by Jenaro L. García-Alcalde

North Gondwanan Emsian events

Departamento de Geología, Universidad de Oviedo, 33005 Oviedo, Spain

On the basis of lithostratigraphic and biostratigraphic characteristics three Emsian events, first noted in the Czech Republic, have been distinguished in the north Gondwana regions of Spain and adjoining areas. These events, the Basal Zlichov Event (BZE), the Upper Zlichov Event (UZE) and the Daleje-Cancellata Event (DCE) are keystones in the Emsian stratigraphy in that they allow to deal with problems of stage and substage definition from a different all-embracing approach.

Introduction

During the Devonian the Iberian Peninsula and adjoining areas (Armorican Massif, Morocco) belonged to the northern part of the Gondwana continent (Mauro-Ibero-Armorican Province, Carls, 1988). This large paleogeographical unit was separated from the other great super-continent of the period, Euroamerica, by a seaway, the Rheic ocean. The extent of this seaway has been extensively discussed but is no longer considered to have prevented faunal exchange among the bordering continents. Abundant paleontological and stratigraphical information concerning the North Gondwana Devonian stress the rather strong similarity with Euroamerica (García-Alcalde, 1995) especially since the Late Emsian. Nevertheless, the connections between both continents began earlier as can be noticed from the ease with which it is possible to discriminate in North Gondwana Lower Emsian events first noted and described in Euroamerica (Czech Republic).

In this paper three Emsian events, the Basal Zlichov, the Upper Zlichov, and the Daleje-Cancellata, are identified in North Gondwana, and their lithologic and paleontologic features are analyzed in the different areas with special emphasis on those of the Cantabrian region (northern Spain).

Basal Zlichov Event (BZE)

The Basal Zlichov Event (BZE), has been characterized in Bohemia (Czech Republic) as a minor, rather local, and tectonically-controlled event, with slight faunal overturn and very varied lithologic changes matching different geological processes, both transgressive and regressive even in the same basin (Chlupáč and Kukal, 1986; 1988).

Despite this assertion, the BZE seems a distinct and readily traceable event far from Bohemia, in off-shore or mixed facies, and even in near-shore facies by means of more or less indirect correlations.

In Spain the BZE would be represented everywhere by a clear-cut lithologic transition due usually to a transgressive pulse of supra-regional influence belonging to Johnson et al.'s (1985) T-R cycle Ib (Ib2, herein, Figure 2).

In the Palentine Domain (Figure 1), the lower part of the Abadía Fm. (Figure 2) consists of about 30 m of dark grey, micaceous and silty shales. At 20 m. above the base of the Formation, *Nowakia zlichovensensis* occurs; 7 m. above this level, commences 8 m of dark grey mudstones, wackestones, and bioclastic packstones, with hummocky

cross bedding interbedded with very fossiliferous calcareous siltstones. These beds could represent the BZE in the region occurring at the *Polygnathus dehiscens* Zone (*Nowakia zlichovensensis* Zone) (García-Alcalde, et al., 1990, text-figure 5). There, for the first time in the Devonian, very abundant and diverse trilobite faunas occur. These faunas are of mixed Bohemian offshore and Rhenish nearshore character, with species of proetid, aulacopleurid, harpids, cheirurids, and scutelluids, and other forms of the *Reedops-Odontochile* Assemblage, especially *Spinodontochile spinifera*, *Devonodontochile mccoysi*, *Odontochile seillouensis*, *Reedops* cf. *sternbergi*, and other phacopids, homalonotids and asteropyginids (Zone V of Smeenk, 1983; García-Alcalde, et al., 1990). Several of the innovations cited by Chlupáč (1994) as characteristic for the BZE, in particular, the first appearance of true *Kayserops*, and of new species of *Pillettina* and other Asteropyginae, are also recognized there (*K. ogivalis*, *P. aulnensis*). At the same levels occur abundant tabulate (*Cleistodictyum porosum*, *Procterodictyum polentinoi*, and other pleurodictyids) and rugose corals constituting the most diverse Lower Devonian "Cyathaxonia Fauna" known worldwide (Soto and Kullmann, 1996). Trace fossils, e.g. *Chondrites* and *Zoophycos* cover the bottom of the beds. Brachiopods are scarce, of low diver-

Figure 1 Geographical situation of the discussed regions. 1: Cantabrian Mountains (Asturo-Leonian Domain and Palentine Domain, Spain); 2: Eastern Iberian Chains (Spain); 3: Eastern Guadarrama (Spain); 4: Almadén region (Central Iberian Zone, Spain); 5: Anti-Atlas (Morocco); 6: Rade of Brest (Armorican Massif, France)

sity, and of mixed Bohemian-Rhenish affinities, with *Dalejodiscus* spp., *Prokopia* sp., *Rugoleptaena* sp., *Philippotia belairensis*, *Plicanopia carlsi*, *Xana bubo*, and *Bifida lepida*, *Arduspirifer*, *Euryspirifer* of the *pellicoi*-group and *Acrospirifer fallax* have also been found there (Jahnke, et al., 1983; and unpublished data).

In the Asturo-Leonian Domain, the base of the La Ladróna Fm. and correlative Formations (Figure 2), display lithologic characters of the BZE, with a marked change from intertidal Bañugues or

Chron.		Global Event	Faunal Interval	T/R Cycle	Asturo-Leonian Domain				Palentine Domain	Eastern Iberian Chains	Armorican Massif Rade of Brest								
					ASTURIAS		LEON												
EMSIAN	Upper	DCF	13	Ic1	Rañeces Group	Aguión Fm.	La Vid Group	4	Esla Fm.	Coladilla Fm.	Abadía Fm.	Lezna Mb.	Mariposas Fm.	d4by-d4be					
			12																
			11																
			10	Ib4		3		Valporquero Fm.	"Vañes beds"	Requejada Mb.		d4bz		Beg an Arreun Fm.					
			9	Ib3															
	8	Ib2																	
	Lower	UZE	BZE			Ib1		Bañugues Fm.	2	Abelgas Fm.		La Pedrosa Fm.		Felmín Fm.				d4ay	Reun ar C'Frank Fm.
														d4aα-d4aβ					
														d3c	Le Faou Fm.				

Figure 2 Stratigraphical situation of the global events studied herein in the Cantabrian Mountains (Asturo-Leonian Domain and Palentine Domain), Eastern Iberian Chains, and in the Armorican Massif (Rade de Brest, France). Faunal Intervals: modified from García-Alcalde (1996). T/R Cycles: After Johnson et al. (1985).

Felmin Fms. dolomites to open marine shales and limestones. The transition beds contain abundant *Zoophycos* and *Chondrites* and belong to the *Polygnathus dehiscens* Zone, according to Grötsch (1988; text-figure 3). In these beds, brachiopods of the basal part of "Faunal Interval 8" (García-Alcalde, 1996) occur, especially *Arduspirifer* spp., *Euryspirifer* gr. *pellicoi*, *Acrospirifer* gr. *fallax*, and *Plicanoplia carlsi*. The brachiopod fauna would fit in the *Leptaenopyxis kerfornei* Faunizone (Racheboeuf, and Yesou, 1988); such unit is ecologically similar to the French "Faune de Monstres" (Morzadec, et al., 1988), well known immediately prior to the F12 level of the Le Faou Fm. in Brittany. In the uppermost part of the Bañugues Fm. very important coral-stromatoporeid biostromes are developed. Tabulate and rugose corals of the "Cyathaxonia Fauna", very similar to those of the lower part of the Abadía Fm. referred to above, occur from the base of La Ladróna Fm. upwards. The BZE is also represented in the Asturo-Leonian Domain by a very important proliferation of trilobites. Several new species of *Pillettina*, *Pseudocryphaeus*, *Metacanthina*, *Treveropyge*, phacopids, and proetids occur there (Arbizu, 1977; Smeenk, 1983; Truysols, et al., 1990; García-Alcalde, 1995). Dacryoconarids (*Nowakia* cf. *acuaria*, *N.* cf. *zlichovens*, and *Styliolina* sp.) appear for the first time in Asturo-Leonian successions.

The above lithologic and faunal data enable us to correlate the BZE in other Spanish areas. The sandstone-limestone transition in the upper part of the Cercadillo Fm. in eastern Guadarrama (Figure 1), and in the Santa Cruz (d3)/Mariposas (d4) Fms. boundary (Figure 2) in Celtiberia (Figures 1, 2) at the *Polygnathus dehiscens* (or *P. excavatus*) Zone, would correspond to the event (García-Alcalde, 1992). The brachiopod fauna has large forms close to those of the French "Faune de Monstres" cited above in Faunal Interval 8 (García-Alcalde, 1996), especially *Euryspirifer pellicoi*, *Vandercammenina* spp., *Leptaenopyxis* gr. *kerfornei*, and *Acrospirifer* gr. *fallax*. *Arduspirifer* spp. proliferate from the transition upwards, although the genus begins earlier. *Philippotia belairensis* and *Plicanoplia carlsi* occur from the topmost Santa Cruz Fm. upwards (Racheboeuf, 1981; Jahnke, et al., 1983). Trace-fossils (*Zoophycos*) are also abundant in the upper part of the Santa Cruz Formation (Carls, 1988).

The BZE could also be represented in the sandstone/shale to limestone transition between the Risquillo and Herrera Formations

in the southern Central-Iberian Zone (Pardo-Alonso, and García-Alcalde, 1996). Biostratigraphic indexes are scarce, but *Euryspirifer* gr. *pellicoi* and several forms of the genus *Arduspirifer* occur there from the base upwards, and *Acrospirifer fallax*, *Pleurodictyum* cf. *problematicum*, *Combophyllum marianum*, *Adradusia barroisi* and other "Cyathaxonia Fauna" elements are also known in the lower part of the Herrera Fm.

The Palentine faunas cited above are amazingly similar to those of the uppermost part of the Le Faou Fm. in the Rade de Brest (Brittany, France) (Figures 1, 2), constituting the so-called "first Hercynian incursion into Rhenish faunas of the Lower Devonian of the Armorican Massif" (Le Menn, et al., 1976). Thus level F12 of the Le Faou Fm. would represent the BZE in Brittany. The BZE could also be represented at the top of the Montguyon Fm. where similar *Odonotochile* and brachiopod faunas have been reported at the *Polygnathus dehiscens* Zone (Racheboeuf, 1981; Morzadec, et al., 1988; Gourvennec, 1989). The occurrence of phosphatic nodules associated with the BZE in the Armorican Massif has been attributed to a marine transgression (Le Menn, et al., 1976).

Upper Zlichovian Event (UZE)

Even if the BZE is a very important geological marker in Spanish Devonian sections, as indicated by relatively abrupt lithologic and biologic change everywhere, it would not be the most important Zlichovian marker, at least in off-shore facies areas. That distinction goes to the so-called Upper Zlichov Event (UZE), herein. The UZE is probably coupled with one of the minor transgressive pulses of the Johnson, et al. (1985) global T-R cycle Ib (T-R cycle Ib3, herein), slightly older than the important Dalejan transgression (T-R cycle Ib4, herein) (Figure 2). Lithologic change at the UZE is usually not very distinctive but the biostratigraphic signature is profound. It includes the first significant radiation of non bacitrid ammonoids, a major new animal group of high taxonomic level, soon to be a critical tool for Devonian biostratigraphy. The ammonoids appeared at the *Nowakia zlichovens* Zone (in terms of the conodont scale, upper part of the *Polygnathus dehiscens* Zone). After rapid evolution from gyrogonic to advolute forms, the ammonoids set this last shell

coiling pattern, become abundant, and finally reach completely coiled forms as *Mimagoniatites* at the *Polygnathus gronbergi* and *N. barrandei* Zones (Becker, and House, 1994b). According to available biostratigraphic information, the first *Erbenoceras-Mimagoniatites* association seems to occur synchronously and worldwide, or nearly so, and thereby would be the most suitable UZE index. The rapid stepwise evolution through the Zlichovian to the Dalejan resulted in proliferation of many new, sometimes bizarre, forms, the so-called "*Anetoceras* Fauna" (Chlupáč, 1976).

In Palencia, the most suitable, although admittedly weak, litho-event for the UZE could be the transition from the Requejada Lst Member to the overlying "Vañes beds" (Figure 2). The uppermost part of the Requejada Mb. comprises mudstones and bioclastic wackestones and packstones with hummocky and ripple cross bedding. The "Vañes beds" however is a ca. 19 m thick rhythmic sequence of alternating yellowish weathered, nodular or pseudo-nodular, sometimes bioturbated mudstones, wackestones and bioclastic packstones with hummocky cross bedding at the bottom and ripple cross bedding upwards, and interbedded grey, very fossiliferous, calcareous siltstones and shales (García-Alcalde, et al., 1990). *Erbenoceras filalense* and *Mimagoniatites tabuliformis*, the first Palentine representatives of the *Anetoceras* Fauna, occurs ca. 2–3 m. above the Requejada Mb. in the upper part of the *Nowakia barrandei* Zone. A single whorl fragment of *Celaeceras* sp. has been found also at the *Nowakia barrandei* Zone. Species of *Mimagoniatites*, *Mimosphinctes*, and *Celaeceras* occur higher. These forms range up to near the top of the "Vañes beds" across the topmost *N. barrandei*, *N. elegans* and basal *N. cancellata* Zones within the *Polygnathus gronbergi* Zone (Montesinos, and Truyols-Massoni, 1987; García-Alcalde, et al., 1990; Montesinos, 1991; Montesinos, and García-Alcalde, 1996). Orthocone nautiloids and phacopid trilobites are abundant. Tabulate and rugose corals of the *Cyathaxonia* Fauna are quite common but less diverse than in previous beds. Impoverished brachiopod faunas mainly of off-shore facies occur (*Miniprokopia* cf. *Iyriconcha*, *Clorinda* sp., *Lissatrypa* sp., and *Philippotia* sp.) (García-Alcalde, et al., 1990).

In the Asturo-Leonian Domain, identification of the UZE depends on indirect comparison based on conodonts and scanty occurrences of nowakids (García-López, and Arbizu, 1993; García-Alcalde, and Truyols-Massoni, 1994; García-López, and Alonso-Menéndez, 1994; Truyols-Massoni and García-Alcalde, 1994). The UZE can be recognized there from a modest brachiopod radiation (Faunal Interval 9; García-Alcalde, 1996), mainly characterized by the first appearance of *Tetratoma* gr. *amanshauseri*, *Nucleospira* cf. *sirael*, *Spinatrypa* aff. *orba*, *Resserella* sp. *D. Tyersella tetragona*, *Stenorhynchia briceae*, *Boucotstrophia velica*, and *Asturistrophia insolita*; *Schizophoria vulvaria*, *Meganteris archiaci*, *Septathyris* cf. *davousti*, *Euryspirifer pellicoi*, *Plicostropheodonta diffusa*, *Mesoleptostrophia explanata*, pleurodictyid tabulates and skeletal fragments of homalonotids are quite abundant. *Viriattellina* cf. *hercynica* and *V. cf. gracilistriata*, together with *Nowakia* sp., are also present. The UZE would thus coincide very closely to the Lower Emsian/Upper Emsian boundary as discussed in García-Alcalde, and Truyols-Massoni (1994) and in Truyols-Massoni, and García-Alcalde (1994). The related UZE litho-event would be a relatively important dark shale intercalation in the lower half of the La Ladróna and correlative Leonian Formations (Figure 2). In León, ca. 20 m. above the supposed UZE level, *Nowakia cancellata* and conodonts of the *Polygnathus laticostatus* Zone occur (García-Alcalde, and Truyols-Massoni, 1994; García-López, and Alonso-Menéndez, 1994; and unpublished data on the range of *N. cancellata* in the La Vid section, from bed 30c upwards, Truyols-Massoni, pers.com.).

In Celtiberia, *Anetoceras* sp. and *Mimagoniatites* cf. *zorgensis* co-occur in the Mariposas Fm. (at the top of the d4b α subdivision; Carls, 1988) (Figure 2). Such ammonoid association seems a little younger than the Palentine "*Anetoceras* Fauna", because the upper half of d4b α yields abundant *Nowakia elegans* (Truyols-Massoni, pers.comm., based on samples of J. L. García-Alcalde). A more suitable level for the UZE could be the d4 α /d4b α transition (Figure 2) at the *Polygnathus gronbergi* Zone because in the uppermost part of

the d4 α subdivision several forms of García-Alcalde's Faunal Interval 9 (*Resserella* sp. *D. Spinatrypa orba*, "*Uncinulus pila*", *Tyersella tetragona*, and *Schizophoria vulvaria*) occur (author's unpublished data).

In the Dra Plains (Anti-Atlas, Morocco), "*Anetoceras advolvens*" (recto *Erbenoceras filalense*), *Mimosphinctes cantabricus*, *Devonodontochile maccoyi*, *Spinodontochile spinifera*, and other interesting forms occur (Hollard's "Faune 1", 1978, Tab. 2; see also Bultynck, and Hollard, 1980), at the lower part of the Oui n' Mesdour (western Dra) or Mdaouer El Kbir (eastern Dra) Formations. "Fauna 1" directly overlies beds in the uppermost part of the Merza Akhsai Fm. with an abundant and characteristic brachiopod fauna closely similar to that of the "Faune de Monstres" referred to above and to that of the basal part of the Faunal Interval 8 (García-Alcalde, 1996). In these beds large forms of *Euryspirifer* cf. *pellicoi*, *Acrospirifer* gr. *fallax*, *Vandercammenina trigeri*, *Mesoleptostrophia explanata*, *Globithyris* sp., *Straelenia*, *Schizophoria* aff. *vulvaria*, *Meganteris* gr. *archiaci*, *Iridistrophia* sp., and small *Xana bubo*, *Uncinulus* gr. *pila*, *Stenorhynchia subpareti*, *Celtanoplia aulerciana*, *Renaudia* cf. *mainensis*, *Plebejochonetes buchoti* and other Ardenno-Rhenish brachiopods occur. These biostratigraphic markers enable us to suggest:

1) The BZE would be placed around the abrupt sandstone/limestone lithologic transition between the Merza Akhsai and overlying Dra Plains Formations. According to Bultynck and Hollard (1980) such level would correspond to the *Polygnathus dehiscens* Zone. The occurrence of phosphatic pebbles in the uppermost part of the Merza Akhsai Fm. has been interpreted as indicating a stratigraphic gap or condensed sedimentation (Hollard, 1978), but it could also reflect a transgressive phase as in the Armorican sections (see above).

2) The UZE would be placed at the occurrence of black to dark limestone layers in the lower (but not in the lowermost) part of the correlative Oui n' Mesdour and Mdaouer El Kbir Formations. According to Bultynck, and Hollard (1980), the first ammonoids (*Erbenoceras filalense*) occur at the *Polygnathus dehiscens*/*P. gronbergi* Zone boundary, associated with upper Zlichovian dactyloconarids.

Daleje-Cancellata Event (DCE)

The DCE (Walliser, 1984, 1995; House, 1985; Becker, and House, 1994) is a rather peculiar Devonian event. It is recognized half way of a transgressive period (T-R 1b; Johnson, et al., 1985) that began much earlier, perhaps at the beginning of the Emsian Stage in its current definition. The coupled lithologic change is therefore usually observed to be quite gradual. The faunal change appears also very gradual, so that the faunal turnover should be appreciable only after a certain time interval (Walliser, 1984; Chlupáč, and Kukal, 1988). But, despite these apparent constraints the DCE is one of the Devonian events most broadly recognized worldwide. The age and the duration of the Event has been variably interpreted. Carls (1988), Chlupáč (1995, text-figure 4) and Walliser (1995) regard it as a Zlichovian-Dalejan process; according to Carls (1988) the event lasted a timespan equivalent to the *Nowakia elegans*, *N. cancellata*, and *N. richteri* dactyloconarid Zones (*Polygnathus laticostatus* plus the lower part of the *P. serotinus* conodont Zones), whereas according to Chlupáč (1995) and Walliser (1995) it overlaps the *N. barrandei* and the *N. cancellata* Zones (at the *P. nothoperbonus* and *P. laticostatus* Zones). According to Becker, and House (1994, text-figure 9) the DCE would strictly be Dalejan, overlapping the *N. cancellata*-*N. richteri* (*Polygnathus laticostatus*-*P. serotinus* Zones). I agree with the former authors in that the DCE is a Zlichovian/Dalejan event. However, as interpreted here, the event would be restricted to the first clear onset of black shales, coupled to the relatively more marked T-R 1b4 deepening pulse (Figure 2); that is to say, the DCE would be limited to the uppermost *N. elegans* and *N. cancellata* Zones (*P. laticostatus* Zone).

In northern Spain, as in many Bohemian sections the DCE is characterized by the gradual takeover of dark to black shales from limestone and marly rocks at the Zlichovian-Dalejan boundary. The paleontological indexes, *Nowakia elegans* and *N. cancellata* usually appear at the levels where shales start to dominate over limestones. At the same beds or a bit higher, García-López, and Alonso-Menéndez (1994) have found in León conodonts of the *Polygnathus laticostatus* Zone. Grötsch (1988) cited also *P. laticostatus*, in the La Vid Group, in León, at the base of his Esla Fm. (upper part of the unit 2 of the La Vid Group) (Figure 2), but the systematic assignment is discussed by García-López, and Alonso-Menéndez (1994).

In the Palentine Domain, the DCE is recognized at the top of the "Vañes beds" (Figure 2) around the *Nowakia elegans*/*N. cancellata* Zone boundary. Conodonts are not known at this level; the more closest conodont fauna comes from the middle part of the "Vañes beds" at the *N. elegans* Zone, and might correspond to the uppermost *P. gronbergi* Zone (García-Alcalde, et al., 1990). The loosely coiled *Erbenoceras* and *Mimosphinctes*, *Mimagoniatites erbeni* and the complex-sutured *Celaeceras* end before the *N. elegans*/*N. cancellata* Zone boundary (Montesinos, and Truyols-Massoni, 1987; Montesinos, 1991; Montesinos, and García-Alcalde, 1996). *Gyroceratites*, represented by a local species, *G. pallantianum*, occurs higher in the pure shaly facies of the upper Abadía Fm. ca. 12-15 m. above the first occurrence of *N. cancellata*, and associated with *Mimagoniatites* gr. *fecundus* (Montesinos, and Truyols-Massoni, 1987; Montesinos, 1990). Because of the general scarcity of fossils other than dactyconarids in the pure shaly facies of the Abadía Fm., other faunal markers for the DCE are lacking.

The DCE is readily recognizable in the Asturo-Leonian Domain, both in León, as indicated above, and in Asturias (García-Alcalde, 1992; García-Alcalde, and Truyols-Massoni, 1994; Truyols-Massoni, and García-Alcalde, 1994). The massive onset of fine siliciclastic sediments that indicates the deepening event, prevented the occurrence of abundant benthonic faunas, and the neotonic and planctonic ones are also scanty. The faunal change was quite gradual and marked by the occurrence of some new species rather than by the demise of the precedent ones. As interpreted here, such change occurred in beds younger than the BCE climax, belonging to the Faunal Interval 10 (García-Alcalde, 1996). Thus, in thin bioclastic limestone lenses of the *Nowakia cancellata* Zone the successive appearance of brachiopods of mixed affinities as *Crinistrophia* cf. *elegans*, *Aesopomum* n. sp., *Reticulariopsis* cf. *indifferens*, *Straeleina* cf. *losseni*, *Triathyris* n. sp. A, *Brachyspirifer* aff. *carinatus*, "*Uncinulus suborbignyanus*", *Arduspirifer* (*Arduspirifer*) *latronensis*, *Plicathyris collensis*, *Protodouvilleina taeniolata*, *Anathyris phalaena* and *Struveina ferronesensis* is prominent. A similar brachiopod change is recorded at the upper half part of the Mdaouer El Kbir Fm. in the eastern Dra Plains (Morocco) (Hollard, 1978, and author's data), from the *Polygnathus laticostatus* Zone upwards. The deepening event related to the DCE is very clear in the condensed sequences of the eastern Anti-Atlas region (Bou Tchrafine and Hamer el Khdad, Tafilalet). In the Bou Tchrafine sections a few meters (usually less than 2 m) above dark to black limestones with ammonoids of the "*Anetoceras* Fauna" (*Erbenoceras filalense* and others), thin-bedded marly nodular limestones and interbedded dark calcareous shales of the *Nowakia elegans*-*N. cancellata* Zones are found. This level represents the DCE in the region, although other faunal indexes are not as yet well known. In the Hamer el Khdad region, the Lower Emsian successions are developed on the famous "Kess-Kess" (bioclastic wackestones and packstones mud mounds) (Brachert et al., 1992). In this region, the DCE is recorded at the top of the Kess-Kess and represents the end of these peculiar bioclastic accumulations. In both regions, the beginning of the main Dalejan deepening phase, represented by the onset of dark to black shales with sparse mudstone nodules is recorded a few meters above the first occurrence of *N. cancellata* (Alberti, 1980, and author's unpublished data).

As quoted above, Carls (1988) interpreted the DCE in Celtiberia as coupled to the entire phase of pelagic shaly facies deposition from the base of the d4b β submember of the Mariposas Fm.

(and correlative units in Guadarrama) (Figure 2) upwards, at the *Polygnathus laticostatus* plus the lower part of the *P. serotinus* Zones, and *Nowakia elegans* to *N. richteri* Zones. This author emphasizes also the remarkable similarity of the DCE development everywhere although minor differences can occur.

More work is required to identify precisely the DCE in the Armorican Massif (France). The range of index fossils, as *Nowakia elegans* or *N. cancellata* is not yet well known. Moreover outcrops are usually poor and very tectonized at the critical levels. The available information in the Rade of Brest indicates the best interval to investigate the event could be at the transition between the Reun ar C'Hrank and Beg an Arreun Fms. (Figure 2). Immediately prior to this level, typical Upper Emsian trilobites, such as *Rhenops lethacae*, and dactyconarids as *Nowakia* cf. *zlichovensensis* occur. And ca. 8-10 m. above the base of Beg an Arreun Fm., *Uncinulus suborbignyanus* and conodonts of the *Polygnathus laticostatus* Zone have been found (Bultynck and Morzadec, 1979). *Nowakia cancellata* occur at the upper part of the Beg an Arreun Fm. (Morzadec, 1983), probably high in their normal stratigraphical range.

Chronostratigraphical remarks

Recent chronostratigraphic developments makes precise dating of the BZE difficult. The Pragian/Emsian (P/E) boundary definition, related to the incoming of *Polygnathus dehiscentis* or the closely related but perhaps older *P. kitabicus* (Yolkin, et al., 1994) is unfortunate. Objections concern the problematic identification, even by specialists, of conodonts of the *P. pirenae*-*P. dehiscentis* lineage (Mawson, 1995), lack of clear auxiliary means for identification of the P/E boundary (Chlupáč, 1995), and drastic reduction, after the new definitions, of the original scope of the Pragian and Siegenian Stages (Carls, and Valenzuela-Ríos, 1993; Chlupáč, 1995). Apart from differences in the assessment on what must be regarded as "classic Siegenian or Emsian" (García-Alcalde, 1992; contra Carls, 1987, 1988; Carls, and Valenzuela-Ríos, 1993; Weddige, 1996), the P/E *kitabicus* boundary appears considerably older than the lowest Zlichovian and thereby than the BZE.

Mawson (1995) has vigorously confronted the biostratigraphic "revolution" involved in Yolkin et al.'s (1994) proposals. That author considers the holotype of *P. kitabicus* to be a large specimen of *P. pirenae*, and in the other hand *P. excavatus* to be a junior synonyme of *P. dehiscentis*. If these assertions should finally be agreed the "*P. dehiscentis*" Pragian/Emsian boundary would return to a closer stratigraphic position to the BZE as suggested by García-Alcalde (1992, 1996) and García-Alcalde, et al. (1997) and the takeover of Pragian beds in the Emsian would therefore be less substantial than reported by Chlupáč (1995). The proximity of such events, the BDE and the incoming of *P. dehiscentis*, appears indeed clear in eastern Guadarrama (Central Spain). There, the onset of transgressive carbonate rocks related to the BZE at the top of Member 7 of the Cercadillo Fm. (Bultynck, 1979) occurs at the upper part of the *P. kitabicus* zone (sensu Yolkin, et al., 1994) and therefore close to the base of the *P. dehiscentis* (*P. excavatus*) Zone according to the occurrence of *Polygnathus* forms close to "*P. excavatus*", and *P. pannonicus* (Bultynck, pers. comm.).

In any case a joint conodont revision of the *P. pirenae*-*P. dehiscentis* lineage by specialists and final agreement are badly need to resolve these important stratigraphic topics. As such, Mawson's proposal to go back to SDS for re-definition of the base of Emsian seems logical.

The occurrence of rather distinct faunal turnover in both the Lower Emsian/Upper Emsian and Zlichovian/Dalejan boundaries in their respective type areas has usually been interpreted as recording a single, perhaps global event and thereby the equivalence of both substage boundaries has often been asserted. Nevertheless, many authors have suggested the base of the Upper Emsian would be a bit older than the base of Dalejan (Lütke, 1979; Morzadec, 1983; Morzadec, et al., 1988; García-Alcalde, and Truyols-Massoni, 1994;

Truyols-Massoni, and García-Alcalde, 1994; among other). From the above discussion it appears both levels are tied to close but separated events, respectively the UKE and the DCE. Therefore the interval between the UZE level and the first occurrence of *Nowakia cancellata*, would be the best stratigraphic horizon to choose a re-defined Lower Emsian/Upper Emsian boundary stratotype. The Faunal Interval 9 (García-Alcalde, 1996) would be an outstanding auxiliary fossil sequence in approaching this re-definition in the Western Europe near-shore facies realm. Concerning to the conodont biostratigraphy, the UZE occurs in the *P. gronbergi* Zone. A possible subdivision of that zone based in more precise studies on the *P. perbonus*, *P. nothoperbonus* and *P. gronbergi* ranges, could perhaps provide the necessary fossil-guides to international correlation. In the other hand, the Dalejan, the *N. elegans/N. cancellata* boundary and the DCE have repeatedly been related with the incoming of *P. laticostatus*, but the range of this species is not yet well known because it is regarded alternatively as older and as younger than the base of Dalejan (Truyols-Massoni, and García-Alcalde, 1994). The revision of the *P. laticostatus* lineage would therefore be another unavoidable goal for the conodont specialists.

Acknowledgments

This study is a contribution to the basic research project of the Dirección General de Investigación Científica y Técnica (DGICYT), Spain, PB-94/1324 "Eventos geo-biológicos en el Devónico del Macizo Ibérico (España)" and IGCP 421 "North Gondwana Mid-Palaeozoic Bioevent/Biogeography patterns in relation to crustal dynamics". Many thanks are due to Miss Heather Stoll who has greatly improved the English text.

References

- Alberti, G K B, 1980, Neue Daten zur Grenze Unter Mittel-Devon, vornehmlich aufgrund der Tentaculiten und trilobiten im Tafilalt (SE-Marokko). Neues Jahrbuch Geologie Paläontologie Mh., v. 1980, no.10, pp.581-594.
- Arbizu, M, 1977, Asteropyginae (Trilobita) du Devonien des Montagnes Cantabriques (Espagne). Bulletin Societe Geologique et Mineralogique de Bretagne: s. C. v. 9, no. 2, pp. 59-102.
- Becker, R.T. and House, M.R. 1994, International Devonian goniatite zonation, Emsian to Givetian, with new records from Morocco. Courier Forschungsinstitut Senckenberg, v. 169, p. 79-135.
- Brachert, T C, Buggisch, W, Flügel, E, Hüssner, H M, Joachimski, M M, Tournier, E, and Walliser, O H, 1992, Controls of mud mound formation: the Early Devonian Kess-Kess carbonates of the Hamar Laghdad, Antiatlás, Morocco: Geologische Rundschau, v. 81, no. 1, pp. 15-44.
- Bultynck, P, 1979, Excursion in the Devonian of the Sierra de Guadarrama between Cercadillo and La Riba de Santiuste, in García-Alcalde, J L, Arbizu, M A, García-López, S, and Méndez-Bedia, I eds, Meeting of the International Subcommittee on Devonian Stratigraphy. Guidebook of the field trip: Servicio de Publicaciones de la Universidad de Oviedo, pp. 32-34.
- Bultynck, P, and Hollard, H, 1980, Distribution comparée de Conodontes et Goniatites dévoniens des plaines du Dra, du Ma'der et du Tafilalt (Maroc): Aardkundige Mededelingen, v. 1, pp. 1-73.
- Bultynck, P, and Morzadec, P, 1979, Conodontes de la coupe de Reun ar C'Hrank en Lanvéoc (Rade de Brest) Emsien du Massif Armoricaire (France) Corrélations biostratigraphiques: Geobios, v. 12, no. 5, pp. 675-685.
- Carls, P, 1987, Ein Vorschlag zur biostratigraphischen Redefinition der Grenze Gedinium/Siegenium und benachbarter Unter-Stufen. Stratigraphische Argumente und Korrelationen: Courier Forschungsinstitut Senckenberg, v. 92, pp. 77-121.
- Carls, P, 1988, The Devonian of Celtiberia (Spain) and Devonian paleogeography of SW Europe, in: McMillan, N J, Embry, A F, and Glass, D J eds, Devonian of the World: Memoirs of the Canadian Society of Petroleum Geologists, v. 14, no. 1, pp. 421-466.
- Carls, P, and Valenzuela-Ríos, J I, 1993, Materials near the redefined base of the Emsian stage: Newsletter of the Subcommittee on Devonian Stratigraphy, v. 10, p. 30.
- Chlupač, I, 1976, The oldest goniatite faunas and their stratigraphical significance: Lethaia, v. 9, pp. 303-315.
- Chlupač, I, 1994, Devonian trilobites-evolution and events: Geobios, v. 27, no. 4, pp. 487-505.
- Chlupač, I, 1995, Evaluation of Some Devonian Standard Boundaries. Nova Acta Leopoldina NF, v. 71, no. 291, pp. 41-52.
- Chlupač, I, and Kukal, Z, 1986, Reflection of possible global Devonian events in the Barrandian area, C.S.S.R., in Walliser, O ed, Global Bio-Events. A critical approach: Lecture Notes in Earth Sciences, v. 8, pp. 169-179.
- Chlupač, I, and Kukal, Z, 1988, Possible global events and the stratigraphy of the Palaeozoic of the Barrandian (Cambrian-Middle Devonian, Czechoslovakia): Sbornik geologických Ved. Geologie, v. 43, pp. 83-146.
- García-Alcalde, J L, 1992, El Devónico de Santa María del Mar (Castrillón, Asturias, España): Revista Española de Paleontología, v. 7, no. 1, pp. 53-79.
- García-Alcalde, J L, 1995, L'évolution paleogeographique pre-Varisque de la Zone Cantabrique septentrionale (Espagne): Revista Española de Paleontología, v. 10, no. 1, pp. 9-29.
- García-Alcalde, J L, 1996, El Devónico del Dominio Astur-Leonés en la Zona Cantábrica (N de España): Revista Española de Paleontología, no. extraordinario, pp. 58-71.
- García-Alcalde, J L, Arbizu, M, García-López, S, Leyva, F, Montesinos, R, Soto, F, and Truyols-Massoni, M, 1990, Devonian stage boundaries (Lochkovian/Pragian, Pragian/Emsian, and Eifelian/Givetian) in the Cantabric region (NW Spain): Neues Jahrbuch Geologie Paläontologie Abhandlungen, v. 180, no.2, pp.177-207.
- García-Alcalde, J L, and Truyols-Massoni, M, 1994, Lower/Upper Emsian versus Zlichovian/Dalejan (Lower Devonian) boundary: Newsletters in Stratigraphy, v. 30, pp. 83-89.
- García-Alcalde, J L, Truyols-Massoni, M, Pardo, M, Bultynck, P, and Carls, P, 1997, Devonian chronostratigraphy of Spain. Courier Forschungsinstitut Senckenberg (in press).
- García-López, S, and Alonso-Menéndez, C, 1994, Conodontes del Grupo La Vid, límites Praguense/Emsiense y Emsiense Inferior/Emsiense Superior, Zona Cantábrica (NO de España): Revista Española de Micropaleontología, v. 26, no. 2, pp. 81-97.
- García-López, S, and Arbizu, M, 1993, Nuevos hallazgos de conodontes en el Devónico Inferior de la costa asturiana y su aplicación a la cronoestratigrafía del Grupo Rañeces: Revista Española de Paleontología, no. extraordinario, pp. 78-88.
- Gourvenec, R, 1989, Brachiopodes Spiriferida du Devonien Inferieur du Massif Armoricaire. Systematique-Paleobiologie-Evolution-Biostratigraphie.: Biostratigraphie du Paleozoique, v. 9, pp. 1-155.
- Grötsch, J, 1988, Conodonten und Stratigraphie der unterdevonischen La Vid Formation (Kantabrisches Gebirge, NW-Spanien): Erlanger geologie Abhandlungen, v. 115, pp. 155-198.
- Hollard, H, 1978, Correlations entre niveaux a brachiopodes et a goniatites au voisinage de la limite Dévonien inférieur-Dévonien moyen dans les plaines du Dra (Maroc présaharien): Newsletters in Stratigraphy, v. 7, no.1, pp. 8-25.
- House, M R, 1985, Correlation of mid-Palaeozoic ammonoid evolutionary events with global sedimentary perturbations: Nature, v. 313, pp. 17-22.
- Jahnke, H, Henn, A, Mader, H, and Schweineberg, J, 1983, Silur und Devon im Arauz-Gebiet (Prov.Palencia, N-Spanien): Newsletters in Stratigraphy, v. 13, no. 1, pp. 40-66.
- Johnson, J G, Klapper, G, and Sandberg, C A, 1985, Devonian eustatic fluctuations in Euramerica: Geological Society of America Bulletin, v. 96, pp. 567-587.
- Le Menn, J, Plusquellec, Y, Morzadec, P, and Lardeux, H, 1976, Incursion hercynienne dans les faunes rhénanes du Devonien inferieur de la rade de Brest (Massif Armoricaire): Palaeontographica, A, v. 153, no. 1-3, pp. 1-61.
- Lütke, F, 1979, Biostratigraphical significance of the Devonian dacryoconarida, in House, M R, Scrutton, C T, and Bassett, M G, The Devonian System: Special Papers Palaeontology, v. 23, pp. 281-289.
- Mawson, R, 1995, Early Devonian polygnathid conodont lineages with special reference to Australia: Courier Forschungsinstitut Senckenberg, v. 182, pp. 389-398.
- Montesinos, J R, 1990, Las biozonas de ammonioideos del Devónico (Emsiense inferior-Famenniense inferior): crítica al sistema de clasificación zonal: Revista Española de Paleontología, v. 5, pp. 3-17.
- Montesinos, J R, 1991, Ammonoioideos de las Capas de Vañes (Formación Abadía, Devónico Inferior) del Dominio Palentino (Palencia, NO de España): Cuadernos Laboratorio Xeoloxico de Laxe, v. 16, pp. 193-201.
- Montesinos, J R, and García-Alcalde, J L, 1996, An occurrence of the Auguritid ammonoid *Celaceras* in the Lower Devonian of northern Spain: Palaeontology, v. 39, no. 1, pp. 149-155.

- Montesinos, J R, and Truyols-Massoni, M, 1987, La Fauna de Anetoceras y el límite Zlichoviense-Dalejense en el Dominio Palentino (NO de España): Cuaderno do Laboratorio Xeoloxico de Laxe, v. 11, pp. 191-208.
- Morzadec, P, 1983, Le Dévonien (Emsien-Famennien) de la rade de Brest (Massif Armorica). Lithologie, cartographie, stratigraphie, paléogéographie: Geologie de la France, v. 2, no. 4, pp. 269-310.
- Morzadec, P, Paris, F, Plusquellec, Y, Racheboeuf, P, and Weyant, M, 1988, Devonian stratigraphy and paleogeography of the Armorican Massif (western France), in: McMillan, N J, Embry, A F, and Glass, D J eds, Devonian of the World: Memoirs of the Canadian Society of Petroleum Geologists, v. 14, no. 1, pp. 401-420.
- Pardo-Alonso, M.V. and García-Alcalde, J L, 1996, El Devónico de la Zona Centroibérica. Revista Española de Paleontología, no. extraordinario, pp. 72-81.
- Racheboeuf, P R, 1981, Chonetacés (Brachiopodes) siluriens et dévoniens du sud-ouest de l'Europe: Memoires de la Societe Geologique et Mineralogique de Bretagne, v. 27, pp. 1-294.
- Racheboeuf, P R, and Yesou, H, 1988, La Formation du Faou (Devonien Inferieur du Finistere): nouvelles observations biostratigraphiques et mise en evidence d'une ecozone: Geobios, v. 21, no. 1, p. 41-47.
- Smeenk, Z, 1983, Devonian trilobites of the southern Cantabrian Mountains (Northern Spain) with a systematic description of the Asteropyginae: Leidse Geologische Mededelingen, v. 52, no. 2, pp. 383-511.
- Soto, F, and Kullmann, J, 1996, Hornförmige Eizelkorallen (Rugosa) vom Typ der "Cyathaxonia-Fauna" im Unter-Emsium des östlichen Kantabrischen Gebirges, NW-Spanien: Geobios, v. 29, no. 6, pp. 651-669.
- Truyols, J, Arbizu, M A, García-Alcalde, J L, García-López, S, Méndez-Bedia, I, Soto, F, and Truyols-Massoni, M, 1990, The Asturian-Leonese Domain (Cantabrian Zone), in Dallmeyer, R D, and Martínez-García, E eds, Pre-Mesozoic Geology of Iberia, Springer, pp. 10-19.
- Truyols-Massoni, M, and García-Alcalde, J L, 1994, Faune rhéno-bohémienne (Dacryoconarides, Brachiopodes) à la limite Emsien

inférieur/supérieur au Cabo La Vela (Asturies, Espagne): Geobios, v. 27, no. 2, pp. 221-241.

- Walliser, O H, 1984, Geologic processes and global events: Terra Cognita, v. 4, pp. 17-20.
- Walliser, O H, 1995, Global Events in the Devonian and Carboniferous, in Walliser, O H ed, Global Events and Event Stratigraphy in the Phanerozoic, Springer, pp. 225-250.
- Weddige, K, 1996, Devon-Korrelationstabelle.: Senckenbergiana lethaea, v. 76, no. 1/2, pp. 267-286.
- Yolkin, E A, Weddige, K, Izokh, N G, and Erina, M V, 1994, New Emsian conodont zonation (Lower Devonian): Courier Forschungsinstitut Senckenberg, v. 168, pp. 139-157.

L. García-Alcalde is Professor of Paleontology at the Department of Geology, University of Oviedo, Spain. He holds currently the position of Second Director at the Department of Geology. He has recently been appointed Associate Editor of the new review *Palaeontologica Electronica*. He is Titular Member of the Subcommission on Devonian Stratigraphy from 1989. His research interests are Devonian events, paleobiogeography, and biostratigraphy, with special emphasis on brachiopod taxonomy and biostratigraphy.

Episodes CALLS FOR PAPERS

Episodes is the quarterly science and news journal of the International Union of Geological Sciences (IUGS). It focuses on the publication of results of scientific research and other information addressing issues of interest to the global earth-science community. Special emphasis is given to topics involving geological aspects of population growth and economic development and their resulting impacts on or implications for society. As the principal publication of the IUGS, *Episodes* also carries information about IUGS scientific programs and activities to the extent necessary to communicate effectively with the worldwide IUGS constituency.

Contributions of the following types of manuscripts are here solicited:

- scientific articles
- conference reports
- news and views
- letters to editor
- book reviews
- information on training courses (especially those geared to participants from developing countries)
- noteworthy new publications, including national or regional geologic maps

Episodes also invites photos or other images for the front cover. Photos must be of high technical quality and tell an interesting geological story. A color transparency and one color print (at least 9 cm × 12.6 cm) are required for submission, which should be supplemented with a short explanatory paragraph (no more than 100 words).

Please address all contributions to:

The Editor
Episodes
 P. O. Box 823, 26 Baiwanzhuang Road
 100037 Beijing, CHINA
 Tel: +86-10-68320827; Fax: +86-10-68328928; E-mail: Episodes@public.east.cn.net