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Report on the 7th International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the Kilian Group (Warsaw, Poland, 21st August 2022): State of the art on the current Standard Ammonite Zonation of the Western Tethyan Mediterranean Province

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ABSTRACT

The 7th meeting of the IUGS Lower Cretaceous Ammonite Working Group the 'Kilian Group (KG)' was held in Warsaw, Poland, on 21st August 2022. Need of major changes for the Jurassic/Cretaceous transition, namely to the uppermost Tithonian and lower Berriasian, and for the upper Aptian and Albian schemes is a long-known issue, which are finally conceptualized and hereby introduced into the Standard Mediterranean Ammonite Zonation (SMAZ, Western Tethys). Besides, refinements were added to the Valanginian and Hauterivian stages, discussion on some zonal indices and units are also provided. The KG highlights again the exclusive use of interval zones and subzones.

Most important changes of the uppermost Tithonian–Berriasian stages are the followings: *i)* use of two folded Berriasian is agreed, to be in better accordance with ammonite turnovers and microfossil framework; *ii)* uppermost Tithonian *Lopeziceras chaperi*, top-uppermost Tithonian to lowermost Berriasian *Praedalmasiceras progenitor* and lower Berriasian *Pseudosubplanites grandis* Zones are accepted to be introduced into the SMAZ, these three zones to cover the former *'Berriasella' jacobi* Zone *auctorum* which is formally abandoned; *iii)* lower Berriasian *Delphinella delphinensis* Subzone is accepted as a reliable marker level of the upper *Praedalmasiceras progenitor* Zone; *iv) Strambergella jacobi* Zone is established and discussed. *Tirnovella occitanica* Zone and *Tirnovella subalpina* Subzone are discussed.

Modifications on the Valanginian zonation are the followings: *i) Neocomites premolicus* Subzone is re-defined, *ii) Neolissoceras (Vergoliceras) salinarium* Subzone is introduced; iii) *Neocomites neocomiensiformis* Zone is divided into two subzones, the lower *N. neocomiensiformis* and the upper

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[2] Participants at the meeting with scientific contribution.
[3] Absents at the meeting but provided written scientific contribution. As chair of the group, the report was elaborated with the contribution of S. Reboulet.

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Busnardoites campylotoxus Subzones. Modifications on the Hauterivian stage are the followings: *i)* all horizons are deleted; *ii) Olcostephanus* (*Olcostephanus*) *variegatus* Subzone is introduced; *iii) Balearites angulicostatus* Subzone is introduced; *iv)* all subzonal index-species of the *B. balearis* Zone are assigned to genus *Balearites*; *v) Pseudothurmannia mortilleti* is considered as a senior synonym of *P. catulloi*, therefore its nominal subzone also changed its name to *mortilleti.*

No change in the Barremian scheme, however the base of *Toxancyloceras vandenheckii* Subzone and Zone is defined by the first appearance of the genus *Toxancyloceras*.

Most important changes of the upper Aptian zonation are the followings: *i) Nolaniceras nolani* and '*Hypacanthoplites jacobi*' zones are retained from the SMAZ; *ii)* re-introduction of *Diadochoceras nodosocostatum* Zone is given. For the Aptian–Albian transition interval, introduction of *'Hypacanthoplites' elegans* Zone is accepted, where the Aptian/Albian boundary lies within.

Most important zonal changes of the Albian stage are: *i)* the *Leymeriella*-based succession is abandoned from the SMAZ and replaced by the cosmopolitan *Douvilleiceras*-based succession; *ii) Douvilleiceras leightonense* Zone is introduced; iii) middle Albian *Hoplites dentatus, Euhoplites loricatus, Euhoplites lautus* Zones and *Hoplites spathi* Subzone are retained from the SMAZ and restricted to the Boreal ammonite scheme; *iv) Lyelliceras lyelli* Subzone arisen to zonal rank defining the basal middle Albian; *v) Oxytropidoceras (Oxytropidoceras) roissyanum* Zone is introduced; *vi)* upper Albian zonation based on the phyletic lineage of Mortoniceratids is kept, however generic names of the indices are modified to *Pervinquieria; vii) Pervinquieria pricei* Zone is divided into three subzones of *Hysteroceras varicosum, H. binum* and *H. choffati* from the oldest to youngest; *viii) Pervinquieria inflata* Zone is divided into two subzones of *Hysteroceras bucklandi* and *Cantabrigites* spp.

The KG tributes to our recently deceased ammonitologist colleagues in the Supplement, a discussion on the future work is provided. The next Kilian Group meeting will be held in Hannover, prior to the first day of the 12th International Symposium on the Cretaceous System.

1. Introduction

The 7th meeting of the IUGS Lower Cretaceous Ammonite Working Group (the Kilian Group, KG) took place on Sunday 21st August 2022 at the Warsaw University (Poland), the day before the 11th International Symposium on the Cretaceous System (22–27 August 2022). The meeting is moderated and reported by Szives and Moreno-Bedmar (authors with [1]). The workshop was attended by 9 members from 7 countries (authors, with [2]). Some colleagues who could not attend, submitted contributions that were taken into account during the discussions (see "written scientific contribution") and their names are added here (authors, with [3]).

In this present report, major changes are introduced in the standard zonation for the Jurassic/Cretaceous transition, namely to uppermost Tithonian and lower Berriasian, and also for upper Aptian and Albian schemes. Besides, some refinements were added to the lower Valanginian, Hauterivian and upper Barremian substages.

The end of the meeting was devoted to the tribute to our recently deceased ammonite colleagues, and a discussion on the future work.

2. The Standard Lower Cretaceous Ammonite zonation of the Mediterranean Province

The Standard Mediterranean Ammonite Zonation (SMAZ) is applied to the Mediterranean Province of the Mediterranean–Caucasian Subrealm of the Tethyan Realm *sensu* Westermann (2000) followed by Lehmann et al. (2015). However, 'standard' implies an absolute principle of universality at least for this subrealm. In our opinion this term needs to be kept for three reasons: *1)* to avoid confusion between local zonations that can be different even between geographically close sections; *2)* to keep correlation as clear as possible to other realms and subrealms for non-ammonitologists as well, and *3)* to reflect the standard scientific level of the input data as based only on peer reviewed, already published (or at least accepted) papers.

References to important unpublished data are also mentioned, although not incorporated into the SMAZ until their publication. In different palaeogeographic units its accuracy is limited due to endemic faunas and the non-isochronous appearance of certain ammonite groups as pointed in Reboulet et al. (2018).

The Warsaw meeting mainly dealt with the zonation of the Berriasian, Aptian and Albian as inadequate zonation of these stages was the most chronic problem of the SMAZ since decades (Hoedemaeker et al., 1990). As the stratigraphic position of the former *'Berriasella' jacobi* Zone proven to be stretched from the uppermost Tithonian to lower Berriasian (Frau et al., 2016a), in this report a discussion and proposals on the uppermost Tithonian are also included. A brief state of the art was outlined by Szives, Frau and Moreno-Bedmar and new zonal schemes including the topmost Tithonian were also presented based on biostratigraphic results published since the last meeting at Vienna (Austria; 2017). For Valanginian, Hauterivian and Barremian stages, some modifications on the zonation have been proposed by Company, Reboulet and Frau. After each talk, the KG discussed the possibility of introduction or deletion of some biostratigraphic units.

Three general remarks on the standard zonation are also added as: *a)* even though mostly Interval Zones are in use in the current SMAZ (see Reboulet et al., 2011; Szives et al., 2023 for summary), keeping the development of the ammonite zonation in focus, it is necessary to indicate the type of zones in the definition of new (sub-)zones; *b)* for their definition, it would be preferable to use the term FAD (First Appearance Datum) rather than FO (First Occurrence). The FAD refers to the phyletic appearance meaning we have a good knowledge or understanding of the group and on its phyletic lineage. The FO only refers to sections where the lowest occurrence of the species recorded and restricted to a section. In broader view it means a conceptual approach (= definition of the zone) *versus* a fact-based approach (its identification in a section); *c)* due to the confusion between „horizon" and „biohorizon" (a surface *versus* a short interval), the KG preferred to abandon this term (Reboulet et al., 2018). Moreover, to define the base (and the top) of a (sub-)

zone, it is not necessary to introduce the term „horizon" as this standard zonal scheme is based on ammonite turnovers and not only on the FAD of index-species.

All modifications on the SMAZ are shown in figures (Figs. 1–3), where numbers displayed refer to the numbered chapters in the text. Major observations and all modifications are discussed stage by stage in ascending order.

Besides refining the SMAZ, the KG also envisaged three future tasks for the next meetings: *i)* defining the ammonite assemblage of each biostratigraphic unit; *ii)* collect the available 2 or 3D images of type specimens of the zonal indices; *iii)* start to establish the geochronological aspects of ammonite zonal units integrated into published micropaleontologic, chemo- and magnetostratigraphic data.

2.1. Jurassic/Cretaceous transition

Major changes were accepted (Figs. 1, 2) in the zonation of the Jurassic/Cretaceous (J/K) transition interval which affects the zonation of the uppermost Tithonian and the Berriasian as well.

In the most recent zonal scheme (Gale et al., 2020) the primary marker of base of the Berriasian stage was erroneously interpreted as: "The *lowest occurrence* of the small, globular calpionellid species *Calpionella alpina*, which marks the base of the *C. alpina* Subzone"…. and… "The GSSP level would coincide with the *appearance* of small, orbicular *C. alpina* calpionellids (base of the Calpionella Zone)"; also on their Fig. 27.12: "Calpionellid, FAD of *Calpionella alpina*".

In June 2016, the Berriasian Working Group (BWG1) voted to adopt the *Crassicollaria*/*Calpionella* turnover and base of the Alpina Subzone as the primary marker for the base of the Berriasian stage (Wimbledon, 2017). It led to misunderstanding (see the example above) that *Crassicollaria*/*Calpionella* turnover is not the FAD but the ***acme event*** of *Calpionella alpina,* as it was clarified later in Wimbledon et al. (2020, p. 61): "*marked increase* [acme] in small globular *Calpionella alpina*….. This event (the 'explosion' or 'bloom' …. of some authors) …" *is* the base of the Alpina Subzone of Calpionella Zone. This event is still the recommended primary marker of the basal Berriasian voted by the BWG1, no matter if their GSSP proposal was rejected. This primary marker event does not coincide to any ammonite event, which means the Tithonian/Berriasian (T/B) boundary in terms of ammonites lies within the – here formally abandoned – *'Berriasella' jacobi* Zone *auctorum* Zone (Frau et al., 2016a). A new Berriasian Working Group (BWG2) was formed in 2021 but no voting was completed for selection of a new recommendation on the primary marker (which discussion is out of the scope of this paper).

Szives presented their recently published (Szives and Főzy, 2022) results on ammonites from ammonitico rosso/biancone sections and their stratigraphy across the uppermost Tithonian–lower Berriasian transition from the Hungarian Transdanubian Range. Besides giving several taxonomic clarifications, they established a new uppermost Tithonian–lower Berriasian zonation. Frau pointed that it is supposedly suitable for the Vocontian Basin (VB) settings, but it has to be taken into account that its applicability may not be suitable everywhere as many key areas lack integrated stratigraphy. Further discussion between Szives and Frau clarified some points debated at the meeting and their proposals were accepted as follows.

Relation of proposed and previous (Reboulet et al., 2018; Gale et al., 2020) zonations of the uppermost Tithonian–Berriasian interval, showing changes numbered are visualized on Fig. 1.

(1* in Figs. 1,2). Former *'Berriasella' jacobi* Zone
'Berriasella' jacobi Zone *auctorum* (*fide* Frau et al., 2016a) is abandoned.

Remarks. In previous KG reports from Hoedemaeker et al. (1990) to Reboulet et al. (2018), base of the *'B.' jacobi* Zone matched with the base of Berriasian (marked with black thick horizontal line in Fig. 1) corresponding to the J/K boundary (as indicated in the right part of Fig. 1). This means that the whole *'B.' jacobi* Zone was dated as Berriasian by the former KG reports. However, on the basis of recent investigations (Frau et al., 2016a), it is accepted now (Wimbledon et al., 2020) that the base of the now abandoned *'B.' jacobi* Zone is actually within the uppermost Tithonian (Fig. 1. left column).

It is also accepted here that *'Berriasella' jacobi* should be transferred to genus *Strambergella* (Frau et al., 2016a) and its stratigraphic position is strongly reconsidered as to be younger. Therefore, *'B.' jacobi* cannot be a marker of the basal Berriasian. Due to these reasons, *Strambergella jacobi* must be transferred in a different zonal sense into the upper lower Berriasian interval.

Summarizing our current knowledge on the T/B boundary interval (the former *'Berriasella' jacobi* Zone), the use of any ammonite

<table>
<tr><th colspan="4">Accepted zonation - KG meeting 2022</th><th colspan="4">Reboulet et al. 2018</th></tr>
<tr><th>stage</th><th>substage</th><th>Zone</th><th>Subzone</th><th>stage</th><th>sub-stage</th><th>zone</th><th>subzone</th></tr>
<tr><td rowspan="8">BERRIASIAN (3)</td><td rowspan="3">upper</td><td rowspan="2">Tirnovella alpillensis</td><td>"Thurmanniceras" otopeta</td><td rowspan="8">BERRIASIAN</td><td rowspan="3">upper</td><td rowspan="2">Tirnovella alpillensis</td><td>"Thurmanniceras" otopeta</td></tr>
<tr><td>Tirnovella alpillensis</td><td>Tirnovella alpillensis</td></tr>
<tr><td rowspan="2">Fauriella boissieri</td><td>Berriasella picteti</td><td rowspan="2">Fauriella boissieri</td><td>Berriasella picteti</td></tr>
<tr><td>Malbosiceras paramimounum</td><td>Malbosiceras paramimounum</td></tr>
<tr><td rowspan="4">lower (3)</td><td rowspan="3">Tirnovella occitanica (8)</td><td>Dalmasiceras dalmasi</td><td rowspan="2">middle</td><td rowspan="2">Subthurmannia occitanica</td><td>Dalmasiceras dalmasi</td></tr>
<tr><td>Berriasella privasensis</td><td>Berriasella privasensis</td></tr>
<tr><td>Tirnovella subalpina (9)</td><td rowspan="2">lower</td><td rowspan="2">Berriasella jacobi auctorum (1)</td><td>Subthurmannia subalpina</td></tr>
<tr><td>Strambergella jacobi (7)</td><td></td></tr>
<tr><td>T.</td><td>upper (pro parte)</td><td>Pseudosubplanites grandis (6)
Praedalmasiceras progenitor (4)
Lopeziceras chaperi (1,2)</td><td>Delphinella delphinense (5)</td><td></td><td></td><td></td><td></td></tr>
</table>

Fig. 1. Relation of hereby accepted and previous ammonite zonation (Reboulet et al., 2018) of the Berriasian stage. Note the different stratigraphic position of the base of the stage in terms of ammonite zones, and the accepted two-folded subdivision of the stage. Bold numbers refer to the numbers in the text. Zones/zones and Subzones/subzones are not in perfect scale.

STAGES		ZONES	SUBZONES
HAUTERIVIAN (14)	upper	*Pseudothurmannia ohmi* **(17)**	*Pseudothurmannia picteti*
			Pseudothurmannia mortilleti **(18)**
			P. ohmi
		Balearites balearis	*Balearites angulicostatus* **(16)**
			Balearites krenkeli
			Balearites binelli
			B. balearis
		Plesiospitidiscus ligatus	
		Subsaynella sayni	
	lower	*Lyticoceras nodosoplicatum*	*Olcostephanus (Olcostephanus)variegatus* **(15)**
		Crioceratites loryi **(13)**	*Olcostephanus (Jeannoticeras) jeannoti*
			C. loryi
		Acanthodiscus radiatus	
VALANGINIAN	upper	*Criosarasinella furcillata*	*Teschenites callidiscus*
			C. furcillata
		Neocomites peregrinus	*Olcostephanus (Olcostephanus) nicklesi*
			N. peregrinus
		Saynoceras verrucosum	*Karakaschiceras pronecostatum*
			S. verrucosum
	lower	*Karakaschiceras inostranzewi*	*Neocomites platycostatus*
			K. inostranzewi
		Neocomites neocomiensiformis **(12)**	*Busnardoites campylotoxus*
			Neocomites neocomiensiformis
		"Thurmanniceras" pertransiens	*Neolissoceras (Vergoliceras) salinarium* **(11)**
			Neocomites premolicus **(10)**
BERRIASIAN (3)	upper	*Tirnovella alpillensis*	*"Thurmanniceras" otopeta*
			T. alpillensis
		Fauriella boissieri	*Berriasella picteti*
			Malbosiceras paramimounum
	lower	*Tirnovella occitanica* **(8)**	*Dalmasiceras dalmasi*
			Berriasella privasensis
			Tirnovella subalpina **(9)**
		Strambergella jacobi **(7)**	
		Pseudosubplanites grandis **(6)**	
		Praedalmasiceras progenitor **(4)**	*Delphinella delphinense* **(5)**
T.	upper (pro parte)	*Lopeziceras chaperi* **(1,2)**	

Fig. 2. Standard ammonite zonation of the latest Tithonian–Hauterivian for the Mediterranean Province of the Western Tethyan Realm. Bold numbers refer to the numbers in the text. Zones and Subzones are not in scale. Abbreviation: T: Tithonian.

indices foreshadows two possibilities which both are unconvenient at the moment as both are inconsistent to the present primary marker event of the basal Berriasian: *i)* in the case of using *Lopeziceras chaperi* and *P. progenitor* as zonal indices, present T/B boundary should be situated within the *Praedalmasiceras progenitor* Zone; *ii)* in the case of using *Praedalmasiceras spiticeroides* and any *Delphinella* of the *delphinense* group as zonal indices, present T/B boundary is situated within the *P. spiticeroides* Zone. In the latter case three more handicaps have to be considered: *i)* if using *P. spiticeroides* as a zonal marker, the index lacks in the upper part of the zone (Le Chouet, VB, Frau et al., 2016a) or not present at all (Les Combes, VB, Frau et al., 2016a); *ii) P. spiticeroides* is a rare faunal element; *iii) Delphinella* seem to be facies dependant as they are rare or not present at all in the widespread tethyan ammonitico rosso facies.

Considering that the BWG2 may be voting another primary marker in the near future, we see no problem about the present T/B boundary is lying within an ammonite zone. As a most recent addition (April 2023), BWG2 voted placing the J/K boundary in the upper Tithonian and at the moment the majority of the group do not favour the acme event of *C. alpina* to be the primary marker.

(2* in Figs. 1,2). *Lopeziceras chaperi* Zone of the uppermost Tithonian

Definition. This interval zone is defined between the FAD of its index, *L. chaperi* and the FAD of *Praedalmasiceras progenitor*, the index of the overlying zone. Taxonomic content of the zone was summarized by Frau et al. (2016b) and Szives and Főzy (2022).

Here we propose the extension of *Lopeziceras chaperi* Zone to the Mediterranean Province. *P. spiticeroides* and *E. cularense* being considered as typical faunal elements of *L. chaperi* Zone, therefore there is no need to separate *E. cularense* Subzone as it was proposed previously by Szives and Főzy (2022).

Remarks. The use of *„Ammonites" Chaperi* as a possible index fossil goes back to Kilian (1907, p. 18), Mazenot (1939), Nikolov (1967) and Sapunov (1977), but their zonal divisions were placed into various stratigraphic levels based on different interpretations of this obscure species. Finally, the modern taxonomic revision of *L. chaperi* was given by Frau et al. (2016b). On the basis of his work, Szives and Főzy (2022) proposed its use as an index of the topmost Tithonian with a formal establishment of *L. chaperi* Zone.

In contrast, according to Frau, priority should be given to *P. spiticeroides* since its FAD and concomitant acme marks the evolution and predominance of Dalmasiceratinae over Himalayitinae at the base of the abandoned *'B.' jacobi* Zone discussed above. We all agree this is the main ammonoid evolutionary step observed at that time, with a widespread record through the Tethyan Realm. However, the phylogeny of *Praedalmasiceras* is still not revised and discussed by Frau et al. (2016b), but their data suggest that *P. spiticeroides* can be considered as descendant of *P. progenitor*. Stratigraphic importance of this point needs to be clarified and has to be discussed at the next meeting.

According to Frau et al. (2016b), *P. spiticeroides* – both micro- and macroconchs – is present in France, Tunisia, Spain, Bulgaria, Hungary and doubtfully in Morocco; while *L. chaperi* – both micro- and macroconchs – is reported from Spain, France, Bulgaria, Hungary, and Romania. *P. spiticeroides* is likely present in the southern Mediterranean margin, however it is less frequent than *L. chaperi*. As for *L. chaperi*, no specimens from the southern Tethyan margin have been found yet, however Szives and Főzy (2022, point 5.1.7) have arisen some doubts on ammonite taxonomy of some latest Tithonian genera which may widen the paleogeographic distribution of *Lopeziceras* towards the southern Tethyan margin.

Due to our understanding, both *L. chaperi* and *P. spiticeroides* co-occur with *Elenaella cularense* in the top *Crassicollaria intermedia* calpionellid Subzone, well below the *Calpionella alpina* acme (Tavera et al., 1994; Frau et al., 2016b; Szives and Főzy, 2022), and hence within the uppermost Tithonian. As a taxonomic revision of genus *Lopeziceras* and its allied genera, together with a proposal of *L. chaperi* as a zonal marker have been already published (Szives and Főzy, 2022), its priority over *P. spiticeroides* is considered to be established.

2.2. Berriasian

2.2.1. Lower Berriasian

(3* in Fig. 1,2). Here we propose to apply the two-folded Berriasian (Figs. 1,2) and abandon the term "middle" Berriasian as ammonite and microfossil zonations have to be fit as possible to achieve a better correlated integrated framework. It is also proposed that *Tirnovella occitanica* Zone including *Tirnovella subalpina*, *Berriasella privasensis* and *Dalmasiceras dalmasi* Subzones are incorporated into the lower Berriasian. From ammonite point of view, middle Berriasian is poor in ammonites which are not well investigated yet. Base of the upper Berriasian in ammonite terms remains unchanged and placed at the base of the *Fauriella boissieri* Zone (Fig. 1). Proposal on the two-folded subdivision of Berriasian will be presented to the BWG2.

(4* in Figs. 1,2). *Praedalmasiceras progenitor* Zone

Definition. This interval zone was established by Szives and Főzy (2022) and is defined between the FAD of its index, *P. progenitor* and the FAD of *Pseudosubplanites grandis*, the index of the overlying zone. Here we propose the extension of *P. progenitor* Interval Zone to the Mediterranean Province. Taxonomic content of the zone was summarized by Frau et al. (2016b) and Szives and Főzy (2022).
Remarks. FAD of *P. progenitor* is clearly above the FAD of *P. spiticeroides*, FAD of *E. cularense* and *L. chaperi* are also above the base of the *Crassicollaria colomi* calpionellid Subzone (Frau et al., 2016b), but clearly below the *C. alpina* acme event, the base of the *Calpionella alpina* Subzone (Wimbledon et al., 2020). By accepting the BWG1 decision on the primary marker (see the discussion above at 2.1 chapter), the current T/B boundary lies within the *P. progenitor* Zone that was erroneously interpreted previously by Szives and Főzy (2022, fig. 7). According to Frau, it is debatable whether the use of *P. progenitor* as index species – first proposed by Frau et al. (2016b) – of the basal Berriasian is reliable as its occurrence is discontinuous or spotty in many key localities. In contrast Szives pointed this may change in the future due to further clarification of some allied genera discussed in Szives and Főzy (2022).

(5* in Figs. 1,2). *Delphinella delphinense* Subzone

Definition. This interval Subzone is established here, and covers the upper part of *P. progenitor* Zone, between the FAD of *D. delphinense* and FAD of *Pseudosubplanites grandis*, the index of its nominal, overlying Zone.
Remarks. Frau would favour the use of FAD of *Delphinella* of the *delphinense* group as a zonal index (Frau et al., 2016a) over *P. progenitor*, however its FAD remains controversial as discussed below. FO of *Delphinella* of the *delphinense* group is near the base of *C. alpina* Subzone in the Les Combes section in the VB (Frau et al., 2016a), while FO of the *D. delphinense* group is within the middle *Calpionella ferasini* calpionellid Subzone at Le Chouet section

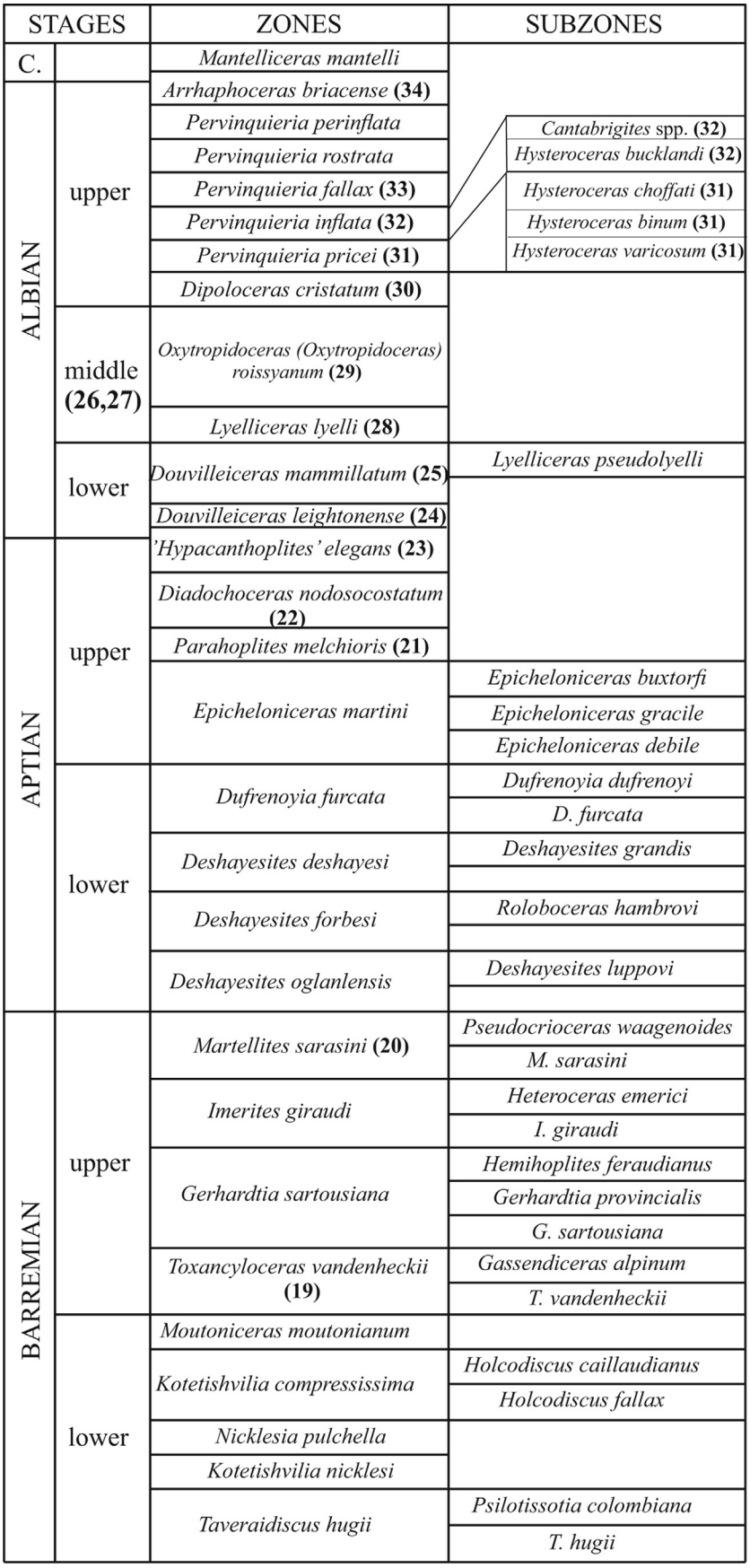

Fig. 3. Standard ammonite zonation of the Barremian–Albian stages of the Mediterranean Province of the Western Tethyan Realm. Bold numbers refer to the numbers in the text. Zones and Subzones are not in scale. Abbreviation: C: Cenomanian.

(Frau et al., 2016a). Although both Szives and Frau agreed that spread of *Delphinella* marks a widespread event through the Western Tethyan realm, *Delphinella* is virtually lacking or very rare in ammonitico rosso succession of eastern Spain (Tavera, 1985) and Hungary (Szives and Főzy, 2022), and occurs probably in younger levels in Bulgaria as detailed below.

In 2013, on the KG meeting in Ankara (Reboulet et al., 2014), Ivanov and Idakieva proposed to insert *Delphinella obtusenodosa* Zone into the standard scheme as the basal zone of the Berriasian based on their data from Berende and Kopanitsa sections (Bulgaria). Later, after incorporating the data from ammonites, calcareous nannofossils and calpionellids, it is documented that the level with the first *Delphinella* (*Delphinella obtusenodosa*, which is of the *D. delphinensis* group *fide* Frau et al., 2016b) corresponds to the base of nannofossil NK-1 Zone and calpionellid *Calpionella remaniella* [*C. ferasini*] Subzone" (Idakieva pers. comm., 2022). Their data are just briefly published (Stoykova et al., 2018) and point that the base of *Delphinella* biostratigraphical unit needs to be correlated to the data of Frau from the VB before putting it into the SMAZ. Moreover, all the ammonite material determined from Bulgaria needs a taxonomic reconsideration following Bulot et al. (2014a), Frau et al. (2015, 2016a,b,c) and Szives and Főzy (2022).

As the exact stratigraphic position of *Delphinella delphinense* interval remains controversial, it is proposed – until its stratigraphic position is clarified – to use this very distinctive level as a subzone.

(6* in Figs. 1,2). *Pseudosubplanites grandis* Zone

Definition. This interval zone was established by Le Hégarat (1973), its emended definition as an interval zone is given here between the FAD of its index, *P. grandis* and the FAD of *Strambergella jacobi*, the index of the overlying zone. Taxonomic content of *P. grandis* Zone was given by Le Hégarat (1973), recently summarized by Szives and Főzy (2022).
Remarks. Use of this zone is agreed by both Szives and Frau, directly overlying *P. progenitor* Zone and the *Delphinella*-bearing beds. According to Szives, the zonal name should be *P. grandis* based on two observations: *i)* Frau suspects a taxonomic priority of *Pseudosubplanites lorioli* (Zittel, 1868) as a senior synonym of *P. grandis* (Mazenot, 1939) that is not yet published; *ii)* FAD of *P. lorioli* appears within the *Delphinella* bed (Frau et al., 2016a) so the supposed synonymy affects the stratigraphic extension of the zone that needs to be clarified.

(7* in Figs. 1,2). *Strambergella jacobi* Zone

Definition. This interval zone is established here and defined between the FAD of its index, *S. jacobi* and the FAD of *Tirnovella occitanica*, the index of the overlying Zone. Taxonomic content of this zone is given by Frau et al. (2016a,b,c).
Remarks. In the light of a recent revision (Frau et al., 2016a,b), Frau suggested to distinguish a *Strambergella* (pro *Berriasella*) *jacobi* unit above the *Pseudosubplanites*-bearing beds that is widely recorded in SE France, southern Spain, Italy, Bulgaria, central Tunisia, Crimea, and doubtfully in Georgia. As the taxonomic content, the widespread paleogeographic distribution of its index and the distinctive nature of this zone is agreed between Frau and Szives, here the zonal rank of this unit is supported in spite of the following uncertainties: *i)* upward extension of *S. jacobi* unit remains to be unclarified since the strong affinities between *Strambergella* and basal *Tirnovella*, as relation between *Tirnovella subalpina* and *T. occitanica* are not yet clarified; *ii)* taxonomic matters between S. *jacobi* and *T. subalpina* are also not clarified as specimens of both species *fide* Le Hégarat (1973) co-occur in SE France key sections. A new, yet unpublished hypothesis of Frau is that *S. jacobi* macroconchs are identical to the type of *T. subalpina*, but inner whorls of the type are covered by matrix which prevents confirmation of the presence of a berriasellid stage in its inner whorls, as it is the main difference between genera *Strambergella* and *Tirnovella*. According to Frau, *T. occitanica* is distinct to early *Strambergella* by the peramorphic predominance of the fasciculate stage through most, if not all of its ontogenesis. Based on field data from the sections Frau published (Frau et al., 2016a,b,c), he would favour that *S. jacobi* Zone reaches the top of the *T. subalpina* 'Zone' of Le Hégarat which needs to be re-discussed in the next meeting after publishing the data.
Discussion. Reintroduction of an abandoned biozonal unit in a different meaning is not advised by the Stratigraphic Guide (https://stratigraphy.org/guide/bio), as "A fossil name once used for a zone is not available for use in a different zonal sense by a later author". Considering this case related to the *Strambergella jacobi* Subzone, another paragraph had been pointed out by Frau: "Named biostratigraphic units will automatically change scope to accord with changes in the scope of taxa defining or characterizing them". Without doubt to be a distinctive marker level, Szives and Frau agreed to use *Strambergella jacobi* Zone in accordance with the changes in its taxonomic and stratigraphic terms executed by Frau et al. (2016a). Reboulet disapproved this idea as its different zonal sense may cause confusion, more particularly for non-ammonitologists who use the SMAZ.

(8* in Figs. 1,2). *Tirnovella occitanica* Zone

Definition. No change.
Remarks. According to Frau, the use of *T. occitanica* Zone foreshadows several problems: *i)* its base has to be established since it has been introduced as an assemblage zone by Le Hégarat (1973) and the assemblage taxa marking the base of *T. occitanica* Zone needs a modern taxonomic revision. Moreover, according to the aim of the KG, this zone has to be defined as an Interval Zone. The taxonomic meaning of the index species fide Le Hégarat is no more adequate, therefore without revision his assemblage zone cannot be used here as a standard zone; *ii)* the lower part of the *T. occitanica* Zone (*T. subalpina* Subzone) is characterised by a drastic drop in ammonites, both in abundance and diversity (Le Hégarat 1973); *iii)* it seems that the index species is not present at the base of the zone it defines which might not be a problem in case of an Interval Zone but still it is in the original meaning of Le Hégarat (1973). This is proved at Berrias where the index occurs well above the level with *T. subalpina* sensu Le Hégarat, *iv)* there is no taxonomic work undertaken on the relationships between T. *occitanica* and T. *subalpina* and their link to 'true' upper Berriasian *Tirnovella* is not proved yet; *v)* accordingly, the use of *T. occitanica* Zone is far for being clear and consistent from place to place in SE France. Only Drôme sections have magnetic–calpionellid calibration of the *T. subalpina* Subzone of Le Hégarat, but this proves to be floating within M17r magnetozone, with no consistent ammonite marker due to drastic drop in fossil assemblages.

Some members share the idea of Frau as *Tirnovella occitanica* Zone should be limited to *Berriasella privasensis* and *Dalmasiceras dalmasi* Subzones. These units have not been defined precisely by Le Hégarat (1973) so it requires further work and to be discussed later.

(9* in Figs. 1,2). *Tirnovella subalpina* Subzone

Definition. No change.
Remarks. Following Bulot (1995), Company suggested to change the generic name of *Subthurmannia occitanica* and *Subthurmannia*

subalpina into *Tirnovella occitanica* and *Tirnovella subalpina*, respectively. Indeed, since Le Hégarat (1973), these two species are currently attributed by most of authors to the genus *Tirnovella* (for instance, see synonymies in Klein 2005). Moreover, from Hoedemaeker et al. (1990) to Hoedemaeker et al. (2000), species *occitanica* and *subalpina* were included in the genus *Tirnovella*. However, in the report of the Lyon meeting (Hoedemaeker et al., 2003), both species suddenly appear with the generic name of *Subthurmannia*, without any explanation in the text; this nomenclature corresponds to Hoedemaeker's take (see synonymies in Klein, 2005). The genus *Subthurmannia* was created by Spath (1939) to refer to several species defined by himself in Pakistan. The affinities of this group with the Mediterranean species are difficult to elucidate. Frau also emphasized that one should remember that most of the *T. subalpina* Subzone is devoid of diagnostic fauna in the VB which marks a deep change with the overlying late Berriasian assemblage.

Here the inclusion of *T. subalpina* Subzone at *Tirnovella occitanica* Zone is maintained and both to be incorporated into the lower Berriasian.

2.2.2. Upper Berriasian

No change in the upper Berriasian ammonite zonal or subzonal scales as base of the upper Berriasian is kept at the base of the *F. boissieri* Zone.

2.3. Valanginian

Company presented his joint work with Reboulet and made some proposals and suggestions that were accepted as follows.

(10* in Fig. 2). *Neocomites premolicus* Subzone

Definition. The Subzone was currently considered as a total range subzone (Reboulet et al., 2018; Kenjo et al., 2021). Due to the introduction of the *N.* (*V.*) *salinarium* Subzone, the *N. premolicus* Subzone is re-defined here as an interval subzone defined between the FAD of the index species which has been well recognized in south-east Spain (Company and Tavera 2015), south-east France (Kenjo et al., 2021) and Morocco (Ettachfini 2004; Reboulet et al., 2022) and the FAD of *N.* (*V.*) *salinarium*, the index of the overlying subzone.

(11* in Fig. 2). *Neolissoceras (Vergoliceras) salinarium* Subzone

Definition. This subzone is introduced here, for the upper part of *'Thurmanniceras' pertransiens* Zone and defined by the FAD of its index species and the FAD of *Neocomites neocomiensiformis*, the index of the overlying zone.
Remarks. Even though the *N.* (*V.*) *salinarium* Subzone was already integrated in the zonal scheme of south-east Spain (Company and Tavera, 2013a,b, 2015) and south-east France (Kenjo 2014), Reboulet's proposal to introduce this Subzone in the standard zonation was not adopted during the last meeting (Reboulet et al., 2018), due to some questions about the FAD of the index. After discussion, Company and Reboulet now agree that the FO of *N. (V.) salinarium* appears to be synchronous between various sections of south-east France and south-east Spain; its relative position in the bioevent succession and in the lithostratigraphic sequence is equivalent in both geographic areas. This species also occurs in Morocco (Ettachfini, 2004), Italy, Austria, Hungary, the Czech Republic, Slovakia and Poland (see synonymy in Klein et al., 2009), and was also found in Mexico (unpublished data).

(12* in Fig. 2). *Neocomites neocomiensiformis* Zone

Definition. It is divided into a lower *N. neocomiensiformis* Subzone and an upper *Busnardoites campylotoxus* Subzone. They are defined by the FAD of their index species. Upper bounding horizon of *B. campylotoxus* Subzone is the FAD of *Karakaschiceras inostranzewi,* index of the overlying zone.
Remarks. The introduction of *B. campylotoxus* Subzone into the standard zonation was proposed by Reboulet et al. (2022). They underlined that the index-species is easy to identify, abundant, and has a widespread palaeogeographic distribution throughout the Mediterranean area. The assemblage characteristic of this interval has been recognized in Morocco (Wippich, 2003; Ettachfini, 2004; Reboulet et al., 2022), south-east Spain (Company and Tavera, 2015), south-east France (Bulot, 1995; Reboulet, 1996) and Crimea (Baraboshkin and Mikhailova, 2000). Reboulet et al. (2022) also provided an updated discussion on the *N. neocomiensiformis* Zone and the *B. campylotoxus* Subzone, and on their equivalent units, in terms of stratigraphic interval, in local zonal schemes of Morocco, Spain and France.

2.4. Hauterivian

Company and Reboulet's proposals and suggestions were accepted as follows.

(13* in Fig. 2). *Crioceratites loryi* Zone

Definition. This interval zone is defined by the FAD of its index species and the FAD of *Lyticoceras nodosoplicatum,* the index of the overlying zone.
Remarks. Bert et al. (2021) proposed *Crioceratites claveli* Zone to replace *Crioceratites loryi* Zone in south-east France. As *C. claveli* has only been reported from France and Italy, the KG suggested that the potential long-distance correlation of the index species should be tested before changing the standard zonation.

For the moment, as a provisional solution, the base of the *C. loryi* Zone is unchanged (and the *A. radiatus* Zone also) and we consider that the base of the *C. loryi* Zone (sensu the KG) is defined by the FAD of the index-species *Crioceratites* group *claveli-loryi*. The KG is waiting for the *C. claveli* to be recognized elsewhere in the Mediterranean Province.

(14* in Fig. 2). Horizons of *Breistrofferella castellanensis*, *Olcostephanus (Olcostephanus) variegatus*, *Cruasciceras cruasense* and *Subsaynella begudensis*

These units are abandoned.
Remarks. The general reasons to delete horizons of the standard zonation were presented in the previous KG report in which the horizons of the Barremian stage were removed (Reboulet et al., 2018). Thus, the standard Hauterivian zonation equates the other Lower Cretaceous stages where the group had already suppressed the horizons. The former *Breistrofferella castellanensis* Horizon, introduced into the standard zonation by Hoedemaeker et al. (2000), was not relevant as its range overlaps almost the whole *A. radiatus* Zone (Reboulet, 1996 and references therein). *Cruasiceras cruasense* and *Subsaynella begudensis* have very restricted distribution (in the platforms bordering the Vocontian Basin) as reported by Reboulet et al. (2009).

(15* in Fig. 2). *Olcostephanus* (*Olcostephanus*) *variegatus* Subzone

Definition. The former *Olcostephanus* (*Olcostephanus*) *variegatus* Horizon is raised here to the rank of a subzone. Its base is defined by the FAD of *Lyticoceras nodosoplicatum* as the FO of *O.* (*O.*) *variegatus* is recorded few beds below the index-species of the zone (see references in Hoedemaeker et al., 2003). The top of this subzone corresponds to the last occurrence of *O.* (*O.*) *variegatus.* The last

specimens of this index species disappear before the end of the *L. nodosoplicatum* Zone; so, the top of the *O. (O.) variegatus* Subzone does not match with the top of the *L. nodosoplicatum* Zone. The top of the *O. (O.) variegatus* Subzone must be put slightly lower than the top of the *L. nodosoplicatum* Zone; see Figure 1a in Reboulet et al. (2018).

Remarks. The index species has been recorded throughout the Mediterranean Province (from Morocco to Bulgaria) and also in Argentina, Colombia and Tanzania (see synonymy in Klein 2005). *O.* (*O.*) *variegatus* is very useful for correlations between the West Mediterranean and North-West European provinces and between the West Mediterranean Province and the Neuquén Basin (Argentina) as reported by Reboulet et al. (2014, see level 9 in figure 4, and level 6 in figure 5, respectively).

(16* in Fig. 2). *Balearites angulicostatus* Subzone

Definition. The base of this subzone is defined by the FAD of its index species and top of the subzone is by the FAD of *Pseudothurmannia ohmi*, index of the overlying zone.

Remarks. Spathiocrioceras seitzi is replaced by *Balearites angulicostatus* as index species of the fourth Subzone of the *Balearites balearis* Zone, as proposed by Lukeneder during the 6th KG meeting (Reboulet et al., 2018). This is justified according to Matamales-Andreu and Company (2019) who considered *S. seitzi* as junior synonym of *B. angulicostatus*. All subzonal index-species of the *B. balearis* Zone are assigned the genus *Balearites* since they seem to constitute a continuous phylogenetic lineage in ascending order (« *balearis—binelli—krenkeli—angulicostatus* », Company et al., 2003, 2010).

(17* in Fig. 2). *Pseudothurmannia ohmi* Zone

Definition. No change.

Remarks. The inverted commas in « *Pseudothurmannia ohmi* » are removed. During the 2008 Vienna meeting (Reboulet et al., 2009), it was recommended to add inverted commas to mean that *P. ohmi* was awaiting a redefinition. This was made by Matamales-Andreu and Company (2019) who completed a huge study on *Balearites angulicostatus* and *Pseudothurmannia ohmi*.

(18* in Fig. 2). *Pseudothurmannia mortilleti* Subzone

Definition. According to Lukeneder's proposal (in Reboulet et al., 2018), it was decided here to use *Pseudothurmannia mortilleti* as index species of the second subzone of the *P. ohmi* Zone, instead of *Pseudothurmannia catulloi* as this latter is considered as a junior synonym (Vermeulen et al., 2002, 2019a,b; Vermeulen 2003, 2005; Company et al., 2003, 2005, 2008, 2010; Lukeneder, 2012, 2017). More recently, *P. catulloi* and *P. mortilleti* Subzones were synonymized by Matamales-Andreu and Company (2019), following Company et al. (2003).

2.5. Barremian

(19* in Fig. 3). *Toxancyloceras vandenheckii* Zone

Definition. Company and Reboulet suggested only a small modification regarding the *Toxancyloceras vandenheckii* Subzone and Zone. Its base is now defined as an interval zone by the FAD of the genus *Toxancyloceras* instead of by that of the index species. Indeed, according to Bert et al. (2018), the FO of *T. vandenheckii* seems to be shortly preceded by the FO of another species of the same genus, *Toxancyloceras canuti*. To maintain the stability of the standard zonation and waiting to confirm the stratigraphic distribution of *T. canuti* in other Mediterranean basins, the group agreed to define the base of the *T. vandenheckii* Zone and Subzone by the FAD of the genus.

Remarks. This species is dedicated to Abbot Van den Hecke. Astier, when defined it, wrote as „*Vanden-Heckii*". This is not a *lapsus calami*, because he wrote it the same way every time he cited the species. In addition, his work was published in two different media (in the Annales des Sciences Physiques et Naturelles de Lyon and as an independent publication by the author) and Astier did not proofread it. The case probably was that Astier derived the specific name of the species from the latinized version of Van den Heckee which is Vandenheckius, and its genitive is Vandenheckii. This is explained in the ICZN 31.1 article and was quite common among the authors of the mid-19th century (*duvalii*, *emericii*, *hugii*, *jeanottii* etc.). This article overwrites article ICZN 32.5.1, therefore the rightful specific name is „*vandenheckii*".

(20* in Fig. 3). *Martelites sarasini* Zone

Definition. No change.

Remarks. Concerning the content of the *M. sarasini* Zone, a suggestion was made by Frau as to replace the *Pseudocrioceras waagenoides* Subzone by the *Pseudocrioceras mazierei* Subzone, see Frau and Delanoy (2022) for further explanations. This point will be discussed more extensively at the next meeting.

2.6. Aptian

The two-folded Aptian is kept here.

2.6.1. Lower Aptian

No change in lower Aptian ammonite scale.

2.6.2. Upper Aptian

Several changes are proposed in Warsaw by Szives as recent zonal standards of the upper Aptian (Reboulet et al., 2018; Gale et al., 2020) are partly due to the proposed retention of zonal indices of '*Nolaniceras nolani*' and '*Hypacanthoplites jacobi*' Zones (Bulot et al., 2014b; Frau et al., 2016a).

Changes of these indices involve the problem of basal Albian ammonite scale. It is a long-known fact that zonation of the lower Albian in terms of ammonites using the *Leymeriella* lineage is highly problematic (detailed in Kennedy et al., 2000). As a result, the SMAZ of these substages was highly inaccurate as it was previously pointed out since Hoedemaeker et al. (1990) through Reboulet et al. (2018) and Gale et al. (2020). In 2017 on the Vienna meeting, KG members postponed changing the Aptian and Albian zonation due to lack of experts on the meeting, but explained the need for major modifications during the next meeting in 2022.

In order to make a good progress during the KG meeting in Warsaw in 2022, a small group of Aptian—Albian experts — Szives, Owen, Latil, Robert, Lehmann and Moreno-Bedmar — were previously evoked to make suggestions towards the necessary changes of the Aptian and Albian SMAZ scheme. Zonation of the upper Aptian to upper Albian is strongly modified on the basis of the detailed proposal by this group (Szives et al., 2023). Changes and suggestions were accepted as follows.

(21* in Fig. 3). *Parahoplites melchioris* Zone

Definition. No change.

Remarks. Use of *P. melchioris* as a zonal index is debatable as detailed in Szives et al. (2023). Nothing is agreed as a replacement and this point will be a task of the next meeting.

(22* in Fig. 3). *Diadochoceras nodosocostatum* Zone

Definition. D. nodosocostatum Zone emerged to zonal rank as its index is common in the Western Tethys (Klein and Bogdanova,

2013) and also can provide a supraregional correlation possibility. This interval zone is defined between the FAD of its index, *D. nodosocostatum* and the FAD of *'Hypacanthoplites' elegans*, index of the overlying newly introduced zone. Exact FAD of *D. nodosocostatum* needs to be clarified in a well documented continuous section as only the genus was documented from the Albian GSSP (Kennedy et al., 2000, 2014, 2017) Integration of this zone into the SMAZ is supported by Aptian–Albian ammonite experts and also by Bulot et al. (2014b) and accepted here.
Remarks. Reboulet et al. (2018) discussed the idea to emerge *D. nodosocostatum* Subzone to zonal rank, but the KG rejected it pointing out several problems. On the basis of the most recent investigation (Szives et al., 2023), problems cited by Reboulet et al. (2018) are mostly solved.

(23* in Fig. 3). *'Hypacanthoplites' elegans* Zone

Definition. Defined by Szives et al. (2023) between the FAD of its index, *'H.' elegans* and the FAD of *Douvilleiceras leightonense* the index of the overlying, newly introduced zone. From stratigraphic point of view, the Aptian/Albian boundary lies within this zone. Consecutive succession of *'H.' elegans*, *D. leightonense* and *D. mammillatum* can be documented at the GSSP section (Kennedy et al., 2000) with the FAD and LAD events of both ammonite zonal indices, allowing a precise correlation to an integrated framework including FAD event of the primary marker (*Microhedbergella renilaevis* planktic foraminifer) of basal Albian. Due to these reasons, integration of this zone into the SMAZ is accepted here.
Remarks. The uppermost Aptian '*Hypacanthoplites jacobi*' Zone was retained by Bulot et al. (2014b) but as no replacement offered, it was kept until the most recent scales (Reboulet et al., 2018; Gale et al., 2020). '*H. jacobi*' was considered as a synonym of *Hypacanthoplites plesiotypicus* (Kennedy et al., 2000) which is known only from the northern margins of the Tethys and have more extended stratigraphic occurrence than '*H. jacobi*'. Due to these circumstances, we agree abandoning the '*H. jacobi*' Zone. Szives et al. (2023) discussed the problem and suggested to be replaced by the newly introduced *'Hypacanthoplites' elegans* Interval Zone, where the Aptian–Albian boundary lies within. Although generic affiliation of the index is debatable (Bulot 2010; Lehmann et al., 2020) and therefore should be put in quotation marks (for more details see Szives et al., 2023), this doesn't affect its use as a stratigraphical index.

2.7. Albian

Inapplicability of several Albian zonal indices in the Mediterranean settings was obvious since long ago as – discussed lately in details by Szives et al. (2023) – the zonation was established (Hoedemaeker et al., 1990) on ammonites occurring in the NW European subprovince (or Boreal-Atlantic Subrealm *sensu* Lehmann et al., 2015).

Proposals and suggestions presented by Szives based on Szives et al. (2023) were accepted as follows.

2.7.1. Lower Albian

Previous zonation of the early Albian was based on *Leymeriella* species (Reboulet et al., 2018; Gale et al., 2020), however problems related to their applicability is a long-known issue detailed in Kennedy et al. (2000, p. 599), recently discussed by Szives et al. (2023). Latter authors doubt the usefulness of the *Leymeriella* lineage in the Mediterranean area and suggested to abandon it and offered a replacement.

(24* in Fig. 3). *Douvilleiceras leightonense* Zone

Definition. The zone was introduced and fully discussed by Szives et al. (2023). *D. leightonense* Zone is defined between the FAD of its index and the FAD of *Douvilleiceras mammillatum*, the index of the overlying zone. In the GSSP section, FAD of *D. leightonense* can be precisely correlated to the primary marker of the Albian stage (Kennedy et al., 2000). Due to these reasons, integration of this zone into the SMAZ is accepted here.
Remarks. According to Szives et al. (2023), *D. leightonense–D. mammillatum* succession characterizes the lower Albian of the Western Tethys. Ammonite content of continuous ammonitiferous basal Albian sections is a mixture of an endemic acanthohoplitinid–hypacanthoplitinid assemblage and very primitive *Douvilleiceras* which may allow a correlation possibility across the Mediterranean and also to the Boreal *Leymeriella* zonation. Klein and Bogdanova (2013, p. 62) have given a complete account of *D. leightonense* demonstrating its wide geographic distribution. Although different taxonomic concepts were arisen about genus *Douvilleiceras* (Kennedy and Klinger, 2015 *vs*. Futakami and Haggart, 2018), all authors considered *D. leightonense* as the ancestor of *D. mammillatum*.

(25* in Fig. 3). *Douvilleiceras mammillatum* Zone

Definition. No change. This zone is defined above the *D. leightonense* Zone, between the FAD of *D. mammillatum*, and its upper bounding event, FAD of *Lyelliceras lyelli*, the overlying zone.
Remarks. D. mammillatum Zone should be maintained as an interval zone. As the index has wide paleogeographic distribution (Klein and Bogdanova 2013), from a supraregional correlative point of view *D. mammillatum* offers excellent possibility including the Boreal Realm (Owen 1999), across Mangyshlak (Saveliev 1974, 1981) towards Japan.

2.7.2. Middle Albian

(26* in Fig. 3). *Hoplites dentatus*, *Euhoplites loricatus*, *Euhoplites lautus* Zones

Retained Zones from the SMAZ, restricted to the Boreal ammonite scheme.
Remarks. Present Mediterranean middle Albian zonation based on boreal Hoplitids cannot be applicable in Tethyan settings, as discussed in detail by Szives et al. (2023). The need of change was obvious since long time as "The genus *Hoplites* and its direct successor *Euhoplites* are unknown [or rare] outside the European Province" (Owen, 1999). These zonal indices albeit are present in some Tethyan assemblages (Breistroffer, 1947; Eristavi, 1955; Gebhard, 1983), but rare occurrences are not eligible to provide a solid base for establishing a standard zonation on them.

(27* in Fig. 3). *Hoplites spathi* Subzone

This subzone is abandoned from the SMAZ and restricted to the Boreal ammonite scales.

(28* in Fig. 3). *Lyelliceras lyelli* Zone

Definition. Lyelliceras lyelli Subzone here arisen to an interval zonal rank and is defined between the FO of its index, *L. lyelli* and the FAD of *Oxytropidoceras (Oxytropidoceras) roissyanum*, the index of the overlying zone. In contrast to the original concept of *L. lyelli* to be a taxon range zone (Latil, 1995), Szives et al. (2023) modified it to interval zone based on the fact that exact LAD of *L. lyelli* is uncertain related to the overlying zonal index, *Oxytropidoceras (O.) roissyanum*.
Remarks. Owen (1984) suggested, and it was accepted by the Copenhagen Symposium (Birkelund et al., 1984), that base of the

middle Albian should be drawn at the FAD of *Lyelliceras lyelli*, which was further supported by Hart et al. (1996) and Kennedy (in Gale et al., 2011). This species is one of the few, during the Aptian–Albian times, which may serve as an excellent marker fossil in its level agreed in both most recent zonal schemes (Reboulet et al., 2018; Gale et al., 2020), and has a worldwide distribution detailed recently in Szives et al. (2023). Cooper (1982), Latil (1995), and Kennedy and Klinger (2008) provided a taxonomic, stratigraphic and paleogeographic examination of the subfamily, including *L. lyelli*.

(29* in Fig. 3). *Oxytropidoceras (Oxytropidoceras) roissyanum* Zone

Definition. This interval zone is defined between the FAD of its index and the FAD of *Dipoloceras cristatum*, the index of the overlying zone. *O. (O.) roissyanum* is always a rare faunal element, but displays a wide paleogeographic distribution discussed by Szives et al. (2023). Integration of this zone into the SMAZ is accepted here.
Remarks. First Kotetishvili (1986, p. 71) published about *O. (O.) roissyanum* Zone as a biostratigraphic unit characterising the upper middle Albian, between her *Hoplites dentatus* Zone and the overlying „*Actinoceramus* beds" which are right below her *H. orbigny* Zone. Faunal content of *Oxytropidoceras* spp. Zone from the Col de Palluel section was given by Kennedy in Gale et al. (2011). In 2010, Bulot and Latil sent a written contribution on the Albian zonation, but as most of the specialists were absent at the Dijon meeting, the discussion was shortened and the KG considered that it was impossible to make good decisions (Reboulet et al., 2011). Raisossadat et al. (2021) also discussed the regional middle Albian biostratigraphy of NW Iran and concluded *Oxytropidoceras* spp. as useful middle Albian markers.

Szives et al. (2023) established formally the *O. (O.) roissyanum* Zone but as the genus appears already at the base of the Albian in the GSSP section (Kennedy et al., 2000), the use of *Oxytropidoceras* spp. Zone is not supported unless we use this generic term *sensu* Bulot (2010) who considered it in a restrictive sense, i.e. only to the *Oxytropidoceras (O.) roissyanus* group.

2.7.3. Upper Albian

(30* in Fig. 3). *Dipoloceras cristatum* Zone

Definition. No change. This zone is defined between the FAD of its index, *D. cristatum* and the FAD of *Pervinquieria pricei*, the index of the overlying zone (Reboulet et al., 2011). *D. cristatum* is always a rare faunal element although with worldwide distribution (see Kennedy and Klinger, 2023). Indirect correlation of this zone towards the Boreal, Central Atlantic, and southern Gondwanan Realms is possible as detailed in Szives et al. (2023).

Zonation based on *Mortoniceras* phyletic lineage was introduced into the SMAZ during the Dijon meeting (Reboulet et al., 2011), and recently discussed by Szives et al. (2023) including taxonomic and stratigraphic debates of their indices. On the basis of examination of their generic types, Kennedy (in Gale et al., 2019; Gale and Kennedy, 2020) separated *Pervinquieria* from *Mortoniceras*, though this was not accepted generally (Jattiot et al., 2022). Here we adopt the view of Kennedy on the basis of Szives et al. (2023) and use the generic name *Pervinquieria* for these species.

In a written contribution by López-Horgue, posterior to the Warsaw meeting but following an oral introduction on the subject on the Cretaceous Symposium (López-Horgue and Owen, 2022), a more refined subdivision is proposed. Hereby acceptance of his detailed proposal as subzonal division – instead of assemblage composition – is based on two points: *i)* the expanded sections of the Basque–Cantabrian Basin localities allow the detailed stratigraphy of the *Hysteroceras* lineage, and *ii)* the relative abundance of *Hysteroceras* usually higher than associated Mortoniceratinae, therefore a precise stratigraphic recognition of the zone is possible in absence of Mortoniceratinae. His proposal is accepted as follows.

(31* in Fig. 3). *Pervinquieria pricei* Zone

Definition. No change in zonal terms, but *P. pricei* Zone is split into three subzones based on *Hysteroceras* species which are highly valuable due to their: *i)* short stratigraphic range; *ii)* relative abundance, usually higher than associated Mortoniceratinae; *iii)* cosmopolitan character as being common elements in the North Atlantic province (Owen, 2012) and the Tethyan Realm and outside (references in Szives et al., 2023). They can be applied as interval subzones as FAD of each *Hysteroceras* spp. may define the bases of their nominal subzones and they follow each other in ascending order. The *Hysteroceras*-based succession and biozonation from the oldest to youngest is:

i) *Hysteroceras varicosum* Subzone is defined by the FAD of the marker, correlates with the FAD of *P. pricei.* It covers the lowest part of the *P. pricei* Zone. Additionally, the base is also defined by the FAD of typical forms of *H. orbignyi* whose transitional forms from *Brancoceras* occur at the upper *Dipoloceras cristatum* Zone. Equivalent to the *H. orbignyi* Subzone of Spath (1941) and Owen (1976).
ii) *H. binum* Subzone (middle *P. pricei* Zone). Equivalent to the homonym subzone in López-Horgue et al. (1999, 2009).
iii) *H. choffati* Subzone (upper *P. pricei* Zone). Base as FAD of the marker and top as FAD of *P. inflata.* Equivalent to the homonym subzone in López-Horgue et al. (1999, 2009). Morphological changes in the inoceramid species *Actinoceramus sulcatus* occur at around the base of the *H. binum* Subzone, and late forms of *Actinoceramus concentricus* characterize the *H. binum* and *H. choffati* Subzones (Gale and Owen, 2010), these latter being common in Tethyan areas (López-Horgue et al., 2009).

(32* in Fig. 3). *Pervinquieria inflata* Zone

Definition. Subdivision of *P. inflata* Zone into two subzones by Owen (2012) was proposed by López-Horgue and accepted as follows:

i) *Hysteroceras bucklandi* Subzone (lower *P. inflata* Zone), where FAD of this species correlates to the FAD of *P. inflata. H. bucklandi* total range does not expand up to the top of *P. inflata* Zone;
ii) *Cantabrigites* spp. Subzone, where the FAD of the genus occurs in the upper part of the *P. inflata* Zone (Owen, 2012). These forms correspond to the *C. minor* species, therefore FAD of this genus may be considered as the base of an upper subzone in *P. inflata* Zone. As many Mortoniceratinae, *Cantabrigites* spp. occur subordinate, but their distribution is cosmopolitan.

(33* in Fig. 3). *Pervinquieria fallax* Zone

Definition. No change.
Remarks. López-Horgue emphasized the definition of *P. fallax* Zone is problematic since: *i)* observations made in the occurrences of ammonites in the uncondensed succession of the Col de Palluel (Gale et al., 2011) show that *P. fallax* co-occurs with *Cantabrigites minor*; *ii) P. fallax* is considered as an ally of *P. rostrata* where most of the known examples come from condensed successions and the complete ontogenetic stages of both species are not well defined;

iii) holotype of *P. fallax* is a phragmocone, also from a condensed interval with reworked elements from the Cenomanian Cambridge Greensand (Owen, 2012). A revision of the *Pervinquieria* lineage from uncondensed successions would help to understand the real nature of this important interval (López-Horgue and Owen, 2022).

(34* in Fig. 3). *Arrhaphoceras briacensis* Zone

Definition. This zone is defined between the LAD of *P. perinflata* (equivalent the LAD of genus *Pervinquieria*) and the FAD of *Mantelliceras mantelli*, the index of the overlying zone and emended to use as an interval zone. This means *A. briacensis* Zone stretches up into the lowermost Cenomanian (Fig. 3) and base of the Cenomanian – defined by the FAD of a planktic foraminifer at the Mont Risou GSSP section (Kennedy et al., 2004) – is hardly concordant with any ammonite event. First characteristic Cenomanian ammonites, namely *Neostlingoceras oberlini* or *Mantelliceras mantelli* appear well above the primary marker. Characteristic assemblage of the zone is discussed by Szives et al. (2023).

Remarks. In contrast to Scholz (1973) and Szives et al. (2023), this zone should be defined as an interval zone here in accordance with the aims of the KG (see Reboulet et al., 2011). As Reboulet emphasized, the KG's method is to build the standard zonation by using interval (sub-)zones. Moreover, on the field it is not easy to recognize the base of an assemblage zone as many taxa are needed. On the basis of his points, it is accepted here *A. briacensis* Zone to be used as an Interval Zone. Bert debated this point and the KG will return to this issue during the next meeting.

3. A tribute to deceased ammonitologist colleagues and next meeting of the KG

At the end of the meeting, Szives presented a short tribute as homage to our deceased ammonitologist colleagues: Luc Bulot (1959–2022), Robert Busnardo (1926–2018), Irina Mikhailova (1929–2022), Todor Nikolov (1931–2021), Hugh Gwyn Owen (1933–2022) and Jean Vermeulen (1945–2021). Homages of late members of the Kilian Group are provided as a Supplementary Material.

The next Kilian Group meeting will be held in Hannover, prior to the first day of the 12th International Symposium on the Cretaceous System. All Lower Cretaceous ammonitologists are warmly welcome into the KG, please contact the chair, S. Reboulet (stephane.reboulet@univ-lyon1.fr).

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.cretres.2023.105716.