Olcostephanus (O.) tenuituberculatus* morph A (Bulot, 1995), *O. (O.) drumensis pelegrinus* (Sayn) nom.nud., *O. (O.) josephinus* (d'Orbigny, 1850), and *Neocomites (N.) teschenensis* (Uhlig, 1901).

If Bulot (1995) is right in banning the presence of true *Busnardoites campylotoxus* (Uhlig, 1901) to the upper part of the Stephanophorus Zone (in contrast to the data of Reboulet, 1995), this zone could be, together with the overlying Inostranzewi Zone, a substitute for the the upper part of the Pertransiens Zone (Horizon of *Baronnites hirsutus*) and the current Campylotoxus Zone. The Salinarium Zone, defined in SE Spain (Company, 1987) as the biostratigraphic interval between the first appearance of *B. hirsutus* and the appearance of *Saynoceras verrucosum* (d'Orbigny, 1841), cannot be an alternative for the Campylotoxus Zone, for, although it would occupy the same inter-

val as the *Stephanophorus* and *Inostranzewi* zones as proposed by Bulot & Thieuloy (Company, 1987), ammonites identical to the index species, *Vergolicerias salinarium*, were already found in the *Otopeta* Zone in France according to Bulot & Thieuloy (1995) and own investigations.

Horizon of *Baronnites hirsutus* (basal part of the *Stephanophorus* Zone)

The base of this horizon was defined by Company (1987) as the level of the first appearance of *Baronnites hirsutus* (Fallot & Termier, 1923); later Bulot & Thieuloy (1995) defined the top of the horizon as the level of the first appearance of *Busnardoites subcampylotoxus* Nikolov, 1977.

B. hirsutus is easy to identify and the ammonite association of the horizon is significantly distinct from that of the *Pertransiens* Zone (see Zone of *Olcostephanus stephanophorus*). However, the known distribution is limited (France and Spain only), so that its value as a standard subzone for the entire Mediterranean region is still unclear.

Horizon of *Busnardoites subcampylotoxus* (middle part of the *Stephanophorus* Zone)

The horizon was defined by Bulot & Thieuloy (1995) as the biostratigraphic interval between the first appearance of *B. subcampylotoxus* and that of *B. campylotoxus*. Hitherto no French specimen of *B. subcampylotoxus* has been figured; the species was merely mentioned in a faunal list from the shallow water deposits of the Carejuan section (Bulot et al., 1995b) and it is not figured in Bulot's unpublished thesis (1995). All other French records are uncertain. Despite the fact that Bulot & Thieuloy (1995) mention four successively appearing species of *Busnardoites* (*B. roberti* Bulot, 1995, nom. nud., *B. subcampylotoxus*, *B. campylotoxus*, and *B. meganae* Bulot 1995, nom. nud., respectively), it is not possible to estimate the correlation value of this horizon before Bulot's data are published. Neither is it possible to judge its validity as to the composition of its characteristic ammonite association against the overlying *Campylotoxus* Horizon, nor to judge whether it is justified to abandon the *Campylotoxus* Zone. According to Nikolov (1977) and Bulot & Thieuloy (1995) *B. subcampylotoxus* appears earlier than *B. campylotoxus*. Company (1987), however, recorded *B. subcampylotoxus* at the top of his *Salinarium* Zone, just before the appearance of *Saynoceras verrucosum*.

Horizon of *Busnardoites campylotoxus* (upper part of the *Stephanophorus* Zone)

The horizon was defined by Bulot & Thieuloy (1995) as the biostratigraphic interval between the first appearance of *B. campylotoxus* and that of *Karakaschiceras inostranzewi*.

B. campylotoxus has a very wide distribution within the Mediterranean Region (Nikolov, 1977; Reboulet, 1995); specimens of this species were mentioned from Pakistan (Fatmi, 1977) and Madagascar (Collignon, 1962), but these identifications are probably not correct. Justification of this horizon awaits further discussion and publication of more details about the genus *Busnardoites*. Moreover, this horizon should not be confounded with the Zone of *B. campylotoxus*, which was introduced by Thieuloy (1973) and defined by Busnardo & Thieuloy (1979) as the interval between the first appearance of the name-giving species and the first appearance of *Saynoceras verrucosum*, which is considerably higher than the first appearance of *K. inostranzewi*.

Such a drastic change in the concept of a biostratigraphic unit, while keeping the same name, is not recommended by the International Subcommission on Stratigraphic Nomenclature. The use of this horizon is therefore discouraged.

Zone of *Karakaschiceras inostranzewi*

The zone was defined by Bulot & Thieuloy (1995) as the biostratigraphic interval between the first appearance of *K. inostranzewi* and that of *Saynoceras verrucosum*.

K. inostranzewi can easily be distinguished from *K. biassalense* (Karakasch, 1889). It is recorded from the Crimea, Roumania (?), France, Spain, and Morocco (see Company, 1987). The accompanying ammonite fauna is characteristic: *Neohoplloceras provinciale* (Sayn, 1907), *Valanginites paludensis* Thieuloy, 1977, *Saynoceras fuhri* Bulot, Company & Thieuloy, 1990, and *Karakaschiceras biassalense*.

According to Bulot & Thieuloy (1995), *K. inostranzewi* and *K. biassalense* have exactly the same stratigraphic range. The reasons for abandoning the Horizon of *K. biassalense* of Bulot et al. (1992b) and Bulot & Thieuloy (1993) are not explained in Bulot & Thieuloy (1995); they refer to the unpublished thesis of Bulot (1995). The distribution and the high frequency of *K. biassalense* are in favour of this species as index species of the zone instead of *K. inostranzewi*.

Horizon of *Karakaschiceras pronecostatum* (sensu Bulot et al., 1992a-b: middle part of Verrucosum Zone)

This horizon was defined as the biostratigraphic interval between the first appearance of *K. pronecostatum* (Felix, 1891) and that of *Varltheideites peregrinus* Rawson & Kemper, 1978. It was introduced by Bulot et al. (1992a) and defined by Reboulet et al. (1992) and by Bulot et al. (1992b).

According to Bulot & Thieuloy (1995) the variability of *K. pronecostatum* is very great and will be discussed and illustrated in the unpublished thesis of Bulot (1995). Only one specimen of this species has been figured by Thieuloy et al. (1990) under the name of *K. biassalense*; it was later included in *K. pronecostatum* by Bulot et al. (1992b). In the vast collection of one of the authors (J.K.) the specimens of *Karakaschiceras* from the Pronecostatum Horizon of the La Charce section (beds 204-211) are not really comparable with the original material of Pictet & Campiche studied by J.K. in Lausanne. According to Bulot & Thieuloy (1995) *K. pronecostatum* is reported from France, Austria, The Crimea, Algeria, Pakistan, and Madagascar, and possibly from Roumania, Bulgaria, Spain and Morocco. It has also been reported from Poland

In this horizon lay the acmes of *Neohoplloceras depereti* (Sayn, 1907) and *Rodighieroites lamberti* (Sayn, 1907). However, until now the latter two species have not been found outside France with certainty; furthermore how *K. pronecostatum* precisely looks like is still obscure at this moment. This must be cleared before acceptance as a standard horizon.

Horizon of *Varltheideites peregrinus* (sensu Bulot et al., 1992a-b: upper part of the Verrucosum Zone)

This horizon was defined as the biostratigraphic interval between the first appearance of *V. peregrinus* and that of *Himantoceras trinodosum* Thieuloy, 1964; it was introduced by Bulot et al. (1992a) and defined by Reboulet et al. (1992) and Bulot et al.

(1992b). *V. peregrinus* is easily identifiable when complete.

It was first described from North Germany and is now found in France, Switzerland, Spain (Klein, in prep.), and perhaps in Italy (Cecca, 1995; Faraoni et al., 1997). This horizon is expected to be recognized all over the Mediterranean region and to be of importance for Boreal-Tethyan correlation.

Horizon of *Breistrofferella castellanensis* (lower part of the Radiatus Zone)

The horizon was introduced by Bulot et al. (1992b) for the lower part of the Radiatus Zone but not formally defined. *B. castellanensis* (d'Orbigny, 1840) is reported from France, Switzerland, Spain, Tunisia, Caucasus (?), and northern Germany (Klein, in prep.). It may be of importance for Boreal-Tethyan correlation. The first appearance of this species can be considered a good indicator of the Valanginian-Hauterivian boundary in the absence of *Acanthodiscus*. After verification of the determination of this species in the Caucasus, this species may be considered to formally define this horizon and it may be included in the standard zonal scheme for the Mediterranean region.

Horizon of *Leopoldia buxtorfi* (upper part of the Radiatus Zone)

This horizon is introduced by Arnaud et al. (1992) in a stratigraphic diagram of the Carejuan section as the upper part of the Radiatus Zone without formal definition. *L. buxtorfi* Baumberger, 1905, is at this moment known from Switzerland, France, and possibly Algeria and northern Germany. The species is only found in condensed platform sections and is therefore not useful for correlation over the entire Mediterranean Region.

Horizon of *Olcostephanus (Olcostephanus) variegatus* (lower part of the Nodosoplicatum Zone)

The horizon was introduced by Bulot (1990) and later defined by Bulot et al. (1992b) as the basal part of the Nodosoplicatum Zone without defining its top. It is probably the last species of *Olcostephanus* before extinction of the genus. *O. (O.) variegatus* (Paquier, 1890) is recently extensively described by Bulot (1990).

According to Bulot the species is of great importance for interregional correlation, for it has a nearly worldwide distribution and has been found in Switzerland, France, Great Britain, Tanzania, and possibly Peru, Colombia and Mexico. It is a small disadvantage that the first appearance of the species is slightly below that of *Lyticoceras nodosoplicatum* (Kilian & Reboul, 1915), but the high frequency and the wide distribution favour a more universal use of this horizon.

Horizon of *Lyticoceras collignoni* (upper part of the Nodosoplicatum Zone)

The horizon was introduced by Bulot et al. (1995b) but not defined. The type specimen of this undiagnosed species is according to Bulot et al. (1995b) *Lyticoceras cryptoceras* Thieuloy, non d'Orbigny, in Kemper et al. (1981: pl. 42, fig. 2). This species has hitherto been mentioned only from France.

Lyon proposals

Horizon of *Karakaschiceras quadrirangulatum* (lower part of the Campylotoxus Zone)

This horizon was defined by Atrops & Reboulet (1995a) as the biostratigraphic interval between the first appearance of *Busnardoites campylotoxus* and that of *Saynoceras fuhri*.

Atrops & Reboulet (1995a-b) recorded a single specimen of *K. quadrirangulatum* (Sayn, 1907) (though questionably) at the very base of the Campylotoxus Zone in the La Charce section. The second specimen was reported from the middle of the name-bearing horizon. In the Vergol section no *K. quadrirangulatum* was found in its name-bearing horizon, but only in the Horizon of *K. biassalense*. Later Reboulet (1995) omitted the dubious specimen from La Charce, which implies that the first appearance of the species is in the middle of its name-bearing horizon only in the La Charce section.

Whether the large calcareous specimens of *K. quadrirangulatum* depicted by Atrops & Reboulet (1995a) belong to the same species as the limonitized type specimen of Sayn, cannot be established; it was only guessed by Atrops & Reboulet (1995a). The type specimen originates from Beaumugne, where only the Verrucosum Zone (with pyritized ammonites) is well exposed. Kutek et al (1989) cited this species from the Pertransiens Zone and from high in the Verrucosum Zone. Perhaps it concerns two homeomorphic species of *Karakaschiceras*. All together, it is recommended here to abandon this Horizon.

Horizon of *Saynoceras fuhri* (lower middle part of the Campylotoxus Zone)

This horizon was defined by Atrops & Reboulet (1995a) as the biostratigraphic interval between the first appearance of the name-giving species and that of *Karakaschiceras biassalense*.

S. fuhri is easily identifiable. In the reference sections of Vergol and La Charce the name-giving species is relatively abundant. Insertion of this horizon in the Mediterranean standard zonation is at this moment not recommendable because of the limited information available on its distribution (only France) and the lack of a significantly distinct ammonite association.

Horizon of *Karakaschiceras biassalense* (sensu Atrops & Reboulet, 1995a: upper middle part of the Campylotoxus Zone)

At first this horizon was informally proposed by Cotillon (1971) to represent the interval now occupied by the upper part of the current Campylotoxus Zone up to the first appearance of *Acanthodiscus radiatus* at the base of the Hauterivian Stage. Since the redefinition of the Verrucosum Zone by Moullade (1966), Moullade & Thieuloy (1967), and Busnardo & Thieuloy (1979) it was retained in a restricted sense as the upper part of the Campylotoxus Zone and informally conceived as the biostratigraphic interval from the first appearance of the name-giving species to the first appearance of *Saynoceras verrucosum* (d'Orbigny, 1841) (Bulot et al., 1992b; Bulot & Thieuloy, 1993). In 1995, however, Bulot & Thieuloy replaced it without any arguments by the Zone of *Karakaschiceras inostranzewi*, which has the same characteristic ammonite association. Atrops & Reboulet (1995b) still stick to the Horizon of *K. bias-*

salense, but inserted a new horizon, the Horizon of *Neocomites (Eristavites) platycostatus*, between it and the Zone of *S. verrucosum*. They defined the horizon as the biostratigraphic interval between the last occurrence of *S. fuhri* and the first appearance of *N. (E.) platycostatus* Sayn, 1907.

The Horizon of *K. biassalense* in the sense of Atrops & Reboulet (1995a) is of limited use. However, if it is used in the sense of Bulot et al. (1992b) it may be a good, or even preferable substitute for the Inostranzewi Zone and has the potential to be inserted in the standard zonation for the Mediterranean region.

Horizon of *Neocomites (Eristavites) platycostatus* (upper part of the Campylotoxus Zone)

This horizon was defined by Atrops & Reboulet (1995b) as the biostratigraphic interval between the first appearance of the name-giving species and that of *Saynoceras verrucosum*.

The distribution of *N. (E.) platycostatus* is, according to our present knowledge, rather wide: France, Switzerland, Spain, Czech Republic, and Sumatra (Indonesia) (Baumberger, 1925). Notwithstanding the wide horizontal distribution, the horizon does not have a significantly distinct ammonite association.

On account of its wide distribution the species may well function as an important correlation tool. Its use as a Mediterranean standard horizon is, however, not recommended.

Horizon of *Neocomites neocomiensis* (lower middle part of the Verrucosum Zone)

This horizon was defined by Atrops & Reboulet (1993) as the biostratigraphic interval between the disappearance of *Saynoceras verrucosum* and that of *Karakaschiceras pronecostatum* (Felix, 1891) sensu Atrops & Reboulet, 1992. The interval with many pyritized specimens ('riche en exemplaires pyriteux') of *N. neocomiensis* (d'Orbigny, 1841) in the Angles section is not accompanied by other characteristic ammonite species. *N. neocomiensis* was reported to be present up to the Horizon of *Olcostephanus nicklesi*. In 1995 Reboulet showed that in the Vergol, Morenas, and Gouravour sections the frequencies of *N. neocomiensis* in the Horizon of *N. neocomiensis* and in the overlying Horizon of *K. pronecostatum* are not perceptibly different, and that in the Angles section the acme of this species is even situated in the Horizon of *K. pronecostatum*.

The lack of any characteristic species in the Neocomiensis Horizon makes it unsuitable for insertion in the Mediterranean Standard zonation. *N. neocomiensis* has been reported outside the Mediterranean region from Indonesia (Baumberger, 1925; von Koenigswald, 1939), China (He Guo-xiong & Xia Jin-bao, 1984), and Mexico (Böse, 1923; Gonzales Arrelola et al., 1995)

Horizon of *Karakaschiceras pronecostatum* (sensu Reboulet et al., 1992: upper middle part of the Verrucosum Zone)

This horizon was defined as the biostratigraphic interval between the first appearance of *K. pronecostatum* and that of *Varlheidites peregrinus*.

The species concept of *K. pronecostatum* is not yet clear (see foregoing chapter). The larger specimens of Reboulet (1995: pl. 1, figs. 2, 8) are not comparable with the

specimens of Pictet and Campiche. Only the specimen depicted on pl. 1, fig. 7 compares well with the holotype. It is difficult to demarcate the specimens called *K. pronecostatum* of the Pronecostatum Horizon from those called *K. biassalensis* of the underlying Verrucosum Horizon. This is the reason why Reboulet et al. (1992) found the first specimen that they called *K. pronecostatum* in bed 204 of the La Charce section, Bulot et al. (1992a) in bed 207, and Klein (own investigation) in bed 208 (bed numbers of Bulot et al., 1992a).

Because of the uncertainty of the identity of *K. pronecostatum*, this horizon (sensu Bulot & Thieuloy and sensu Atrops & Reboulet) cannot yet be unambiguously applied in the standard Mediterranean ammonite zonation.

Horizon of *Varlheideites peregrinus* (sensu Reboulet et al., 1992: upper part of the Verrucosum Zone)

This horizon was defined (Reboulet et al., 1992; Reboulet, 1995) as the biostratigraphic interval between the first appearance of *V. peregrinus* and that of *Olcostephanus nicklesi* (Wiedmann & Dieni, 1968). According to Reboulet et al. (1992) it is characterized by the association of the name-giving species with *Rodighieroites cardulus* (Company, 1987), *Neocomites neocomiensis* and *N. retowskyi* (Sarasin & Schöndel-mayer, 1901).

It is important to note that the use of the latter species in characterizing the horizon, was based on a misidentification, because *N. retowskyi* is a lower Berriasian species (type species of the genus *Pseudoneocomites* Hoedemaeker, 1982). Also should be mentioned that Reboulet later (1995) reidentified *Rodighieroites cardulus* as *R. belimelensis* (Mandov, 1976), following Bulot et al. (1992b). According to Reboulet et al. (1992) the base of the horizon in the La Charce section lies a few beds below the level where Bulot et al. (1992a) drew the base of the horizon. This is probably due to collection failure. Nevertheless, the horizon has the potential for insertion in the standard zonation of the Mediterranean region (see foregoing chapter) and is important for Tethyan-Boreal correlations.

Horizon of *Karakaschiceras companyi* (lower middle part of the Trinodosum Zone)

This horizon was defined by Reboulet (1995) as the biostratigraphic interval between the first appearance of *K. companyi* Reboulet, 1995, and that of *Criosarasinella furcillata* Thieuloy, 1977. According to Bulot et al. (1992b) and Reboulet (1995) this biostratigraphic interval has a low ammonite diversity. The name-giving species has not yet been reported from other areas outside S.E. France, limiting the potential of the horizon to be inserted in the standard zonation of the Mediterranean region.

Horizon of *Criosarasinella subheterocostata* (upper part of the Trinodosum Zone)

The horizon was defined by Reboulet (1995) as the biostratigraphic interval between the first appearance of *C. subheterocostata* Reboulet, 1995, and that of *Teschentes callidiscus* Thieuloy, 1971. The associated ammonite fauna is similar to that of the Horizon of *Criosarasinella furcillata*. *C. subheterocostata* is a new name for *C. heterocostata* Thieuloy, 1977, non Mandov, 1976, which has been found only in France.

The lack of a characteristic fauna of its own and the fact that *C. subheterocostata* has not yet been reported from outside France, makes this horizon unsuitable for inser-

tion in the standard zonation of the Mediterranean region at the moment.

Horizon of *Lyticoceras nodosoplicatum* (lower part of the Nodosoplicatum Zone)

This horizon was defined by Reboulet (1995) as the biostratigraphic interval between the first appearance of the name-giving species and that of *Lyticoceras bargemense* Reboulet, non Kilian, 1995. According to Bulot et al. (1992b) and Reboulet (1995) the ammonite association is characteristic: *Olcostephanus (Olcostephanus) variegatus* (Paquier, 1890), *Spitidiscus fasciger* Thieuloy, 1972, *Abrytusites thieuloyi* Vasíček & Michalik, 1986, and *A. julyani* (Honnorat-Bastide, 1890). According to Reboulet (1995), *Lyticoceras cryptoceras* (d'Orbigny, 1840) is also an important species in this horizon. *L. nodosoplicatum* Kilian & Reboul, 1915, is known from France, Spain (Klein, in prep.), and Bulgaria. *L. cryptoceras* is reported from France, Spain (Klein, in prep.), Bulgaria, Italy, and perhaps Switzerland. *Spitidiscus fasciger*, *A. thieuloyi* and *A. julyani* are reported outside France from the Carpathians, Spain, and Bulgaria. *Olcostephanus (O.) variegatus* has an almost global distribution (see foregoing chapter).

One may consider to abandon the Horizon of *L. nodosoplicatum* in favour of *O. (O.) variegatus*.

Horizon of *Lyticoceras bargemense* (sensu Reboulet, 1995: upper part of the Nodosoplicatum Zone)

This horizon was defined by Reboulet (1995) as the biostratigraphic interval between the first appearance of the name-giving species and that of *Subsaynella sayni* (Paquier, 1900).

The name of this horizon and of its index species must be abandoned, because *Hoplites (Leopoldia) bargemensis* Kilian, 1910, is an objective synonym of *Leopoldia castellanensis* var. *varappensis* Baumberger, 1906, which Thieuloy (1977) considered to belong to *Breistrofferella*. Kilian (1910), however, wrote that his *H. (L.) bargemensis* looks like *Hoplites dubisiensis* Baumberger, 1906. The latter was placed into *Neohoploceras* and synonymized with *Neohoploceras schardti* (Baumberger, 1906) by Thieuloy et al. (1990). Later Kilian (in Kilian & Reboul, 1915) treated *Leopoldia bargemensis* as a variety of *L. dubisiensis* (= *Neohoploceras schardti*). Adding to the confusion Thieuloy et al. (1990) considered *L. dubisiensis* var. *bargemensis* Kilian & Reboul, 1915, to be a senior synonym of *Lyticoceras claveli* Busnardo & Thieuloy, 1989. This opinion was followed by Reboulet (1995). Thus *Hoplites (Leopoldia) bargemensis* Kilian, 1910, has successively been placed in the genera *Breistrofferella*, *Neohoploceras* and *Lyticoceras*. Furthermore *L. claveli* can only with difficulty be distinguished from *Acanthodiscus (Neocomites) paludensis* Kilian & Reboul, 1915; they may be synonyms. Finally, Bulot et al. (1995b) believe that *Lyticoceras bargemense* Reboulet, non Kilian is a junior synonym of *L. collignoni* Bulot, 1995. The latter assumption cannot be true.

Comparison and correlation of the Grenoble and Lyon schemes (Fig. 1)

1) Bulot, Thieuloy, Atrops, and Reboulet define the base of the Horizon of *Baronnites hirsutus* by the first appearance of the name-giving species. Atrops & Reboulet included the Horizon of *Baronnites hirsutus* in the Pertransiens Zone. Bulot & Thieuloy (1995), however, included this horizon in their Stephanophorus Zone, because the

first appearance of both index species is at the same level. It should be mentioned, however, that Thieuloy (1979) reported *B. hirsutus* from bed 47 of the Barret-le-Bas section, which is appreciably (9 beds) below the first appearance of *O. (O.) stephanophorus*. Bulot et al. (1995a), however, reidentified this specimen as *Baronnites* sp. indet. If this specimen would turn out to be a true *hirsutus* after all, the base of the Stephanophorus zone and the Hirsutus Horizon would not coincide at all.

2) Bulot & Thieuloy (1995) include the Pertransiens and Stephanophorus zones in the lower Valanginian. They draw the boundary between the lower and upper Valanginian at the base of the Inostranzewi Zone based on several arguments (see Bulot & Thieuloy, 1995: 19). Their proposal is new in the discussion about the boundary between the lower and upper Valanginian; it is the result of high-resolution collecting in the field during the last years and of the increasing knowledge of the distribution of Lower Cretaceous ammonite genera and species. Atrops & Reboulet (1995a), however, draw the boundary between the lower and the upper Valanginian at the base of the Verrucosum Zone as is currently done since Moullade (1966). Hoedemaeker (1982: 42-45) gives a detailed historical review of the lower/upper Valanginian boundary, which he prefers to draw at the base of the Campylotoxus Zone on historical grounds and on the basis of priority.

3) Whether the base of the Horizon of *Busnardoites subcampylotoxus* and the base of the Horizon of *Karakaschiceras quadristrangulatum* exactly correlate is not sure. Bulot & Thieuloy (1995) drew the base of their Stephanophorus Zone at the fourth bed above the base of their 'faisceau S' of the Barret-le-Bas section at the level of the first appearance of *Busnardoites* sp. juv. cf. *subcampylotoxus*; according to them *B. campylotoxus* appears much later. In the La Charce and Les Prades sections Reboulet (1995) drew the base of his Horizon of *K. quadristrangulatum* at the base of what he interpreted as a 'double lowstand systems tract', which is also the level of the first appearance of *B. campylotoxus*. The 'faisceau S' and the 'double lowstand systems tract' may well represent equivalent intervals, because Reboulet (1995) reported the last *Baronnites hirsutus* from the first bed of his 'double lowstand systems tract V3' of the Les Prades section, Bulot (1995) only a few centimetres below this bed, and Bulot & Thieuloy (1995) a few centimetres below the first bed of their 'faisceau S' in the Barret-le-Bas section. Therefore both levels seem to correlate quite well. Thus there is a discrepancy in the interpretation of the scope and identity of *Busnardoites campylotoxus*.

4) The bases of the Inostranzewi Zone and of the Horizon of *Saynoceras fuhri* coincide. According to Bulot & Thieuloy (1995) *S. fuhri* appears together with *Karakaschiceras inostranzewi* at the base of the Inostranzewi Zone. This knowledge was derived from the fossil distribution in the Carejuan section (Bulot et al., 1995b), where both species appear in bed 56. The Horizon of *S. fuhri* is defined by Atrops and Reboulet (1995a) by the first appearance of this species.

5) The base of the Horizon of *Karakaschiceras pronecostatum* sensu Bulot et al. and the base of the Horizon of *K. pronecostatum* sensu Atrops et al. do not exactly correlate. Their concepts of the index species are slightly different, especially its distinction from *K. biassalense*. Nevertheless, in the key-section of La Charce the discrepancy is not too big, only a few beds. So for convenience sake the bases can be drawn at the same level.

6) The same is the case for the Horizon of *Varlheidites peregrinus* sensu Bulot et al.

IGCP Proj. 262 (at Mula, 1993) & 362 (at Piobbico, 1995)		Bulot et al., 1993		Hoedemaeker, 1995; Hoedemaeker & Leereveld, 1995
Zones	Horizons	Zones	Horizons	Zones
<i>P. angulicostata</i>	<i>P. catulloi</i>			<i>P. catulloi</i>
	<i>P. angulicostata</i> auct.			<i>P. ohmi</i>
<i>P. (B.) balearis</i>				<i>P. (B.) balearis</i>
' <i>P. ligatus</i> '		<i>P. ligatus</i> (non sensu Moullade & Thieuloy, 1967)	<i>S. mimica</i>	<i>P. ligatus</i>
<i>S. sayni</i>		<i>S. sayni</i>		<i>S. sayni</i>
	<i>C. cruasense</i>		<i>C. cruasense</i>	

Fig. 2. Newly proposed upper Hauterivian zones and horizons.

and the Horizon of *V. peregrinus* sensu Atrops et al. The discrepancy in the La Charce section is small and probably merely due to collection failure.

7) The base of the Radiatus Zone is defined by Reboulet (1995) to coincide with the first appearance of the genus *Acanthodiscus*. He found *A. rebouli* Kilian 1915 in bed 189 (= bed 250 of Bulot et al., 1992b) of the La Charce section, but he did not figure the specimen. Also Mutterlose (1996) recommended to define the base of the Radiatus Zone (= the base of the Hauterivian) as coinciding with the first appearance of the genus *Acanthodiscus*. We prefer to define the base of the Radiatus Zone with the first appearance of *A. radiatus* Bruguière, 1789. The first *A. radiatus* was found by Bulot et al. (1992b) in bed 254 and the first *Acanthodiscus* sp. in bed 252.

8) The base of the Horizon of *Olcostephanus* (*O.*) *variegatus* and the base of the Horizon of *Lyticoceras nodosoplicatum* almost correlate. *O. (O.) variegatus* is found by Bulot et al. (1992b) only three beds below the first appearance of *L. nodosoplicatum*. Reboulet (1995), however, found them appearing at the same level.

New upper Hauterivian zones and horizons (Fig. 2)

Zone of *Plesiospitidiscus ligatus*

Bulot et al. (1992b) defined this zone as the biostratigraphic interval between the first appearance of *P. ligatus* (d'Orbigny, 1841) and that of *Balearites balearis* (Nolan, 1894).

This new biostratigraphical unit is not the same as the Ligatus Zone defined by Moullade & Thieuloy (1967), because the species called *P. ligatus* by Moullade & Thieuloy (1967) is not the same as *P. ligatus* d'Orbigny, 1841 (Bulot et al., 1992). The base of this newly defined unit lies well below the base of the old Ligatus Zone of Moullade & Thieuloy (1967) and therefore includes a part of the old Sayni Zone, which was decapitated.

At the base of the zone the index species is associated with *Subsaynella mimica* Thieuloy & Bulot, 1992, and *Pseudomoutoniceras annulare* (d'Orbigny, 1842); in the

upper part in the La Charce section it is associated with *Crioceratites majoricensis* (Nolan, 1894), *Acrioceras (Paraspinoceras) pulcherrimum* (d'Orbigny, 1842), *Protacrioceras ornatum* (d'Orbigny, 1850), *Paraspiticeras precrassispinum* (Roch, 1930), and *Megacrioceras doublieri* (Jaubert, 1856).

To establish a correlation with other areas it is important to revise the *Plesiospidiscus ligatus* group as announced by Bulot et al. (1992b). Awaiting this revision, the Ligatus Zone should remain in the standard zonation scheme of the Mediterranean region.

Horizon of *Subsaynella mimica*

This horizon is defined by Bulot et al. (1995b) as the beds that contain the acme of *S. mimica* at the base of the Ligatus Zone sensu Bulot et al. (1992). It is not defined by the first occurrence of *S. mimica*, as this species appears a little below (6 m) the entry of *Plesiospidiscus ligatus* in the La Charce section.

S. mimica is known from France, Algeria and perhaps from Spain, so use as a Mediterranean standard horizon marker is not feasible at the moment.

Zone of *Pseudothurmannia ohmi*

This zone was introduced by Hoedemaeker (1995) and defined in Hoedemaeker & Leereveld (1995) as the biostratigraphic interval between the first appearance of *P. ohmi* (Winkler, 1868) (= *P. angulicostata* auctorum) and that of *P. catulloi* (Parona, 1897). The Ohmi and Catulloi zones together embrace the old Zone of *P. angulicostata*.

Hoedemaeker (1995) described an ammonite association which is quite distinct from the one of the underlying Balearis Zone and still more distinct from the one of the overlying Catulloi Zone. *P. ohmi* has a full Mediterranean distribution (see Hoedemaeker, 1995), so the Ohmi Zone has the potential to be used as a Mediterranean standard zone.

Zone of *Pseudothurmannia catulloi*

This zone is introduced by Hoedemaeker (1995) and defined in Hoedemaeker & Leereveld (1995) as the biostratigraphic interval between the first appearance of *P. catulloi* and that of *Avramidiscus hugii* (Ooster, 1860).

The faunal change between the Catulloi Zone and the underlying Ohmi Zone is very great. According to Hoedemaeker (1995) these two zones have, apart from some long-ranging species, only 3 species in common: *P. ohmi*, *P. mortilleti* (Pictet & De Loriol, 1858), and *Psilotissotia favrei* (Ooster, 1860). All other 20 species of the Catulloi Zone do not occur in the underlying Ohmi Zone, but continue their ranges into the overlying Hugii Zone. The change with the overlying Hugii Zone is therefore less sharp, but great enough to distinguish the two Zones. *P. catulloi* has also a wide Mediterranean distribution (see Hoedemaeker, 1995), so the Catulloi Zone has all the requisites to be a candidate for a Mediterranean standard zone.

Hoedemaeker (1995) argues that the lower boundary of the Barremian Stage should be drawn at the base of the Catulloi Zone. However, most specialists still prefer the base of the Hugii Zone as the base of this Stage.

IGCP 262 (at Mula, 1993) & 362 (at Piobbico, 1995)		Company et al., 1995; Delanoy, 1997		Vermeulen, 1996, 1998	
Zones	Horizons	Zones	Horizons	Zones	Horizons
<i>M. sarasini</i>	<i>T. ridzewskyi</i>	<i>M. sarasini</i>	<i>L. puzosianum</i>		
<i>I. giraudi</i>		<i>I. giraudi</i>	<i>H. emerici</i>		
<i>H. feraudianus</i>		<i>H. feraudianus</i>	<i>I. giraudi</i>		
			<i>E. magnini</i>		
			<i>H. feraudianus</i>		
<i>G. sartousiana</i>		<i>G. sartousiana</i>	<i>C. limentinum</i>	<i>G. sartousiana</i>	<i>G. provincialis</i> <i>G. sartous. & G. provinc.</i> <i>G. sartousiana</i>
<i>A. vandenheckii</i>		<i>A. vandenheckii</i>	<i>E. barremense</i>	<i>H. sayni</i>	<i>H. rusticus</i> <i>H. sayni</i> <i>H. uhligi</i> <i>M. tirolensis</i>
<i>H. caillaudianus</i>		<i>M. moutonianum</i>		<i>C. darsi</i>	<i>P. caicedi</i> <i>C. heinzi</i> <i>C. darsi</i> <i>S. deeckeii</i>
		<i>K. compressissima</i>		<i>K. compressissima</i>	<i>P. communis</i> <i>H. caillaudi. & N. didayana</i> <i>K. compressissima</i>
<i>K. nicklesi</i>	<i>N. pulchella</i>		<i>H. fallax</i>	<i>N. pulchella</i>	<i>H. fallax & H. nodosus</i> <i>N. pulchella</i>
		<i>K. nicklesi</i>	<i>N. pulchella</i>	<i>K. nicklesi</i>	<i>A. camelinus</i> <i>K. nicklesi</i>
<i>A. hugii</i>		<i>A. hugii</i>		<i>P. colombiana</i>	<i>P. colombiana</i>
				<i>P. mazuca</i>	<i>P. mazuca</i>
				<i>A. hugii</i>	<i>A. hugii</i>

Fig. 3. Newly proposed Barremian zones and horizons.

Barremian zones and horizons (Fig. 3)

Zone of *Avramidiscus hugii*

The Hugii Zone was introduced by Busnardo (1984) and defined by Hoedemaeker & Bulot (1990) as the biostratigraphic interval between the first appearance of *Avramidiscus hugii* and that of *Kotetishvilia nicklesi* (Hyatt, 1903). The genus *Avramidiscus* was introduced by Vermeulen (1996b) with *A. gastaldianus* (d'Orbigny, 1850) as type species and containing also *hugii*, *kiliani* (Paquier, 1900), *vandeckii* (d'Orbigny, 1850), *seunesi* (Kilian, 1889), and *fallacior* (Coquand, in Matheron, 1879). Hoedemaeker (1995) stated that '*Spitidiscus*' *hugii* and *oosteri* belong to a yet unnamed generic group of the Holcodiscidae and '*Spitidiscus*' *vandeckii* and *kiliani* to another.

Company et al. (1995) adopted this definition of the Hugii Zone, but they did not find a specific fauna for this zone. Vermeulen (1996a), however, changed the original definition of the Hugii Zone by defining its upper boundary in the Angles Stratotype at the level of the first appearance of *Psilotissotia mazuca* (Coquand, 1880), which he considered a senior subjective synonym of *P. chalmasi* (Nicklès, 1890). He proposed to divide the Hugii Zone sensu Hoedemaeker & Bulot (1990) into three zones: the Hugii Zone at the base, the Mazuca Zone in the middle and the Colombiana Zone at the top. It is recommended by the International Subcommittee on Stratigraphic Nomenclature that when a zone is subdivided into two or more zones, the original name should

not be employed for any of the subdivisions. It is however permitted to introduce subzones and horizons. A Hugii Subzone or Horizon may exist as a part of the Hugii Zone.

A. hugii has been found in France, Switzerland, Spain, Bulgaria, and the Slovak Republic; Sakhelashvili (1995) reports for the first time *A. hugii* from Georgia. Subsequently Kvantaliani & Sakhelashvili (1996) adopted the Hugii Zone as the base of the Barremian in Georgia.

The Hugii Zone sensu Vermeulen (1996a) - This biostratigraphic unit is defined in the stratotype of the Barremian Stage near Angles as the biostratigraphic interval between the first appearance of *Avramidiscus hugii* in bed 72 and that of *Psilotissotia mazuca* in bed 74.

The Mazuca Zone sensu Vermeulen (1996a) - This biostratigraphic unit was defined in the stratotype near Angles as the biostratigraphic interval between the first appearance of *P. mazuca* and that of *P. colombiana* (d'Orbigny, 1842). *P. mazuca* is according to Vermeulen (1996a) a senior synonym of *P. chalmasi*. *P. mazuca* was only described by Coquand (1880), but not depicted by him, nor by Heinz (1886).

Together with the name-giving species he reported *Arnaudiella malladae* (Nicklès, 1894) and *Psilotissotia bertrandi* (Nicklès, 1894) from this subzone. The remainder of the ammonite association hardly differs from the underlying association of the Subzone of *Avramidiscus hugii* or from the overlying fauna of the Colombiana Zone. *P. mazuca* was reported by Vermeulen (1996a) from Spain, France, Algeria, and with doubt from Colombia. He reported *Arnaudiella malladae* from France, Spain, Roumania, and Colombia and *P. bertrandi* from France and Spain.

Whether the Mazuca Zone should be introduced as a standard subzone or horizon depends on further research. The frequency of these ammonites is small. Company et al. (1995) did not find *P. mazuca*, *P. bertrandi*, and *A. malladae* in their sections, but reported only *Discoidella faurei* (Ooster, 1860) from the Hugii Zone. *P. bertrandi* was reported by Tzankov & Breskovsky (1985) from the Brestak section together with *Kotetishvilia compressissima*. The genus *Discoidella* was defined by Vermeulen (1995b) and has *D. couratieri* Vermeulen, 1995, as type species.

The Colombiana Zone sensu Vermeulen (1996a) - This biostratigraphic unit was defined by Vermeulen (1996a) in the Angles stratotype as the biostratigraphic interval between the first appearance of *Psilotissotia colombiana* and that of *Kotetishvilia nicklesi* (Hyatt, 1903). New elements in the fauna are *Subpulchellia* aff. *schlumbergeri*, *Avramidiscus intermedius* (d'Orbigny, 1840), and *Acrioceras tabarelli* (Astier, 1851).

P. colombiana is reported by Vermeulen (1996a) from France, Colombia and with doubt from Spain.

The workability of the Colombiana Zone as a standard subzone or horizon is not great because of the low frequency of the name-giving species. *P. colombiana* was for the first time reported from outside Colombia in France by Vermeulen (1996a). He also reports the species with a question mark from Spain, for he (oral commun., 1997) synonymized *Pulchellia lapparenti* (Nicklès, 1894, p. 50, pl. 6, fig. 12) with *P. colombiana*, or it may be a juvenile *Nicklesia*.

Zone of *Kotetishvilia nicklesi*

The Nicklesi Zone was proposed by Vermeulen during the meeting of the Lower Cretaceous Cephalopod Team in Digne (Hoedemaeker & Bulot, 1990). The base of this zone was defined by the first appearance of *K. nicklesi*. The upper boundary of the Nicklesi Zone is still in discussion. Hoedemaeker & Bulot (1990), Hoedemaeker et al. (1993), Hoedemaeker et al. (1995), and Hoedemaeker & Leereveld (1995) define the upper boundary of this zone by the first appearance of *Holcodiscus caillaudianus* (d'Orbigny, 1850), the base of the Caillaudianus Zone; Company et al. (1995) draw the upper boundary by the first appearance of *Kotetishvilia compressissima* (d'Orbigny, 1840), the base of the Compressissima Zone; Vermeulen (1996a) finally draws the upper boundary at the first appearance of *Nicklesia pulchella* (d'Orbigny, 1840), the base of the Pulchella Zone.

The fauna contains, besides the index species and some long ranging cephalopods, *Emericiceras*, *Acrioceras*, *Subpulchellia castellanensis* (Hyatt, 1903) and in Spain *S. oehlerti* (Nicklès, 1894) (Company et al., 1995).

Vermeulen (1998b) subdivides the Nicklesi Zone (as he conceived it) into two horizons, the Horizon of *Kotetishvilia nicklesi* at the base and the Horizon of *Almohadites camelinus* (d'Orbigny, 1850) at the top. The latter horizon may have some potential of becoming a standard horizon. The range of *K. nicklesi* is long and overlapping the range of *Nicklesia pulchella*, the index species of the overlying zone. A Nicklesi Horizon at the base of the Nicklesi Zone is not necessary.

The Nicklesi Zone is firmly established as a result of the publications of Company et al. (1995) and Vermeulen (1996a).

Zone of *Nicklesia pulchella*

The Pulchella Zone was introduced by Busnardo (1965) for the whole of the lower Barremian. Hoedemaeker et al. (1993), however, lowered its rank to horizon, because *N. pulchella* was found only in two beds in the upper part of the Nicklesi Zone in the stratotype near Angles. This view was adopted by Company et al. (1995), but not by Vermeulen (1996a).

In the stratotype of Angles, Vermeulen studied the beds 105 to 114 (in fact 33 beds), which had not been studied by Busnardo (1965). Vermeulen proposed again a Pulchella Zone, which he defined as the biostratigraphic interval between the first appearance of the name-giving species (in bed 109-3) and that of *Kotetishvilia compressissima* (in bed 115). He gave ample arguments for his proposal (Vermeulen, 1996a: 201-202).

Whether it is important to establish a Pulchella Zone instead of a Pulchella Horizon is yet unclear. Both Company et al. (1995) and Vermeulen (1996a) find their first specimens of *Nicklesia pulchella* in association with the last specimens of *Kotetishvilia nicklesi*. They also found their first *Anahamulina subcincta* (Uhlig, 1883) just before or together with *N. pulchella*, but the remainder of the two accompanying faunas is not comparable. Vermeulen (1996a) advanced some technical arguments to reweight the decision of Hoedemaeker et al. (1993) to lower the rank of the Pulchella Zone to horizon. However the only real argument would be the long reputation of *N. pulchella* and its use since 1965 as a zonal index. Nevertheless there is still nothing against its rank of horizon or subzone. A Pulchella Zone as proposed by Vermeulen would,

however, subdivide the Nicklesi Zone into two zones and it is not recommended by the International Subcommission on Stratigraphic Nomenclature that one of the subdivisions keeps the original name. To avoid confusion it would be permissible to subdivide the Nicklesi Zone into two subzones.

Vermeulen (1998b) subdivided his Pulchella Zone into two horizons, a lower Horizon of *N. pulchella* (which is equivalent to the Pulchella Horizon of Hoedemaeker et al., 1993) and an upper Horizon of *Holcodiscus fallax* (Coquand, in Matheron, 1879) and *Holcodiscus nodosus* (Karakasch, 1907). In the same bed as the two latter species he found a badly preserved specimen that may be *K. compressissima*.

Zone of *Holcodiscus caillaudianus*

Holcodiscus caillaudianus was for the first time used as name-giving species for a zone by Kilian (1889) in the "horizon de Combe Petite à *Holcodiscus caillaudi*". In 1895 he changed names and distinguished beds with "*Holcodiscus caillaudi* and *Emericiceras Emerici*", which contains a fauna that he considered characteristic for the lower Barremian. In 1907, however, he changed the name of this zone into "Zone des *Pulchellia compressissima* d'Orb. und des *Holcodiscus fallax* Math. Sp." and finally in 1910 into "Zone des *Crioceras Emerici* d'Orb. und des *Pulchellia compressissima* d'Orb. sp."

Drushchits (in Drushchits & Kudriavtsev, 1960) uses *Holcodiscus caillaudianus* as the name-giving species of a Caillaudianus Zone that embraces the 'middle' part of the Barremian (the lower part being in his view the Angulicostata Zone). Patruilius (1969), who regarded the Angulicostata Zone as uppermost Hauterivian, keeps using this species as a marker for the lower Barremian in Roumenia together with *Torcapella suessi* (Simionescu, 1898). This idea was followed by Stranik et al. (1974) for Tunisia, by Egoyan (1977) for the North Caucasus, by Kotetishvili (1980, 1986) for the main part of the lower Barremian of Georgia, and by Kakabadze (1989) for the lower Barremian of Georgia.

The Lower Cretaceous Cephalopod Team (Hoedemaeker & Bulot, 1990), at last, proposed to use the Caillaudianus Zone for the upper part of the lower Barremian of the Mediterranean Region, without much argumentation. It was considered to represent the biostratigraphic interval from the first appearance of *H. caillaudianus* up to the first appearance of *Ancyloceras vandenheckii* (Astier, 1851). It covers the interval between the beds with *Nicklesia pulchella* and the base of the upper Barremian.

Company et al. (1995) decided not to use the Caillaudianus Zone, because *Holcodiscus fallax* is the first *Holcodiscus* that appears in this interval, whereas *H. caillaudianus* is rare and appears at a somewhat higher level. According to their investigations the former zones of Busnardo (1984), the Compressissima and Moutoniceras zones, are more workable and better recognizable in the Mediterranean region than the Caillaudianus Zone. Also Vermeulen (1996a) did not discuss the Caillaudianus Zone, but sticks to his heterophylic biozonation based only on Pulchellidae. *H. caillaudianus* (typical form) appears in the Compressissima Zone (Clos de Barral section); the last *H. caillaudianus* was recorded in the newly introduced Darsi Zone (Vermeulen, 1996a). In the Angles section *H. caillaudianus* was only reported from the Compressissima Zone (Vermeulen, 1996a, 1998b).

Whether one should maintain the Caillaudianus Zone or switch to a Compressissima Zone, is a question of appreciation. The two index species *Holcodiscus caillaudi-*

anus and *Kotetishvilia compressissima* have almost the same vertical distribution in the Mediterranean region. *Holcodiscus caillaudianus* has the oldest 'rights'. An argument for adopting a Compressissima Zone is the better knowledge in Spain and in France of the range of *Kotetishvilia compressissima*, especially in the Barremian stratotype. Company et al. (1995) found only *Holcodiscus* cf. *caillaudianus* in their sections and in the stratotype near Angles it is quite rare; only Vermeulen (1996a, 1998b) mentions it. Both genera *Holcodiscus* and *Kotetishvilia* are rare or absent in America and Asia. Recently Kvantaliani & Sakhelashvili (1995) report *K. compressissima* from Georgia. Kvantaliani & Sakhelashvili (1996) adopt a Compressissima Zone for (Western) Georgia, but below a Caillaudianus Zone.

In accordance with the findings of Company et al. (1995) and of Vermeulen (1996a) we recommend to replace the Caillaudianus Zone by the Compressissima Zone and by the Moutonianum Zone (see below) as standard zones of the Mediterranean region, partly returning to the original views of Busnardo (1965, 1984).

Zone of *Kotetishvilia compressissima*

Both Company et al. (1995) and Vermeulen (1996a) prefer to return to the Compressissima Zone of Busnardo (in the sense of 1984, not in the sense of 1965) and to abandon the Caillaudianus Zone, because Busnardo's zone appears to be more workable than the latter. Busnardo introduced this zone, but Company et al. (1995) defined it as the biostratigraphic interval between the first appearance of *K. compressissima* and that of *Moutoniceras moutonianum* (d'Orbigny, 1850).

Also Vermeulen (1996a) defined the base of the Compressissima Zone with the appearance of the name-giving species in the Angles stratotype, but its top by the first appearance of *Coronites* (*Coronites*) *darsi* Vermeulen, 1995a, which appears slightly above that of *M. moutonianum*. The first *K. compressissima* occurs together with the last *Nicklesia pulchella*.

Vermeulen (1997a) distinguished two horizons in his Compressissima Zone, a lower Horizon of *Nicklesia didayana* (d'Orbigny, 1841) and an upper Horizon of *Pulchellia communis* (Bürgl, 1956). A year later, however, he distinguished 4 horizons: a Horizon of *K. compressissima* at the base, followed by a Horizon of *H. caillaudianus* and *N. didayana* in which *H. caillaudianus* is already frequently present, then a Horizon of *P. communis* and finally at the top a Horizon of *Subtorcapella deecke* (Kilian & Reboul, 1915). It should be noted that the concept of horizon of Vermeulen differs from the concept of the other authors referred to in this paper. Vermeulen's horizons are vague, and may be regarded rather as thin intervals characterized by the acmes of the name-giving species, than as small zones defined by the first appearance of the index species. The species *N. didayana* is known from the western part of the Mediterranean region and possibly from Colombia. *P. communis* and *S. deecke* are rare in the Mediterranean region and the horizons based on these species have therefore little potential of becoming standard horizons.

Horizon of *Holcodiscus fallax* (lower part of the Compressissima Zone)

At the base of the Compressissima Zone Company et al. (1995) distinguished a Horizon of *Holcodiscus fallax* as a biostratigraphic interval containing, apart from *Holcodiscus fallax* also *Holcodiscus nicklesi* Karakasch, 1907, *Dissimilites dissimilis*

(d'Orbigny, 1842), and *Holcodiscus gastaldianus* (d'Orbigny, 1850). Whether they found true *H. gastaldianus* or *H. 'gastaldii'* Kilian, 1889, non d'Orbigny, 1850, is not clear. The top of the Fallax Horizon is not defined, but drawn before the appearance of *H. cf. caillaudianus*.

The Fallax Horizon that Vermeulen (1998b) distinguished in the upper part of his Pulchella Zone is presumably equivalent to the Fallax Horizon of Company et al. (1995).

Zone of *Moutoniceras moutonianum*

Busnardo (1984) introduced a Moutoniceras Zone in the uppermost part of the lower Barremian. Company et al. (1995), who preferred to abandon the Caillaudianus Zone, followed Busnardo's view (1984), but instead of a Moutoniceras Zone Company et al. preferred a Moutonianum Zone. They defined their Moutonianum Zone as the biostratigraphic interval between the first appearance of *M. moutonianum* and that of '*Ancyloceras vandenheckii*'. The genus *Moutoniceras* is already present with *M. nodosum* (d'Orbigny, 1850) in their Compressissima Zone. A similar distribution has been found in the stratotype near Angles, for Vermeulen (oral commun., 1997) reported *M. nodosum* from bed 112-5 in the upper part of his Pulchella Zone and from the lower part of his Compressissima Zone. *M. moutonianum* is found in France, Spain and questionably in Roumenia, Poland and Colombia.

If the Compressissima Zone is preferred above the Caillaudianus Zone, a choice remains between the Moutonianum Zone and the Darsi Zone of Vermeulen, 1997a (not of Vermeulen, 1996a, because the latter comprises also the Sayni Subzone). On account of arguments presented in the next paragraph we prefer the Moutonianum Zone instead of the Darsi Zone. The former has, however, the disadvantage that it has not been recognized in the stratotype near Angles.

Zone of *Coronites darsi* (two different concepts)

Vermeulen (1996a) defined his Darsi Zone as the interval between the first appearance of *C. darsi* Vermeulen, 1994 and that of *Gerhardtia sartousiana* (d'Orbigny, 1841). Vermeulen (1996a) subdivided this zone into two subzones: a lower Subzone of *C. darsi* with the same base as the zone of that name, and an upper Subzone of *Heinzia sayni*, of which the ammonite association differs markedly from the underlying Darsi Subzone. The boundary between the subzones is the first appearance of *H. sayni* (Hyatt, 1903).

A year later, however, presumably as a consequence of this marked difference in the composition of the ammonite assemblages of the two subzones, Vermeulen (1997a) restricted the Darsi Zone to the lower part of his former Darsi Zone, i.e. to his former Darsi Subzone. In order to avoid confusion it is recommended by the International Subcommittee of Stratigraphic Nomenclature not to use the name of the former unsubdivided zone for one of its subdivisions, if a formerly defined zone was subdivided into two new zones. Therefore we recommend to use the Moutonianum Zone instead of the Darsi Zone. Besides, *Coronites darsi* is not a well-known species. According to Vermeulen (1995a, 1996a) *C. darsi* has been found in France, Spain and Algeria and questionably in Bulgaria and Colombia. According to Vermeulen (oral communication 1997) its presence in Bulgaria is pretty sure.

Vermeulen (1997a) distinguished three horizons in his new Darsi Zone (= his former Darsi Subzone): a lower Horizon of *C. darsi*, a middle horizon of *Curiolites heinzi* (Sayn, 1891, non Coquand, 1880), and an upper horizon of *Pulchellia caicedi* (Karsten, 1886). According to Vermeulen (1997a) the unfigured and poorly described *Ammonites heinzi* Coquand, 1880, should be abandoned. A year later he distinguished two more horizons at the top of his new Darsi Zone above the Caicedi Horizon, viz. a Horizon of *Macroscaphites tirolensis* (Uhlig, 1887) and at the very top a Horizon of *Holcodiscus uhligi* Karakasch, 1907. According to recent correlations of Hoedemaeker (in press) the first *Ancyloceras vandenheckii* was found in SE Spain at a level below the level in which *M. tirolensis* was found in the French Angles section. So the biostratigraphic relations in the middle part of the Angles stratotype are still unclear due to the scarceness of ammonites.

Zone of *Heinzia sayni*

Vermeulen (1997a) also changed the rank of his Sayni Subzone into 'zone' without changing the scope or fossil assemblage of the subzone. This is permissible. The new Sayni Zone (= former Sayni Subzone) is therefore acceptable as a zone. The Sayni Zone was defined by Vermeulen (1996a) as the biostratigraphic interval between the first appearance of *H. sayni* and that of *G. sartousiana*. It approximately covers the same stratigraphic interval as the Vandenheckii Zone.

The Sayni Zone was subdivided by Vermeulen (1998b) into a lower Horizon of *H. sayni* and an upper Horizon of *Hemihoplites rusticus* Vermeulen, 1996. The vertical and horizontal distribution of this new species should be examined first before this horizon can be introduced as a standard Mediterranean zone.

It is not clear whether the Vandenheckii Zone should be preferred above the Sayni zone (= former Sayni Subzone). The Vandenheckii Zone was defined by Hoedemaeker & Bulot (1990) as the biostratigraphic interval from the first appearance of the index species to the first appearance of *Gerhardtia sartousiana*. '*Ancyloceras*' *vandenheckii* and *H. sayni* are distributed all over the Mediterranean region; the latter species was reported from Colombia by Vermeulen (1996a), the former species (*Ancyloceras* cf. *vandenheckii*) probably occurs there also (Kakabadze & Hoedemaeker, 1997). The Barremian Stage Working Group (Rawson, 1996) recommended in Brussels that the base of the upper Barremian should be defined by the first appearance of the ammonite *Ancyloceras vandenheckei* [sic]. A choice for a Sayni Zone instead of a Vandenheckii Zone only slightly effects this recommendation. However, the existence of two zones based on the same species name *sayni* should be avoided, especially if they occur stratigraphically close in two successive stages.

Horizon of *Emericiceras barremense* (upper part of the Vandenheckii Zone)

The Barremense Zone of Busnardo (1984) was rejected by the IGCP 262 team (Hoedemaeker & Bulot 1990), because of the uncertainty of the identity of the index species. Instead of '*Emericiceras*' *barremense* the species *Ancyloceras vandenheckii* was preferred as index species. Company et al. (1995), however, reintroduced the Horizon of *E. barremense* as the upper part of the Vandenheckii Zone and defined it as the biostratigraphic interval from the first appearance of *E. barremense* (Kilian, 1895) to that of *G. sartousiana*. The name-giving species is known from Spain, France, South Tirol,

Roumenia, and perhaps from Bulgaria.

Whether a Horizon of *E. barremense* can be recognized in the Angles stratotype section is not clear. Vermeulen (1998b) reported this species from the base of his Sayni Horizon. Busnardo (1965) reported *E. cf. barremense* only from a section in the neighbourhood of the Angles section. From the Angles section itself he mentioned only *E. cf. clausum* from the interval between bed 152 to 157 and *Emericiceras* sp. indet. from the intervals between bed 158 to 161 and bed 162 to 164.

A Horizon of *E. barremense* could provisionally be accepted. In this respect it is important to know at what level(s) this species appears in the sections of SE France.

Subzones of *Gerhardtia sartousiana* and of *G. provincialis*

The Zone of *G. sartousiana* was introduced by Vermeulen at the meeting of the Lower Cretaceous Cephalopod Team in 1990 in Digne (Hoedemaeker & Bulot, 1990). It was defined as the biostratigraphic interval between the first appearance of *G. sartousiana* and that of *Hemihoplites feraudianus* (d'Orbigny, 1841). Vermeulen (1996a) divided the Sartousiana Zone into two subzones, the Subzone of *G. sartousiana* at the base and the Subzone of *G. provincialis* at the top. The presence of *G. provincialis* (d'Orbigny, 1841) in the upper part of the Sartousiana Zone was confirmed by Delanoy (1997, 1998). Due to the work of Vermeulen (1996a) the Sartousiana Zone is well established. Also Delanoy (1995b) and Cecca (1995) recognize this zone in their sections. Recently Kvantaliani & Sakhelashvili (1997) describe *G. sartousiana* from the upper Barremian of Georgia. They propose to adopt a Sartousiana Zone overlying the Vandenheckii Zone in Georgia. The zone seems to be a workable biostratigraphic unit.

The Sartousiana Subzone has the same base as the zone of that name; its top was defined by the first appearance of *G. provincialis*. The Provincialis Subzone was defined as the biostratigraphic interval between the first appearance of the name-giving species and the first appearance of *Hemihoplites feraudianus*. In 1997 Vermeulen changed the rank of these subzones into horizons, because at the boundary between the horizons he introduced a transitional horizon in which primitive morphotypes of *G. provincialis* occur together with late morphotypes of *G. sartousiana*. This transitional horizon seems difficult to recognize and has a low potential for becoming accepted as a standard horizon and may be roughly equivalent to the Horizon of *Camereiceras limentinus* (see next paragraph).

He wrote that the late morphotypes of the *G. provincialis* group in the top part of the zone are the last members of the Pulchelliidae in France. This is confirmed by Delanoy (1995b, 1997, 1998). In Spain, however, Hoedemaeker & Leereveld (1995) reported the last *Heinzia* from the base of the Giraudi Zone and Aguado et al. (1992) the last *Subpulchellia* from the lowermost part of the Feraudianus Zone.

Horizon of *Camereiceras limentinum* (lower upper part of the Sartousiana Zone)

This horizon is defined by Delanoy (1997, 1998) as the biostratigraphic interval delimited by the total range of *C. limentinum* (Thieuloy, 1979). It is situated in the middle of the Sartousiana Zone and approximately separates beds with *G. sartousiana* below from beds with *G. provincialis* above.

In 1979 Thieuloy recognized a guide horizon of *C. limentinum*, an isolated horizon

which separates the Glandasse Limestone Formation from the Urgonian Limestone Formation within the platform sediments of the Vercors Mountains. However, the position of the Limentinum Horizon in the zonal scheme was not accurately known. This horizon has not been found with certainty outside France. It is therefore not yet acceptable as a standard Mediterranean horizon. The ammonite from Roumenia referred to by Avram (1983) as '*Crioceratites* ex gr. *barremense-orbigny*' was identified by Delanoy (1997) as *Camericeras* aff. *limentinum*; Delanoy therefore correlates his Limentinus Horizon with the Roumenian beds containing this species.

Horizon of *Hemihoplites feraudianus* (lower part of the Feraudianus Zone)

Delanoy (1997) subdivided the Feraudianus Zone into two horizons, a lower Horizon of *H. feraudianus* and an upper Horizon of *Emericeras magnini*. The first horizon is defined as the biostratigraphic interval between the first appearance of *H. feraudianus* and that of *E. magnini* Delanoy, 1992. The Feraudianus Horizon is characterized by the association of *H. feraudianus* with *Pseudohaploceras douvillei* (Fallot, 1920), *Spinocroceras polyspinum* Kemper, 1973, and in platform facies *Hemihoplites soulieri* (Matheron, 1878). *S. polyspinum* has been found in France, Italy, Spain, and Georgia, and also occurs in the boreal deposits of Northern Germany. It therefore guarantees a Tethyan-Boreal correlation. This horizon has all the ingredients to be inserted in the standard Mediterranean zonal scheme, but is unnecessary if the next Magnini Horizon is not accepted.

Horizon of *Emericeras magnini* (upper part of the Feraudianus Zone)

The first appearance of *E. magnini* defines the base of the Magnini Horizon. The top of the latter horizon was defined by the appearance of *Imerites giraudi* (Kilian, 1888). *E. magnini* has not yet been found outside France and it is therefore not recommended to insert this horizon in the standard zonal scheme of the Mediterranean region. The first species of *Heteroceras* (*H. baylei*, *H. couletti*) appear in this horizon.

Horizon of *Imerites giraudi* (lower part of the Giraudi Zone)

The base of this horizon was defined by Delanoy (1997) as coinciding with the base of the Giraudi Zone at the first appearance of *I. giraudi*, its top by the first appearance of *Heteroceras emerici* (d'Orbigny, 1841). According to Delanoy (1997) the name-giving species was reported from France, Spain, Bulgaria, Roumenia, and the Caucasus area. The maintenance of this biostratigraphic unit as a separate horizon depends on the acceptance of the next higher Horizon of *H. emerici*. If this is not accepted, the Giraudi Horizon is unnecessary.

Horizon of *Heteroceras emerici* (middle part of the Giraudi Zone)

This horizon is defined as the biostratigraphic interval in which *H. emerici* dominates, in which representatives of the genus *Heteroceras* are abundant, and in which the last *Imerites* occurs. Whether this horizon has a chance to enter the standard Mediterranean zonal scheme, depends on how frequent *H. emerici* occurs and how wide its horizontal distribution is. According to Delanoy it occurs in France, Bulgaria, the Caucasus area, and in Japan.

Horizon of *Leptoceratoides puzosianus* (basal part of the Sarasini Zone)

This horizon is introduced by Busnardo (1965) and defined by Delanoy (1997) as the biostratigraphic interval occupied by the short range of *L. puzosianus* (d'Orbigny, 1842). It is also characterized by the presence of *Martelites sarasini* (Rouchadze, 1933) and *Pseudohaploceras matheroni* (d'Orbigny, 1841); both species have their first appearance in this horizon. If the horizontal distribution (France, Tunisia) of *L. puzosianus* can be enlarged, the horizon certainly has the potential of becoming incorporated in the standard Mediterranean zonal scheme.

Correlations of the Granada scheme of the Barremian Stage with the Nice scheme

1) In the correlation table of Fig. 3 the base of the Compressissima Zone sensu Company et al. (1995) and the one sensu Vermeulen (1996a) are tentatively drawn at the same level. *Holcodiscus fallax* is according to Company et al. (1995) an element of the basal part of the Compressissima Zone, but Vermeulen (1996a) reported this species only from the upper part of his Pulchella Zone. There are three possibilities to explain this discrepancy, which is due to collection failure: either (1) Company et al. (1995) failed to find *H. fallax* in their Pulchella Horizon or (2) Vermeulen failed to find *H. fallax* in the basal part of his Compressissima Zone or (3) Vermeulen failed to find *Kotetishvilia compressissima* in the beds with *H. fallax*.

The discrepancy is probably explained by the third possibility, as it is supported by the results of the investigations of Tzankov & Breskovski (1985), who found in the Brestak-section in Central North Bulgaria the first *H. fallax* at the 27 m and 30 m levels together with *K. compressissima*, *Holcodiscus nicklesi*, *Avramidiscus gastaldianus*, and *Dissimilites dissimilis*. However, they found the first *Nicklesia pulchella* at the 38 m level together with *Moutoniceras moutonianum*, *Holcodiscus caillaudianus* and *Kotetishvilia compressissima*: a mix of zones or perhaps a misidentification of *Nicklesia pulchella*? Moreover, in 1998b Vermeulen mentions a possible specimen of *K. compressissima* collected together with *H. fallax* in the upper part of his Pulchella Zone.

2) The base of Vermeulens' (1997a) Darsi Zone (= Darsi Subzone of Vermeulen, 1996a) may be slightly younger than the base of the Moutonianum Zone of Company et al. (1995), for in the Angles and Clos-de-Barral sections Vermeulen (1996a) found *M. moutonianum* in the top part of his Compressissima Zone. In Spain the ranges of *M. moutonianum* and *K. compressissima* are slightly overlapping (Company et al., 1995), whereas the ranges of *K. compressissima* and *Coronites darsi* have not been reported as overlapping.

The top of the Moutonianum Zone and the top of the Darsi Zone may approximately be drawn at the same level, for according to Vermeulen the overlying Sayni Zone is approximately equivalent to the Vandenheckii Zone. The correlation between the Moutonianum Zone and the Darsi Zone given by Vermeulen (1998b) is probably not correct; he drew the base of the Moutonianum Zone approximately in the middle of the Darsi Zone.

3) The Sayni Zone is approximately equivalent to the Vandenheckii Zone, because the first specimens that have been called *Heinzia 'provincialis'* by various authors (Vermeulen, 1980a; Avram, 1983; Company et al., 1995; Hoedemaeker & Leereveld, 1995; Cecca & Pallini, 1995), appear together with *Ancyloceras vandenheckii* at the base of the

Vandenheckii Zone. These specimens, however, are probably identical with *Heinzia sayni*. Vermeulen (1996a) states that *Gerhardtia provincialis* is frequently confounded with *H. sayni*, which characterizes the lower part of the Sayni Zone, whereas *G. provincialis* characterizes the Provincialis Subzone, which is the upper part of the Sartousiana Zone.

According to Vermeulen *H. sayni* is quite different from *G. provincialis* and does not have the striking narrow siphonal furrow of the latter. D'Orbigny (1850) diagnosed *Ammonites provincialis* as 'espèce voisine de l'*A. galeatus*, mais s'en distinguant par un sillon profond sur le milieu du dos de la coquille.' Sayn (1891: 153) did not propose a type species for his new subgenus *Heinzia*. Hyatt (1903) introduced *H. sayni* as a new name for *Pulchellia provincialis* Sayn, 1891, non d'Orbigny, 1850, and subsequently designated *H. sayni* Hyatt, 1903, as type species of *Heinzia*. Roman (1938), followed by Wright (1996), however, erroneously considered *Ammonites provincialis* d'Orbigny, 1850, the type species. Only recently Vermeulen (1996a) figured what he considers to be a specimen of *H. sayni*.

It is quite possible that the specimens of *Heinzia 'provincialis'* of Avram (1983), Company et al. (1995), Hoedemaeker & Leereveld (1995), and Cecca & Pallini (1995) are in reality specimens of *H. sayni*. The latter species is the first *Heinzia* and this genus appears at the base of the upper Barremian.

In this respect it is relevant to note that in the Angles section ammonites are very rare between beds 125 to 146. This interval comprises three sequence boundaries bounding two depositional sequences. The first *H. sayni* was found above this virtually ammonite-barren interval just above the third sequence boundary, whereas in the Río Argos section near Caravaca (SE Spain) the first *A. vandenheckii* and the first *H. sayni* (called *H. provincialis* by Hoedemaeker & Leereveld, 1995) were found together at a level that correlates with a level in the first depositional sequence in the Angles section, and that is situated below the level in which *Macroscaphites tirolensis* was found (Hoedemaeker & Leereveld, 1995; Hoedemaeker, in press). This would imply that the horizons with *Holcodiscus uhligi* and *M. tirolensis* (which comprise the fossil-poor interval) would form part of the Vandenheckii/Sayni Zone instead of the Darsi Zone, and that the first find of *H. sayni* in the Angles section is apparently stratigraphically too high; *Ancyloceras vandenheckii* has not been found in that section.

Conclusions

Of the Valanginian to Barremian biostratigraphic units proposed since 1993 the following have in our opinion the greatest potential to be accepted as part of the standard zonation of the Mediterranean region:

Horizon of *Karakaschiceras biassalense* sensu Bulot et al. (1992b)

Horizon of *Karakaschiceras pronecostatum*

Horizon of *Varlheideites perigrinus*

Horizon of *Breistrofferella castellanensis*

Horizon of *Olcostephanus variegatus*

Zone of *Plesiospidiscus ligatus* sensu Bulot et al (1992b)

Zone of *Pseudothurmannia ohmi*

Zone of *Pseudothurmannia catulloi*

Zone of *Kotetishvilia compressissima* (the horizon of that name at the base of the Zone is unnecessary)

Zone of *Moutoniceras moutonianum*.

Of the Valanginian to Barremian biostratigraphic units proposed since 1993 the following have in our opinion the lowest potential to be accepted as part of the standard zonation of the Mediterranean region:

Horizon of *Kilianella thieuloyi*

Horizon of *Busnardoites subcampylotoxus*

Horizon of *Busnardoites campylotoxus*

Zone of *Karakaschiceras inostranzewi*

Horizon of *Leopoldia buxtorfi*

Horizon of *Lyticoceras collignoni*

Horizon of *Karakaschiceras quadristrangulatum*

Horizon of *Saynoceras fuhri*

Horizon of *Karakaschiceras biassalense* sensu Reboulet

Horizon of *Neocomites platycostatus*

Horizon of *Neocomites neocomiensis*

Horizon of *Karakaschiceras companyi*

Horizon of *Criosarasinella subheterocostata*

Horizon of *Lyticoceras nodosoplicatum*

Horizon of *Lyticoceras bargemense*

Horizon of *Subsaynella mimica*

Zone of *Avramidiscus hugii* sensu Vermeulen

Zone of *Psilotissotia mazuca*

Zone of *Psilotissotia colombiana*

Zone of *Holcodiscus caillaudianus*

Horizon of *Subtorcapella deecke*

Horizon of *Holcodiscus uhligi*

Horizon of *Macroscaphites tirolensis*

Horizon of *Hemihoplites rusticus*

Horizon of *Camereiceras limentinum*

Horizon of *Gerhardtia sartousiana* and *G. provincialis*

Horizon of *Hemihoplites feraudianus*

Horizon of *Emericiceras magnini*.

The insertion of the following newly proposed Valanginian to Barremian biostratigraphic units into the standard zonation of the Mediterranean region is worth discussing:

Zone of *Olcostephanus stephanophorus*

Horizon of *Barronites hirsutus*

Zone of *Kotetishvilia nicklesi*

Zone of *Nicklesia pulchella*

Horizon of *Holcodiscus fallax*

Horizon of *Pulchellia communis*

Horizon of *Nicklesia didayana*

Zone and Horizon of *Coronites darsi*

Horizon of *Curiolites heinzi*

Horizon of *Pulchellia caicedi*
Zone and Horizon of *Heinzia sayni*
Horizon of *Emericiceras barremense*
Subzone and Horizon of *Gerhardtia sartousiana*
Subzone and Horizon of *Gerhardtia provincialis*
Horizon of *Imerites giraudi*
Horizon of *Heteroceras emerici*
Horizon of *Leptoceratoides puzosianum*.

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