Report on the 4th International Workshop of the Lower Cretaceous Cephalopod Team (IGCP-Project 362)

Peter F. Rawson & Philip J. Hoedemaeker (Reporters) and Maria B. Aguirre-Urreta, Emil Avram, Mohssine Ettachfini, Simon R.A. Kelly, Jaap Klein, Eliso Kotetishvili, Hugh G. Owen, Pierre Ropolo, Michael R.A. Thomson, Max Wippich & Zděnek Vašíček

Rawson, P.F., Ph.J. Hoedemaeker, M.B. Aguirre-Urreta, E. Avram, M. Ettachfini, S.R.A. Kelly, J. Klein, E. Kotetishvili, H.G. Owen, P. Ropolo, M.R.A. Thomson, M. Wippich & Z. Vašíček. Report on the 4th International Workshop of the Lower Cretaceous Cephalopod Team (IGCP-Project 362). — Scripta Geol., Spec. Issue 3: 3-13, 7 figs., Leiden, December 1999.
P.F. Rawson, Department of Geological Sciences, University College London, London WC1E 6BT,England (UK); Ph.J. Hoedemaeker, National Museum of Natural History, Postbus 9517, 2300 RA Leiden, The Netherlands.

Keywords: Ammonites, Correlation, Lower Cretaceous.
The Working Group proposes only one modification to its current zonation of the Mediterranean Region, the addition of a *cristatum* Subzone in the lower part of the *inflatum* Zone (upper Albian). But in the light of newly published research it highlights levels/areas where further work is required, especially to resolve conflicting zonal schemes. It also proposes a 'Tethyan Province' zonation for the middle Albian. Alternative correlations for the Boreal/Tethyan Valanginian to Barremian stages are tabulated, one based on ammonite evidence alone, the other with additional biostratigraphical data coupled with sequence stratigraphy and magnetostratigraphy.

Contents

Introduction

The Lower Cretaceous Cephalopod Team originated as a group of specialists collaborating to establish an ammonite zonation for the Mediterranean Region of Tethys on behalf of IGCP Project 262 (Tethyan Correlation). An initial zonation was agreed at the first workshop, in Digne, France (11-15 July 1990), and published later that year (Hoedemaeker & Bulot, 1990). The second workshop, in Mula, SE Spain (2-5 July 1992) modified some aspects of the zonal scheme (Hoedemaeker et al., 1993). Papers originating from the first two workshops were published in Mémoire HS 20 of *Géologie Alpine*.

When IGCP Project 262 finished, the Cephalopod Team joined the replacement Project 362 (Tethyan-Boreal Cretaceous) and began to focus also on correlation with Boreal areas. A third workshop was held in Piobbico, Italy (5-8 July 1994). There it was agreed that no changes should be made to the team's Mediterranean zonation (Hoedemaeker et al., 1995). The proceedings were published as volume 51 of the *Memorie descrittive della Carta Geologica d'Italia* (1995). Most of the papers focused on

Tethyan faunas but Rawson (1995) reviewed the Boreal pre-Aptian sequences of NW Europe and proposed a Tethyan-Boreal correlation for the Valanginian to Barremian stages.

Most of our members also belong to appropriate Stage Working Groups of the Cretaceous Subcommission of IUGS, of which Peter Rawson is Chairman. The Subcommission held its second International Symposium on Cretaceous Stage Boundaries in Brussels, Belgium, in September 1995 and the proceedings were published the following year (Rawson et al., 1996).

All this activity has focused attention on many outstanding problems and stimulated much new research. This provided the background to our fourth Workshop, held in London, England, from 8-14 September, 1997. Sadly, illness prevented our Chairman, Philip Hoedemaeker, from attending the meeting. Twelve members attended from 9 countries; Argentina, Czech Republic, France, Georgia, Germany, Morocco, The Netherlands, Romania, and the United Kingdom. We were also delighted to welcome Dr Raymond Casey for our discussions on the Aptian and Albian. The range of expertise represented embraced areas from the Arctic (Spitsbergen and East Greenland), through NW Europe and Tethys to South America and the Antarctic. The papers in this volume reflect this.

Below we summarise the main conclusions of our discussions on zonation and correlation.

Zonation of the Mediterranean Region

No changes are proposed to the zonation published after our second workshop, with the exception of an additional subzone in the Albian. The zonation is summarised in Fig. 1. However, further modification will become necessary in the light of current and projected research, as indicated below:

Valanginian

The lower Valanginian zonation will need to be reconsidered when Bulot publishes the detailed evidence for his proposed *stephanophorus* and *inostranzewi* Zones (see Bulot, 1995). A summary is published in Bulot & Thieuloy (1995).

The upper Valanginian *trinodosum* and *callidiscus* Zones in our initial zonation were replaced later by the *pachydicranus* Zone (Hoedemaeker et al., 1993). This should be reinvestigated; some members believe we should go back to the former scheme (see also Bulot & Thieuloy, 1995).

Several 'horizons' additional to those shown in our chart have been recognised in slightly conflicting schemes produced by Bulot, Thieuloy and co-workers on the one hand (e.g. Thieuloy et al., 1990; Bulot & Thieuloy, 1995) and Atrops & Reboulet (e.g. 1993, 1995) on the other. The two versions are summarised in Fig. 2. Our Working Group will try to secure agreement on a unified scheme before modifying our chart.

Hauterivian

The recent proposals of Hoedemaeker (1995) and Hoedemaeker & Leereveld

STAGES		ZONES	SUBZONES	HORIZONS
ALBIAN	upper	*S. (S.) dispar*	*S. (S.) dispar*	
			S. (F.) blancheti	
		M. inflatum		
			D. cristatum	
	middle	*E. lautus*		
		E. loricatus		
		H. dentatus	*H. spathi*	
			L. lyelli	
	lower	*D. mammillatum*		
		L. tardefurcata		
APTIAN	upper	*H. jacobi*		
		A. nolani	*D. nodosocostatum*	
	middle	*P. melchioris*		
		E. subnodosocostatum		
	lower	*D. furcata*		
		D. deshayesi		
		D. weissi		
		D. tuarkyricus		
BARREMIAN	upper	*M. sarasini*		*H. ridzewskyi*
		I. giraudi		
		H. feraudianus		
		H. sartousiana		
		A. vandenheckii		
	lower	*H. caillaudianus*		
		S. nicklesi		*N. pulchella*
		S. hugii		
HAUTERIVIAN	upper	*P. angulicostata auct.*	*P. cattulloi*	
			P. angulicostata auct.	
		B. balearis		
		"P. ligatus"		
		S. sayni		
				C. cruasense
	lower	*L. nodosoplicatum*		
		C. loryi		*O. (J.) jeannoti*
				C. loryi
		A. radiatus		
VALANGILNIAN	upper	*N. (T.) pachydicranus*		
				N. (T.) callidiscus
			H. trinodosum	*C. furcillata*
				O. (O.) nicklesi
		S. verrucosum		
	lower	*B. campylotoxus*		
		T. pertransiens		
		T. otopeta		
BERRIASIAN	upper	*F. boissieri*	*T. alpillensis*	
			B. picteti	
			M. paramimounum	
	middle	*T. occitanica*	*D. dalmasi*	
			B. privasensis	
			T. subalpina	
	lower	*B. jacobi*		

Fig. 1. Zonal scheme for the Mediterranean Lower Cretaceous (after Hoedemaeker et al., 1995, with the addition of the *cristatum* Subzone).

(1995) to modify the zonation of the *Pseudothurmannia* beds are summarised in Fig. 3. The team recommends:

(a) that more research be initiated on the French Hauterivian, especially on the Upper Hauterivian (with special emphasis on the *Pseudothurmannia* beds);

(b) that E. Avram, F. Cecca, M. Company, Ph. Hoedemaeker and Z. Vašíček form a *Pseudothurmannia* Working Group to agree on a unified scheme.

Bulot & Thieuloy (1992-1995)		Atrops & Reboulet (1992-1995)	
Zones	Biohorizons	Zones	Biohorizons
nodosoplicatum	*collignoni*	*nodosoplicatum*	*bargemensis*
	variegatus		*nodosoplicatum*
loryi	*jeannoti*	*loryi*	*jeannoti*
	loryi		*loryi*
radiatus	*buxtorfi*	*radiatus*	
	castellanensis		
callidiscus		*callidiscus*	
	callidiscus		*callidiscus*
trinodosum	*furcillata*	*trinodosum*	*subheterocostata*
			furcillata
	nicklesi		*companyi*
			nicklesi
verrucosum	*peregrinus*	*verrucosum*	*peregrinus*
	pronecostatum		*pronecostatum*
	verrucosum		*neocomiensis*
			verrucosum
inostranzewi		*campylotoxus*	*platycostatus*
			biassalensis
			fuhri
stephanophorus	*campylotoxus*		*quadristrangulatum*
	subcampylotoxus		
	hirsutus		*hirsutus*
pertransiens		*pertransiens*	
otopeta	*thieuloyi*		
	otopeta		

Fig. 2. Valanginian and lower Hauterivian 'horizons'; alternative schemes.

Barremian

New research on the Spanish and French Barremian has resulted in alternative zonal schemes by Company et al. (1995), Hoedemaeker (1995), Hoedemaeker & Leereveld (1995), and Vermeulen (1996). These are calibrated against the Cephalopod Team's scheme in Fig. 4. The team recommends further collaborative work to produce a consolidated zonation. It recognises that in theshallow water environments of the Mediterranean area pulchelliids are generally more common than contemporaneous holcodiscids and could provide a better and more widely applicable guide for much of the Barremian.

Ropolo et al. (this volume) have reinvestigated the Barremian/Aptian boundary deposits at La Bédoule, SE France, demonstrating a distinctive *Pseudocrioceras* level above *sarasini* Zone faunas and immediately beneath a *Deshayesites* fauna characteristic of the basal Aptian *tuarkyricus* Zone.

IGCP-Project 262 (at Mula, 1993) & 362 (piobbico, 1995)		Bulot et al., 1993		Hoedemaeker, 1995 Hoedemaeker & Leereveld 1995
Zones	Horizons	Zones	Horizons	Zones
P. angulicostata	*P. catulloi*			*P. catulloi*
	P. angulicostata auct.			*P. ohmi*
P. (B.) balearis				*P. (B.) balearis*
"P. ligatus"		*P. ligatus* (non sensu subsequent literature)		*P. ligatus*
S. sayni			*S. mimica*	*S. sayni*
	C. cruasense	*S. sayni*	*S. cruasense*	

Fig. 3. Zonal schemes for the upper Hauterivian *Pseudothurmannia* beds.

Aptian

The team noted that Dr Raymond Casey is presently revising the zonation of the English Aptian, based on abundant new material from the Isle of Wight.

Albian

The team accepted a proposal by E. Kotetishvili and H. Owen that a *Dipoloceras (D.) cristatum* Subzone should be inserted at the base of the *inflatum* Zone.

Tethyan/Boreal correlation

Berriasian

Across the Jurassic/Cretaceous boundary and throughout the Berriasian Stage, Boreal and Tethyan ammonites faunas are very distinct and there is little overlap, rendering correlation extremely difficult. The team has yet to focus on this problem, some aspects of which are summarised by Zakharov et. al (1995). This paper indicates that Russian workers now accept that the lower Berriasian is approximately equivalent to the upper Volgian rather than being represented by a major hiatus in the Boreal area.

Valanginian-Barremian

The provisional correlations summarised by Rawson (1995) at our third workshop are shown on Fig. 5 here. The correlations are based on evidence from Tethyan ammonites that invaded Boreal areas and Boreal ammonites that penetrated the Tethyan seas. At present there is no evidence from ammonites alone that the correlations need modifying, and some additional evidence supports certain correlations:

(a) *Prodichotomites* cf. or aff. *complanatus* occurs in the *verrucosum* Zone in the Czech Republic (Z. Vašíček).

IGCP 262 (at Mula,1993) & 362 (at Piobbico,1995)		Company et al.,1995		Hoedemaeker,1995; Hoed. & Leer.,1995; Delanoy,1997		Vermeulen,1996		Angles
Zones	Horizons	Zones	Horizons	Zones	Horizons	Zones	Horizons	bed
	T. ridzewskyi			*M. sarasini*				
M. sarasini					*L. puzosianum*			177
I. giraudi				*I. giraudi*	*H. emerici*			172?
					I. giraudi			168
H. feraudianus				*H. feraud.*	*E. magnini*			166
					H. feraudianus			164
G. sartousiana				*G. sartousiana*			# *G. provincialis*	
					C. limentinum	*G. sart.*		
							G. sartousiana	160-2
A. vandenheckii			*# E. barremense*	*# A. vandenheckii*			*H. sayni*	
		# A. vandenheckii						147-3
H. caillaudianus		cf. ** M. moutonianum*		*$ H. caillaudianus*		*C. darsi* $	*C. darsi*	125
		* ** K. compressissima*		$		** $ K. compressissima*		115
			% H. fallax					
	N. pulchella		*N. pulchella*	*K. nicklesi*		*% N. pulchella*		109-3
K. nicklesi		*K. nicklesi*				*K. nicklesi*		95
						P. colombiana		89
A. hugii		*A. hugii*		*A. hugii*		*P. mazuca (= chalmasi)*		75
						A. hugii		72

Fig. 4. Alternative zonations for the Barremian stage of the Mediterranean region.
+ = *Holcodiscus fallax*; * = *H. caillaudianus*; # = *Heinzia (Gerhardtia) provincialis*; $ = *Moutoniceras moutonianum*.

(b) *Breistrofferella castellanensis* occurs in the upper part of the *amblygonium* Zone in NW Germany (Stadthagen), together with the first *Acanthodiscus* (J. Klein), and *Breistrofferella* also occurs in the *noricum* Zone of the Mittelland Canal ('Ammonite indet.' in Kemper, 1992, pl. 39, fig. 3). These records support the **approximate** correlation of the *amblygonium* and *noricum* Zones with the *radiatus* Zone.

(c) the *peregrinus* horizon is recognised in Spain, at the same level as in France (J. Klein, pers. commun., 1997).

(d) *Spinocrioceras*, first recorded from N Germany, is now known from Spain (Hoedemaeker & Leereveld, 1995), France (Delanoy & Féraud, 1995), Italy (Cecca & Landra, 1994), and the Caucasus (Rawson, 1995).

(e) *Parancyloceras* occurs high in the Barremian in Romania, though it is not possible to distinguish between the *giraudi* and *sarasini* Zones there (E. Avram).

However, although the primary concern of our Working Group is with ammonites, Hoedemaeker has produced an alternative correlation chart (Fig. 6) incorporating additional biostratigraphical data (21 first and last appearances of dinoflagellates and nannofossils) together with sequence stratigraphic and magnetostratigraphic correlations.

Aptian/Albian correlations

Aptian

The strong dichotomy between Boreal and Tethyan Realms during Berriasian to

ZONE				SUBSTAGE
West European Province		West Mediterranean region		
bidentatum		sarasini giraudi		
stolleyi		feraudianus		UPPER
pingue / innexum		sartousiana		BARREMIAN
denckmanni		vandenheckii		
elegans		caillaudianus		
fissicostatum		nicklesi		LOWER
rarocinctum		hugii		BARREMIAN
variabilis	disco-			
marginatus	falcatus	angulicostatus		
gottschei		balearis		UPPER
speetonensis / staffi		ligatus		HAUTERIVIAN
inversum		sayni		
		nodosoplicatum		
regale		loryi		LOWER
noricum		radiatus		HAUTERIVIAN
amblygonium				
densicostatus				
		callidiscus Hor.		
tuberculata		furcillata Hor.	pachy-	UPPER
bidichotomoides			dicranus	VALANGINIAN
triptychoides		nicklesi Hor.		
crassus		peregrinus Hor.	verrucosum	
polytomus				
hollwedensis				
hapkei		campylotoxus		
clarkei				
multicostatus				LOWER
pavlowi				VALANGINIAN
involutum		pertransiens		
heteropleurum				
robustum		otopeta		

Fig. 5. Provisional correlation of the Tethyan/Boreal Valanginian to Barremian ammonite zones (after Rawson, 1995).

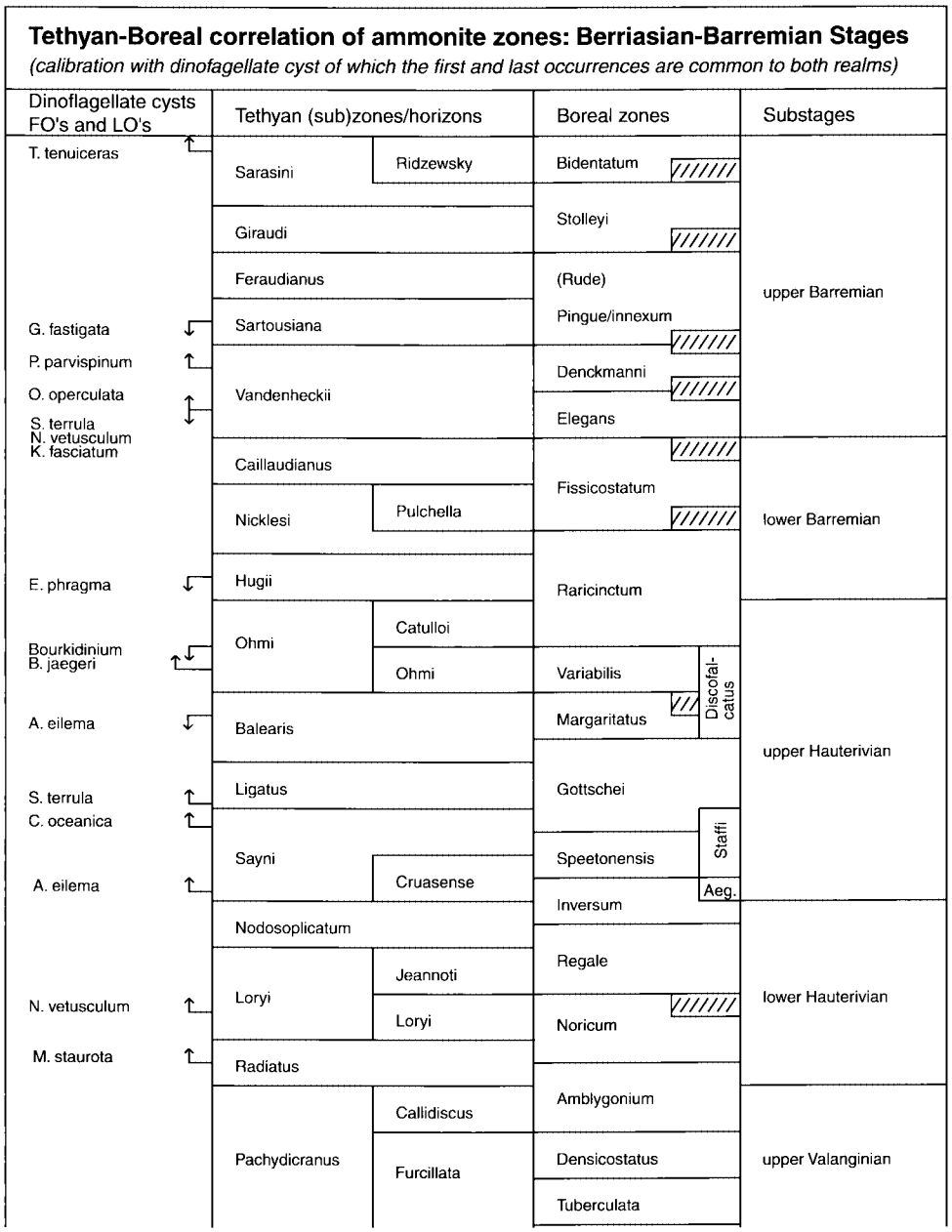
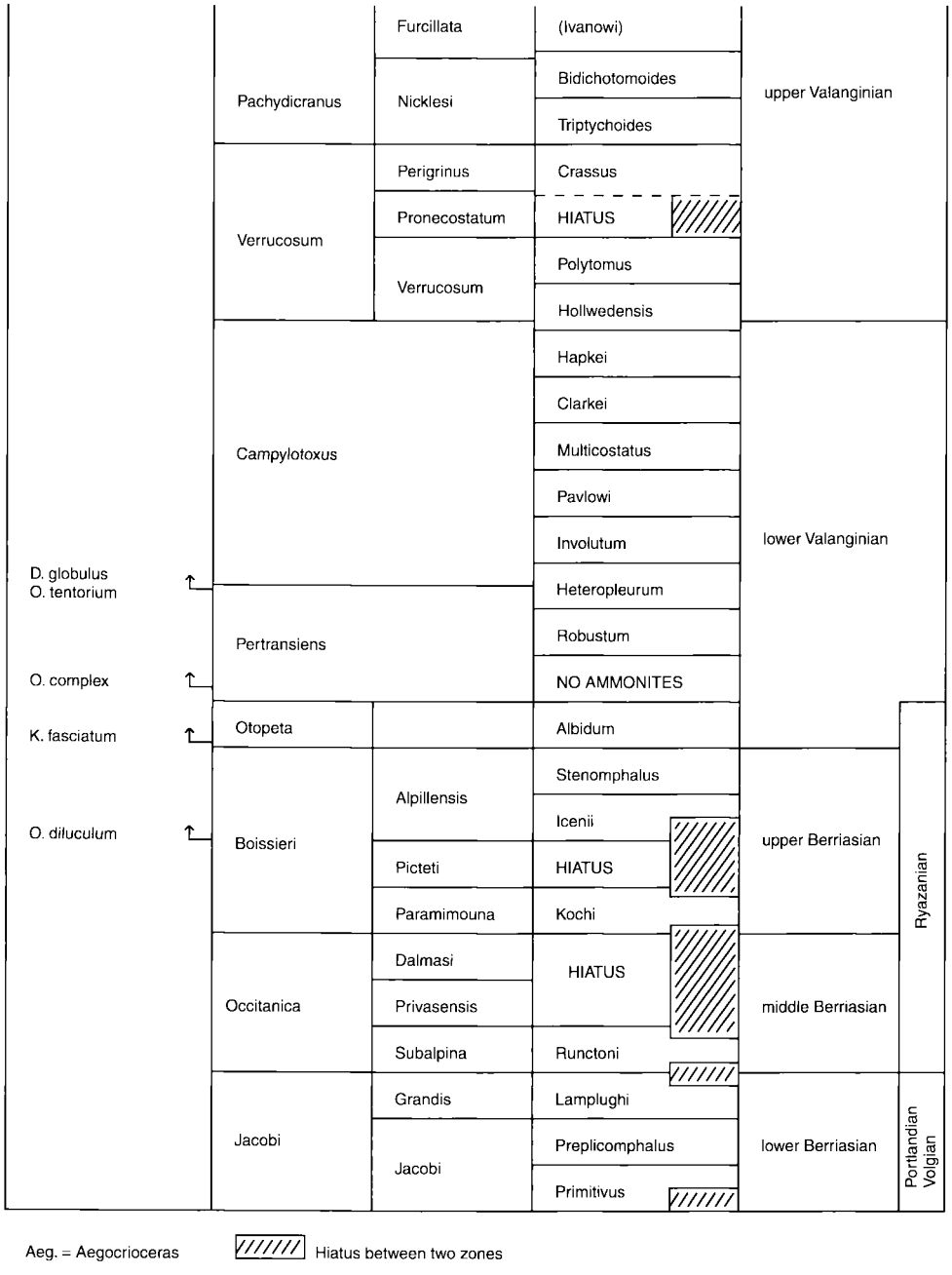


Fig. 6. Alternative correlation of the Tethyan/Boreal Valanginian to Barremian stages (Hoedemaeker, new). Continued on p. 11



Aeg. = Aegocrioceras

Hiatus between two zones

Eurpean Province		Tethyan Province
Zone	Subzone	Zone
Euhoplites lautus *Euhoplites lonicatus* *Hoplites dentatus*	*Hoplites spathi* *Lyelliceras lyelli*	*Oxytropidoceras* spp. *Lyelliceras lyelli*

Fig. 7. European and Tethyan zonation of the middle Albian.

Barremian times had broken down by the Aptian (Hoedemaeker, 1990; Rawson, 1995). Thus the Aptian zonation shown in Fig. 1 is widely applicable across Europe and other areas, subject only to slight modification for regional species.

In NW Europe and East Greenland the appearance of the first deshayesitid ammonite, *Prodeshayesites*, is taken to mark the base of the Aptian. There is a problem in the recognition of the *Prodeshayesites* level in the Mediterranean region, where some records of this genus should be referred to *Deshayesites* and others to the Late Barremian *Martelites* (Ropolo et al., this volume).

True *Prodeshayesites* may not occur in the Mediterranean area: its level may be represented either by a break in the sequence or by the highest part of what is now still considered to be the Barremian sequence.

Albian

As for the Aptian, the 'Mediterranean' scheme is widely applicable across the European Province (Owen, this volume). The lower and upper Albian zonations apply to most of the world. But for the middle Albian the team recognises a 'Tethyan Province' zonation, with a *lyelli* Zone (= *lyelli* Subzone of the European Province) at the base, overlain by a zone of *Oxytropidoceras* spp. representing the remainder of the middle Albian (Fig. 7).

References

Atrops, F. & S. Reboulet, 1993. Nouvelles données sur la zonation par ammonites du Valanginien supérieur de l'hypostratotype d'Angles (Alpes-de-Haute-Provence) et sur ses corrélations. — C.R. Acad. Sci. Paris, 317, II: 499-506.

Atrops, F. & S. Reboulet, 1995. Le Valanginien-Hauterivien basal du bassin vocontien et de la bordure provencale: zonation et corrélations. — C.R. Acad. Sci. Paris, 320, IIa: 985-992.

Bulot, L. G., 1995. Les formations à ammonites du Crétacé inférieur dans le SE de la France (Berriasien-Hauterivien): biostratigraphie, paléontologie et cycles sédimentaires. — Thèse Mus. Natl Hist. Nat., Paris: 1-374, 21 pls.

Bulot, L. & J-.P. Thieuloy, 1995. Les biohorizons du Valanginien du Sud-Est de la France: un outil fondamental pour les corrélations au sein de la Téthys occidentale. — Géol. Alpine, Mem. H.S. 20 (1994): 15-41.

Cecca, F. & G. Landra, 1994. Late Barremian - early Aptian ammonites from the Maiolica Formation near Cesana Brianza (Lombardy basin, northern Italy). — Riv. Ital. Paleont. Strat., 100, 3: 395-422.

Company, M., J. Sandoval, & J.M. Tavera, 1995. Lower Barremian ammonite biostratigraphy in the Subbetic Domain (Betic Cordillera, southern Spain). — Cret. Res., 16: 243-256.

Delanoy, G. & P. Féraud, 1995. On the Genus *Spinocrioceras* Kemper, 1973 (Ammonoidea, Ancyloceratina). — Geol. Jb., A, 141: 201-223, 5 pls.

Hoedemaeker, Ph.J. 1995. Ammonite distribution around the Hauterivian-Barremian boundary along the Río Argos (Caravaca, SE Spain). — Géologie Alpine, Mem. H.S. 20 (1994): 219-277.

Hoedemaeker, Ph. J. & L. Bulot, 1990. Preliminary ammonite zonation for the Lower Cretaceous of the Mediterranean Region. Report of the first meeting of the Lower Cretaceous Cephalopod Team of IGCP Project 262 (Digne, 1990). — Géol. Alpine, 66: 123-127.

Hoedemaeker, Ph. J. & Cecca, F. (reporters), E. Avram, M. Company, G. Delanoy, E. Erba, M. Ettachfini, P. Faraoni, M. Kakabadze, G. Landra, A. Marini, L. Memmi, G. Pallini, P.F. Rawson, P. Ropolo, J. Sandoval, J.M. Tavera & Z. Vašíček, 1995. Report on the 3rd International Workshop on the standard Lower Cretaceous ammonite zonation of the Mediterranean region. — Mem. Descr. Carta Geol. Italia, 51: 213-215.

Hoedemaeker, Ph. J., M.R. Company (reporters), M.B. Aguirre Urreta, E. Avram, T.N. Bogdanova, L. Bujtor, L. Bulot, F. Cecca, G. Delanoy, M. Ettachfini, L. Memmi, H.G. Owen, P.F. Rawson, J. Sandoval, J.M. Tavera, J.-P. Thieuloy, S.V. Tovbina & Z. Vašíček, 1993. Ammonite zonation for the Lower Cretaceous of the Mediterranean region; basis for the stratigraphic correlation within I.G.C.P. Project 262. — Rev. Espan. Paleont., 8: 117-120.

Hoedemaeker, Ph. J. & H. Leereveld, 1995. Biostratigraphy and sequence stratigraphy of the Berriasian-lowest Aptian (Lower Cretaceous) of the Río Argos succession, Caravaca, SE Spain. — Cret. Res., 16: 195-230.

Kemper, E., 1992. Die Tiefe Unterkreide im Vechte-Dinkel-Gebiet. — Staringmonument te Losser: 1-95, 66 pls.

Owen, H.G., 1998. Correlation of Albian European and Tethyan ammonite zonations and the boundaries of the Albian Stage and substages: some comments. — Scripta Geol., Spec. Issue 3: 3-13.

Rawson, P. F., 1995. The 'Boreal' Early Cretaceous (Pre-Aptian) ammonite sequences of NW Europe and their correlation with the Western Mediterranean faunas. — Mem. Descr. Carta Geol. Italia, 51: 121-130.

Rawson, P.F., A.V. Dhondt, J.M. Hancock & W.J. Kennedy (eds), 1996. Proceedings 'Second International Symposium on Cretaceous Stage Boundaries' Brussels 8-16 September 1995. — Bull. Inst. R. Sci. Nat. Belg., 66, Suppl.: 1-117.

Ropolo,P., R. Gonnet & G. Conte, 1998. The '*Pseudocrioceras* interval' and adjacent beds at La Bédoule (SE France): implications to highest Barremian/lowest Aptian biostratigraphy. — Scripta Geol., Spec. Issue 3: 3-13.

Thieuloy, J.-P., M. Fuhr & L. Bulot, L., 1990. Biostratigraphie du Cretace inferieur de l'Arc de Castellane (S.E. de la France). 1: Faunes d'ammonites du Valanginien superieur et age de l'horizon dit de 'La Grande Lumachelle'. — Géol. Med., 17: 55-99.

Vermeulen, J., 1996. Nouvelle biozonation du Barrémien basée sur la famille des Pulchelliidae (Ammonoidea). — Géol. Alpine, 71: 199-211.

Zakharov, V., P. Bown & P.F. Rawson, 1996. The Berriasian Stage and the Jurassic-Cretaceous boundary. In: P.F. Rawson, A.V. Dhondt, J.M. Hancock & W.J. Kennedy (eds) Proceedings 'Second International Symposium on Cretaceous Stage Boundaries' Brussels 8-16 September 1995. — Bull. Inst. R. Sci. Nat. Belg., 66, Suppl.: 7-10.