The Bathonian and Callovian of the Northwest-Iberian Range: Stages of facial and paleogeographical differentiation on an epicontinental platform

S. WILDE

Institut für Geologie, Ruhr-Universität, D-4630 BOCHUM, W-Germany
Kornweg 3, D-4630 BOCHUM

ABSTRACT

The Bathonian and Callovian stages of the NW-Iberian Range, which formations are newly defined, correspond approximately to two «macro-sequences» limited by wide-spread uncorformity horizons. During this time the facial environmental conditions of this epicontinental shallow-marine depositional realm led into an obviously intensified regional differentiation. This is resulted by increasing tectonic activities causing a structural paleogeographical framework with very variable subsidences, supposingly in connection with the initial Biscay spreading phase.

Key words: Jurassic, Bathonian, Callovian, Iberian Range, Stratigraphy, Paleogeography, Formation definitions, Facies differentiation, Epicontinental Platform. Spain, Soria, Logroño, Burgos, Zaragoza Provinces.

RESUMEN

El Bathoniense y Calloviense de la parte NW de la Cordillera Ibérica, cuyas formaciones son nuevamente definidas, corresponde aproximadamente a dos «macro-secuencias» limitadas por discontinuidades muy extensas. Durante estos pisos las condiciones faciales-ambientales de la plataforma marina epicontinental y poco profunda cambiaron, indicando una diferenciación regional intensa. Una activación tectónica tuvo como consecuencia una articulación estructural paleogeográfica con subsidencias locales muy variables, posiblemente conectadas con la fase inicial de la apertura del Golfo de Vizcaya.

Cuadernos de Geología Ibérica N.º 14, 113-142. Madrid, 1990.
Edit. Universidad Complutense.

Palabras clave: Jurásico, Bathoniense, Calloviense, Cordillera Ibérica, Estratigrafía, Paleogeografía, Formaciones definidas, Diferenciación facial, Plataforma epicontinental, España, Prov. de Soria, Logroño, Burgos, Zaragoza.

ZUSAMMENFASSUNG

Das Bathonium und Callovium der NW-Iberischen Ketten, dessen Formationen neu definiert wurden, bilden in etwa zwei «Makrosequenzen», die durch weit verbreitete Diskontinuitäten begrenzt sind. Während dieser Stufen gelangten die Faziesverhältnisse dieses epikontinentalen flach-marinen Ablagerungsraumes zu einer starken regionalen Differenzierung. Eine verstärkte tektonische Aktivierung verursachte eine interne paläogeographische Strukturierung mit unterschiedlichsten Subsidenzen. Ein Zusammenhang mit der Initialphase des Biskaya-Spreading wird angenommen.

Schlüsselwörter: Jura, Bathonium, Callovium, Iberische Ketten, Stratigraphie, Paläogeographie, Formations-Definitionen, Fazies-Differenzierung, Epikontinental-Platform, Spanien, Provinz Soria, Logroño, Burgos, Zaragoza.

INTRODUCTION

During mostly of the Jurassic period in the territories of the Northwest Iberian Range an epicontinental shallow marine realm existed, situated between the deeper open seas of the Proto-Biscay (Atlantic) and the Betic Geosynclinal (Tethys). The marine Jurassic mega-sequence can be devided into six macro-sequences, beginning with the partially evaporitic Carniolas of the late Triasic/early Lias and ending with the start of the limnic-terrestrial Wealden in Upper Kimmeridgian age (Fig. 1).

The fourth and fifth of these macro-sequences, approximately corresponding to the Bathonian and Callovian stages, play a special and important role in the Jurassic depositional evolution. At these times obvious changes of the sedimentary environment took place with destinct regional differentiation of facies and paleogeography, after a longer period of an essentially uniform development.

The studied area consists of two main territories, the Sierra de la Demanda/ de los Cameros and the Sierra del Madero/ del Moncayo. The third, the Zaragoza region (Ricla to Belchite) is included as transitional region between the NW and SE Iberian Range (Aragonese-Levantine branch).

The basal works on marine Jurassic biostratigraphy and paleogeography of the NW-Iberian Range are done mainly by Mensink (1966) and

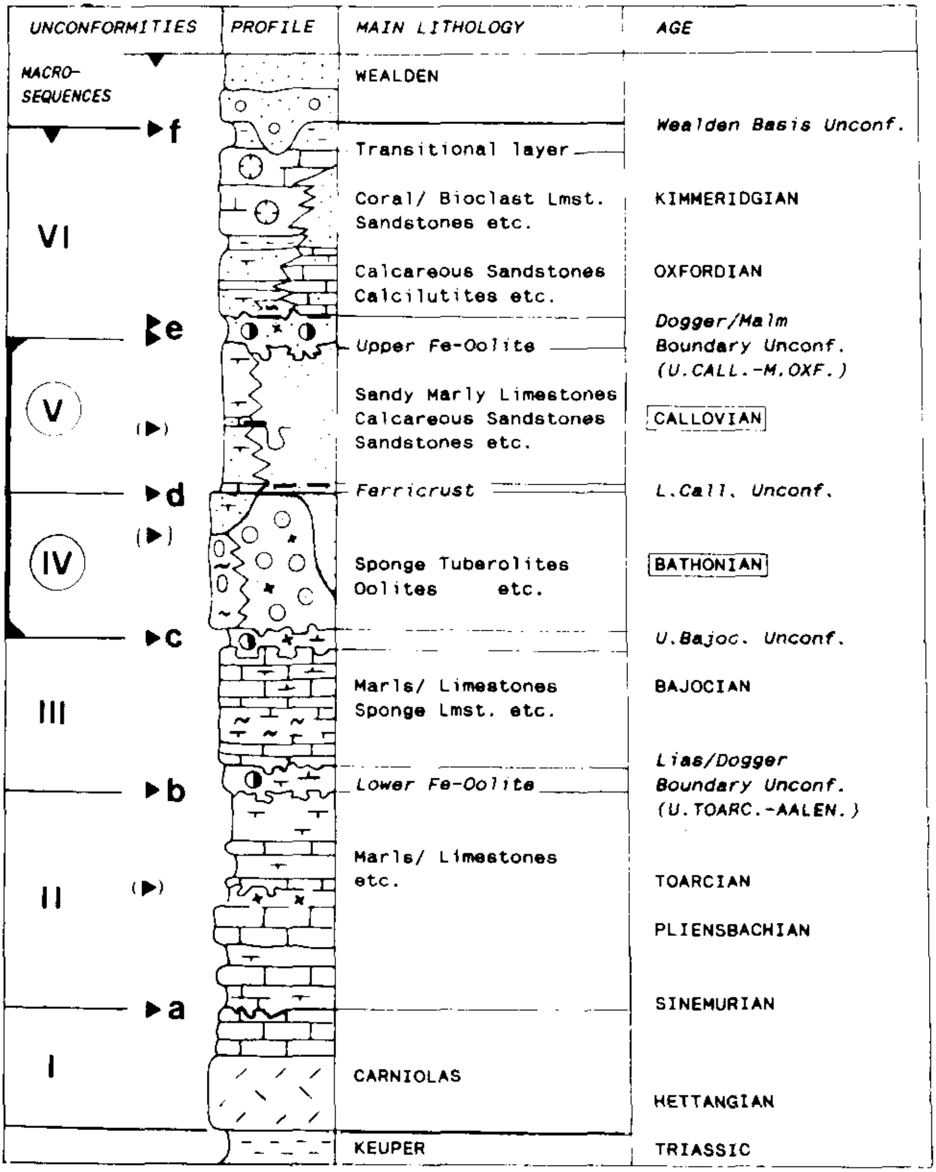


Fig. 1.—Schematic section of the Jurassic mega-sequence with the main lithology and stratigraphical age. It is divided into six macro-sequences limited by superregional un-conformity horizons.

Fig. 1.—Perfil esquemático de la «mega-secuencia» Jurásica con las litologias principales y la división estratigráfica, compuesta de «macro-secuencias» limitadas por discontinuidades con extensión superregional.

Bulard (1972). Since then several special and local studies about this subject are published. Particularly the Paleontology & Facies Working Group of the Bochum University Institute of Geology, directed by Prof. Dr. H. Mensink, are engaged in the NW-Iberian Jurassic since more than a decade. Lower Dogger (Aalenian-Bajocian) sequences are studied by Mertmann (1984/1986), Scheer (in prep.) and Gervais (in prep.). the Lower Callovian Unconformity by Mensink and Mertmann (1984), and the overlying Oxfordian-Kimmeridgian by Benke (1981), Benke *et al.*, (1981), Conze *et al.*, (1984), Dragastan *et al.*, (1987), Errenst (1984, 1987), Wnendt-Juber (1985) and Schudack (1984, 1985/1987), without mentioning the many Diploma works done in this regions. This contribution is based on the first detailled study of Bathonian-Callovian of this regions done in my thesis (Wilde 1987/1988).

THE LIMITING UNCONFORMITY HORIZONS

The two studied macro-sequences are limited by the following main depositional unconformities representing omission or lowest-rate sedimentation phases (Fig. 2).

The Upper Bajocian «Unconformity» is a sequence of low thickness embracing two or three ammonite zones (*niortense, garantiana, parkinsoni* pp.) and is characterized by faunal condensation, hardgrounds, reworked layers, and ammonite enrichment horizons. It is defined as the basal guide layer of the Bathonian macro-sequence.

At the boundary Lower/Middle Bathonian an unconformity of local significance separates discontinuously the Neila from the Montenegro Formation in the Demanda Basin regions.

The Lower Callovian Unconformity appears in the greatest part of the NW-Iberian as hardground or erosional horizon and divides the Bathonian from the Callovian macro-sequence. Usually it is combined with an iron-oxide covering (ferricrust). The horizon is dated with *macrocephalus* zone ammonites (Bulard, 1972, Benke *et al.*, 1981, Mensink & Mertmann 1984).

The Dogger/Malm Boundary Unconformity as the most wide spread of the Jurassic guide horizons terminates the Callovian,macro-sequence. It is characterized by a typically iron-oolitic, often sandy and bioclastic layer, with one or more generations of hardgrounds and/or erosive surfaces. Ammonite faunas verify the stratigraphical reach in the NW-Iberian realm from *lamberti* (late Upper Callovian) up to *plicatilis* zone (early Middle Oxfordian) (Benke, 1981; Bulard, 1972, and others). In the Aragonese and some other SE-Iberian regions the Fe-oolitic omission phase sets in often earlier in Lower or Middle Callovian (Geyer *et al.*, 1974: «Upper Boundary

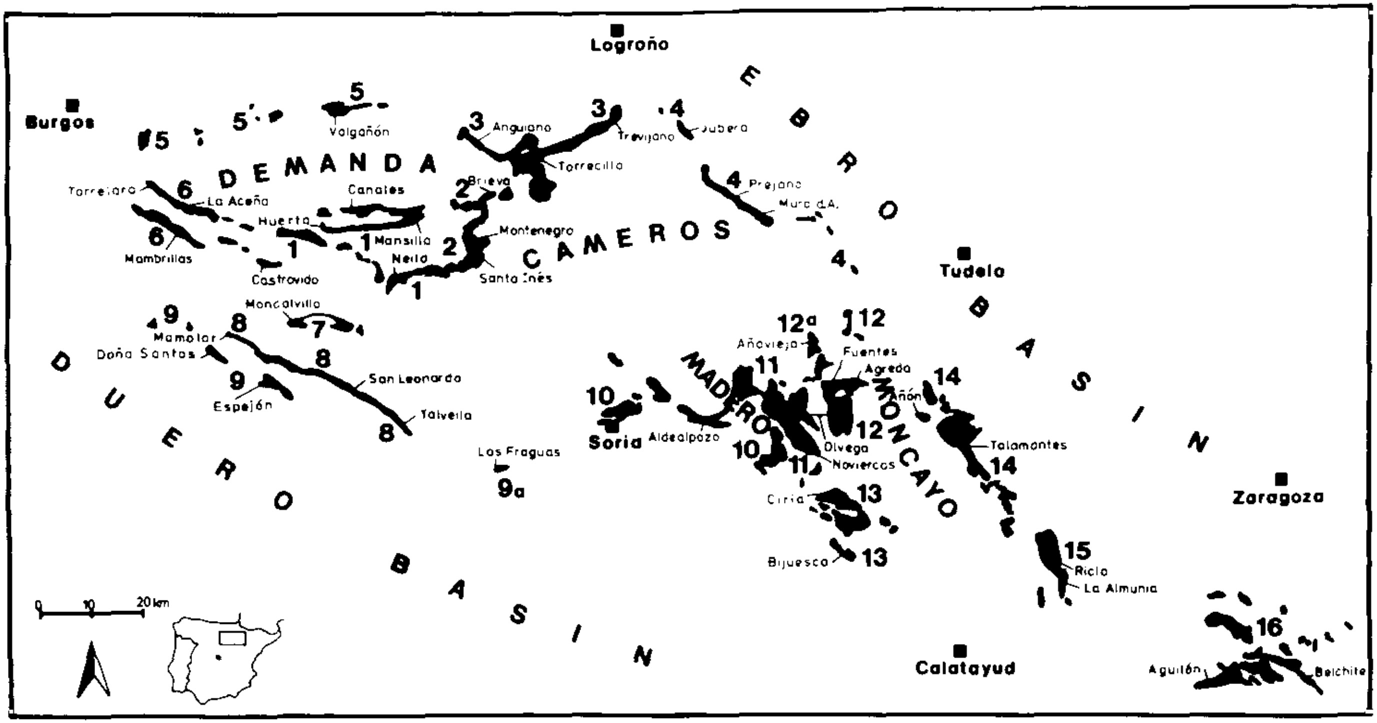


Fig. 2.—The Jurassic outcrops (except Carniolas and Wealden) of the NW Iberian Range with the studied and mentioned profile localities. The numbers 1-15 refer to the used regional division, which are specified in Figs. 3 and 4.

Fig. 2.—Afloramientos jurásicos (sin Carniolas y Wealdense) del NW de la Cordillera Ibérica, con los cortes (perfiles) mencionados e investigados. Los números 1-15 se refieren a la división regional especificada en las Figs. 3 y 4.

(Fe-) Oolite»; Gomez, 1979: "Capas de Oolitos ferruginosos de Arroyofrio»).

THE FORMATIONS

In the Levantine part of the SE-Iberian Range the Chelva Formation («Formación Carbonatada de Chelva») has been nominated by Gomez (1978, 1979) comprising the Toarcian to Oxfordian. His proposal to apply it to the whole Iberian is not to follow. His definition ranges stratigraphically too wide: the major unconformities of the Lias/Dogger as of the Dogger/Malm boundary exists well recognizably also in the Levantine, but unfortunately are not regarded as formation limits. On the other hand in the NW-Iberian the Jurassic is facially more differentiated and thicker. So to my opinion it is useful to establish new formations for the NW-Iberian Bathonian-Callovian (Wilde 1987/1988). They are defined by its stratigraphy, local distribution, lithology and facies types (Fig. 3).

Demanda - Cameros Territory (Fig. 3a, b)

Neila Sponge Tuberolite Limestone Formation
Formación Calizas Espongio-tuberolíticas de Neila

Type locality.—Sierra de Neila (S-Demanda).
Limitation.—Between Upper Bajocian Ammonite Horizons and beginning of sandy-marly Montenegro Fm.
Stratigraphy.—Latest Upper Bajocian (upper *parkinsoni* zone) and early Lower Bathonian (*zigzag* zone, *convergens* subzone).
Lithology.—Mainly tuberoid-rich calcarenites with siliceous sponges («spongiotuberolites»); some silex nodule horizons; thicknesses mostly 15-30 m.
Distribution.—Whole Demanda-Cameros except marginal NE and SW parts.
Facies types:
N-1 Sponge Tuberoid Limestone.—(Bio)tuberomicr(ud)ite with sponges and its fragments, echinoderms, bryozoans, foraminifers, filaments. Main facies.
N-2 Peloid Lmst.—Biopelmicr(ospar)ite. Locally in E-,NE-Demanda, SW-Cameros.
N-3 Tuberoidic Calcilutitic Limestone.—Biomicrite with some tuberoids. Upper part in the SW-Cameros.
N-4 Peloid Tuberoid Lmst.—Biopeltuberomicrite. Top layers in S-Demanda.
N-5 Coated-grain Tuberoid Lmst.—(Tubero)(micro)sparite (coated-grains = micritic-enveloped bioclasts). Top layers in S-, SW-Demanda.
N-6 *Tuberoidic Bioclast Peloid Limestone («Valgaño Member»).*—(tubero)biopelmicr (ospar)ite. Transitional beds to following Montenegro Fm. in N-Demanda.

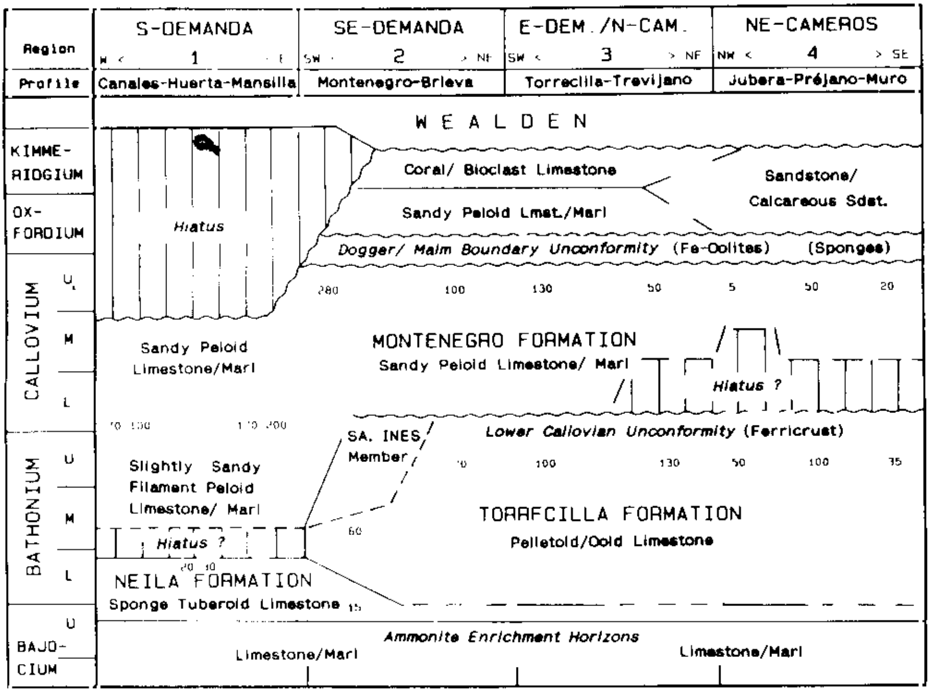

Region
Profile
S-DEMANDA
1
Canales-Huerta-Mansilla
SE-DEMANDA
2
Montenegro-Brieva
E-DEM./N-CAM.
3
Torrecilla-Trevijano
NE-CAMEROS
4
Jubera-Préjano-Muro
KIMME-RIDGIUM
OX-FORDIUM
CALLOVIUM
BATHONIUM
BAJO-CIUM
W E A L D E N
Coral/ Bioclast Limestone
Sandy Peloid Lmst./Marl
Sandstone/ Calcareous Sdst.
Hiatus
Dogger/ Malm Boundary Unconformity (Fe-Oolites) (Sponges)
Sandy Peloid Limestone/Marl
MONTENEGRO FORMATION
Sandy Peloid Limestone/ Marl
Hiatus ?
SA. INES Member
Lower Callovian Unconformity (Ferricrust)
Slightly Sandy Filament Peloid Limestone/ Marl
TORRECILLA FORMATION
Pelletoid/Ooid Limestone
Hiatus ?
NEILA FORMATION
Sponge Tuberoid Limestone
Ammonite Enrichment Horizons
Limestone/Marl
Limestone/Marl

Fig. 3a

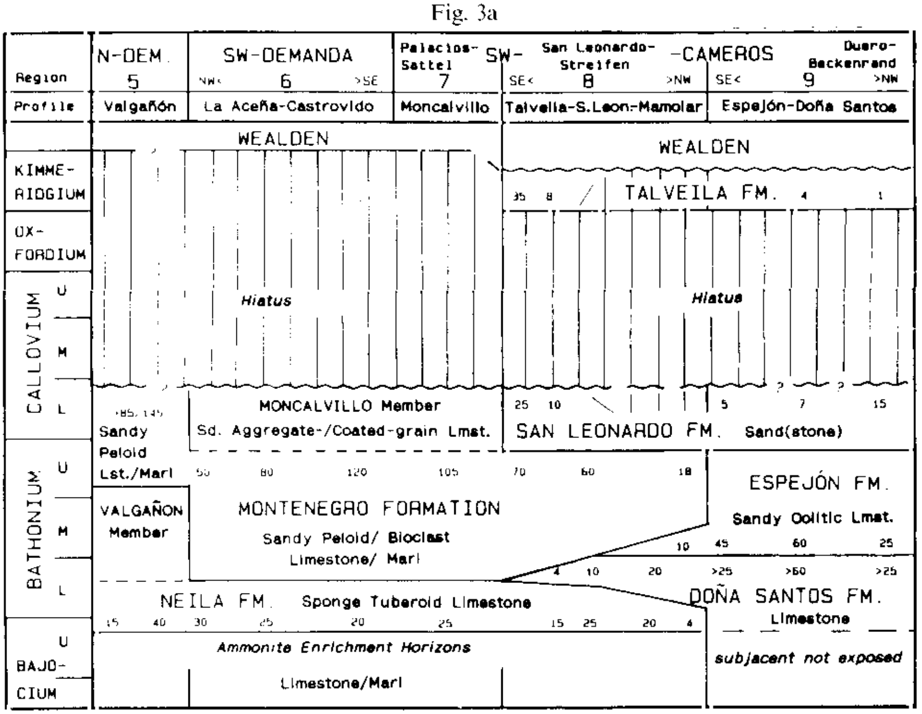

Region
Profile
N-DEM.
5
Valgañón
SW-DEMANDA
6
La Aceña-Castrovido
Palacios-Sattel
7
Moncalvillo
SW-CAMEROS
San Leonardo-Streifen
8
Talveila-S.Leon-Mamolar
Duero-Beckenrand
9
Espejón-Doña Santos
KIMME-RIDGIUM
OX-FORDIUM
CALLOVIUM
BATHONIUM
BAJO-CIUM
WEALDEN
WEALDEN
TALVEILA FM.
Hiatus
Hiatus
MONCALVILLO Member
Sd. Aggregate-/Coated-grain Lmst.
SAN LEONARDO FM.
Sand(stone)
Sandy Peloid Lst./Marl
VALGAÑON Member
MONTENEGRO FORMATION
Sandy Peloid/ Bioclast Limestone/ Marl
ESPEJÓN FM.
Sandy Oolitic Lmst.
NEILA FM. Sponge Tuberoid Limestone
DOÑA SANTOS FM.
Limestone
Ammonite Enrichment Horizons
Limestone/Marl
subjacent not exposed

Fig. 3b

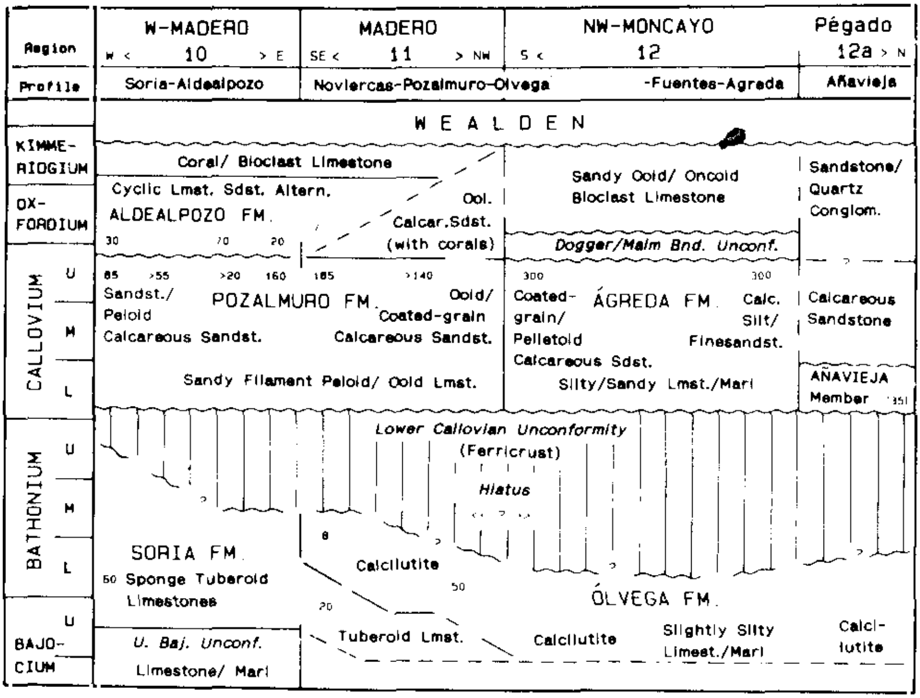

Region
Profile
W-MADERO
W < 10 > E
Soria-Aldealpozo
MADERO
SE < 11 > NW
Novlercas-Pozalmuro-Olvega
NW-MONCAYO
S < 12
-Fuentes-Agreda
Pégado
12a > N
Añavieja
W E A L D E N
KIMME-RIDGIUM
OX-FORDIUM
CALLOVIUM
U
M
L
BATHONIUM
U
M
L
BAJO-CIUM
U
Coral/ Bioclast Limestone
Cyclic Lmst. Sdst. Altern.
ALDEALPOZO FM.
Ool.
Calcar.Sdst.
(with corals)
30 70 20
Sandy Ooid/ Oncoid
Bioclast Limestone
Dogger/Malm Bnd. Unconf.
Sandstone/
Quartz
Conglom.
85 >55 >20 160 185 >140
300 300
Sandst./
Peloid
Calcareous Sandst.
POZALMURO FM.
Ooid/
Coated-grain
Calcareous Sandst.
Sandy Filament Peloid/ Ooid Lmst.
Coated-
grain/
Pelletoid
Calcareous Sdst.
ÁGREDA FM.
Calc.
Silt/
Finesandst.
Silty/Sandy Lmst./Marl
Calcareous
Sandstone
AÑAVIEJA
Member
Lower Callovian Unconformity
(Ferricrust)
Hiatus
SORIA FM.
50 Sponge Tuberoid
Limestones
8
Calcilutite
20
50
ÓLVEGA FM.
U. Baj. Unconf.
Limestone/ Marl
Tuberoid Lmst.
Calcilutite
Slightly Silty
Limest./Marl
Calci-
lutite

Fig. 3c.

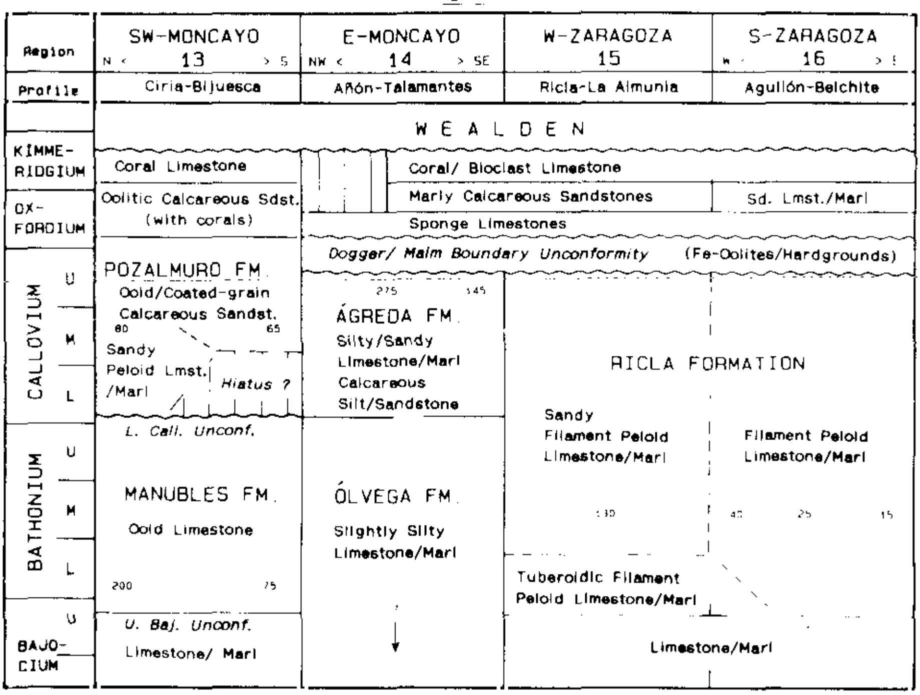

Region
Profile
SW-MONCAYO
N < 13 > S
Ciria-Bijuesca
E-MONCAYO
NW < 14 > SE
Añón-Talamantes
W-ZARAGOZA
15
Ricla-La Almunia
S-ZARAGOZA
W < 16 > E
Aguilón-Belchite
W E A L D E N
KIMME-RIDGIUM
OX-FORDIUM
CALLOVIUM
U
M
L
BATHONIUM
U
M
L
BAJO-CIUM
U
Coral Limestone
Oolitic Calcareous Sdst.
(with corals)
Coral/ Bioclast Limestone
Marly Calcareous Sandstones
Sd. Lmst./Marl
Sponge Limestones
Dogger/ Malm Boundary Unconformity
(Fe-Oolites/Hardgrounds)
POZALMURO FM.
Ooid/Coated-grain
Calcareous Sandst.
80 65
Sandy
Peloid Lmst.
/Marl
Hiatus ?
L. Call. Unconf.
275 145
ÁGREDA FM.
Silty/Sandy
Limestone/Marl
Calcareous
Silt/Sandstone
RICLA FORMATION
Sandy
Filament Peloid
Limestone/Marl
Filament Peloid
Limestone/Marl
130
40 25 15
MANUBLES FM.
Ooid Limestone
200 75
ÓLVEGA FM.
Slightly Silty
Limestone/Marl
Tuberoidic Filament
Peloid Limestone/Marl
U. Baj. Unconf.
Limestone/ Marl
Limestone/Marl

Fig. 3d

Torrecilla Oolitic Limestone Formation.
Formación Calizas Oolíticas de Torrecilla

Type locality.—Area around Torrecilla en Cameros (E-Demanda).
Limitation.—Between Upper Bajocian Ammonite Horizons and the Lower Callovian Unconformity (ferricrust).
Stratigraphy.—Whole Bathonian, including latest Upper Bajocian (upper *parkinsoni* zone) and early Lower Callovian (*macrocephalus* zone).
Lithology.—Mainly oolitic calcarenites; about 50-150 m.
Distribution.—SE-, E-Demanda, N-, NE-Cameros regions.
Facies types:
T-1 Pelletoid/Ooid Limestone.—Oo(bio)sparite, with echinodermal clasts (pelletoids = fully micritized ooids and echinoderms). The main facies.
T-2 Echinoderm Bioclast Peloid Limestone.—Biopel(micro)sparite.
T-3 Slightly Sandy Bioclast Peloid Limestone.—Biopelmicr(ospar)ite.
T-4 Slightly Sandy Ooid Bioclast Peloid Limestone.—(Oo)biopel(micro)sparite.
T-5 Slightly Sandy Coated-grain Ooid Limestone.—Oobiosparite.
T-2 to T-5 («Santa Inés Member») are transitional beds to the following Montenegro Fm. in N- and SE-Demanda.

Doña Santos Limestone Formation.
Formación Calizas de Doña Santos

Type locality.—Doña Santos area (Duero Basin border)
Limitation.—Substitute partially the upper Neila Fm.
Stratigraphy.—Lower Bathonian?
Lithology.—Sponge-free, quartzless limestones; up to 60 m.
Distribution.—Only in parts of SW-Cameros.
Facies types:
D-1 Bioclastic Calcilutitic Limestone.—(Bio)micrite with some fine bioclasts.
D-2 Coated-grain Calcarenitic Limestone.—Bio(intra)pelmicrite/sparite, with some peloids, bioclasts and lumps.

Fig. 3.—Synoptic scheme of the stratigraphical and regional distribution of the Bathonian and Callovian formations of the NW Iberian realm (region numbers see Fig. 2), its main lithology and thicknesses (little numbers), including the adjacent stages. 3a. Demanda-Cameros territory (regions 1-4). 3b. Demanda-Cameros territory continued (regions 5-9). 3c. Madero-Moncayo territory (regions 10-12). 3d. Madero-Moncayo continued (13-14) and Zaragoza territory (15-16).

Fig. 3.—Esquema sinóptico estratigráfico-regional de las formaciones del Bathoniense y Calloviense del NW de la Cordillera Ibérica (números de las regiones, véase Fig. 2), con las litologías principales y los espesores (números pequeños), incluyendo los pisos adyacentes. 3a. Territorio de Demanda-Cameros (regiones 1-4). 3b. Territorio de Demanda-Cameros, cont. (regiones 5-9). 3c. Territorio de Ma-dero-Moncayo (regiones 10-12). 3d. Territorio de Madero-Moncayo, cont. (13-14) y de Zaragoza (15-16).

Espejón Sandy Oolitic Limestone Formation.
Formación Calizas Arenosas Oolíticas de Espejón

Type locality.—Espejón area (Duero Basin border).
Limitation.—Follows the Doña Santos Fm. (or Neila Fm. resp.), substituting the Montenegro Fm., locally only the lowest part of it.
Stratigraphy.—Middle to Upper Bathonian.
Lithology.—Ooid/coated-grain calcarenites with quartz; up to 45 m.
Distribution.—About the same as the Doña Santos Fm.
Facies types:
E-1 Slightly Sandy Ooid Limestone.—Oo(bio)sparite/micrite with coated-grains, bioclasts and some quartz (fine-sand).
E-2 Sandy Coated-grain Limestone.—fine/medium-sandy biosparite.
E-3 Sandstone (fine/medium).—With quarzitic lithoclasts. Local intercalations.

Montenegro Sandy Marly Limestone Formation.
Formación Calizas Margosas Arenosas de Montenegro

Type locality.—Around Montenegro de Cameros (SE-Demanda).
Limitation.—Representing the whole quartz-bearing Dogger, except the Espejon and San Leonardo Formations.
Stratigraphy.—Lower or Middle Bathonian (zigzag or *subcontractus zone*) to Lower or Middle Callovian (*gracilis* or *jason/? coronatum* zone) in Western part, Lower to Upper Callovian (*macrocephalus* to *athleta/lamberti* zone) in the East of the Demanda-Cameros territory.
Lithology.—Rhythmically alternating, sandy marls and limestones with peloids and bioclasts; partially fossil-rich; thickness 5-250 m, very variable.
Distribution.—The whole Demanda-Cameros, except the extreme SW.
Facies types:
M-1 Slightly Filament Peloid Limestone/Marl.—Biopelmicrite with some quartz (silt to fine-sand). Mainly lower part in S- and SW-Demanda.
M-2 Slightly Silty Calcilutitic Limestone/Marl.—(Bio)micrite/microsparite with some fine bioclasts and quartz (silt). Lowest part in SE-Demanda.
M-3 Sandy Peloid Limestone/Marl.—Biopelmicr(ospar)ite with peloids, bioclasts and quartz (well-sorted coarse-silt to fine-saand). Main facies in all regions.
M-4 Sandy Bioclast Limestone/Marl.—Biopelmicrite/micrudite with lumachelle layers, peloids, quartz. Intercalations in SW-Demanda and SW-Cameros.
M-5 Bioclast Peloid Calcareous Sandstone: Biopelmicritic (fine-)sandstone. *SW*-Cameros, within the upper formation part.
M-6 Sandy Aggregate-/Coated-grain Limestone («Moncalvillo Member»).—Bio(pel)-intramicrite/microsparite (aggregate-grains = micritic lumps and

clasts), with peloids, quartz (silt to coarse-sand). Upper part in SW-Cameros and SW-Demanda.
M-7 Sandstone.—Of mostly medium-sized quartz and quartzitic lithoclasts. Locally in SW-Cameros.

San Leonardo Sand Formation.
Formación Arenas de San Leonardo

Type locality.—Along railway-line near San Leonardo (SW-Cameros).
Limitation.—Between Montenegro resp. Espejón and an uncornformity surface upon which the Talveila Fm. (marine Kimmeridgian) follows.
Stratigraphy.—About Lower Callovian?
Lithology.—Sands and sandstones; up to 20 m or more.
Distribution.—Only in parts of the SW-Cameros.
Facies type.—*SL Sand/Sandstone.*—Mostly carbonate-free or decalcified, often graded and cross-stratified, fine- to coarse-sand, locally gravel.

Madero-Moncayo Territory (Fig. 3c, d).

Soria Sponge Tuberolite Limestone Formation
Formación Calizas Espongio-tuberolíticas de Soria

Type locality.—Profile near province capital Soria.
Limitation.—Between Upper Bajocian Ammonite Horizons or equivalent layers and the Pozalmuro or Olvega Fm. resp.
Stratigraphy.—Latest Upper Bajocian (*parkinsoni* zone) and Bathonian in locally different ranges.
Lithology.—«Spongiotuberolites» similar to Neila Fm.; up to 65 m.
Disstribution.—West and central Madero (Soria-Olvega area).
Facies types:
S-1 Sponge Tuberoid Limestone.—(Bio)tuberomicrite with sponges. Main facies.
S-2 Tuberoidic Calcilutitic Limestone.—Bio(tubero)micrite with some tuberoids, filaments and other bioclasts. Upper formation part in the Madero.

Olvega Calcilutitic Limestone Formation
Formación Calizas Lutíticas de Olvega

Type locality.—Madero west of Olvega.
Limitation.—To the top is Pozalmuro Fm.; limit to subjacent is indistinct (proposal for extension down to Lias/Dogger Boundary Unconformity).

Stratigraphy.—Locally different, about Bajocian-Bathonian.
Lithology.—Calcilutites, partially limestone-marl alternations.
Distribution.—Madero, NW- and E-Moncayo regions.
Facies types:
0-1 Peloidic Filament Calcilutite.—(Biopel)micrite. Madero, NW-Moncayo.
0-2 Slightly Biogenic Calcilutite.—Micrite, partially some biogenes. Pégado.
0-3 Slightly Silty Filament Limestone/Marl.—Biomicr(ospar)ite. E-Moncayo.
0-4 Slightly Silty Calcilutite/ Marl.—Micr(ospar)ite. Upper part in E-, NW-Moncayo.

Manubles Oolitic Limestone Formation
Formación Calizas Oolíticas de Manubles

Type locality.—Ciria area, at Manubles creek.
Limitation.—Between Upper Bajocian and Lower Callovian Unconformities.
Stratigraphy.—Whole Bathonian, minor parts of adjacent sub-stages.
Lithology.—Massive calcarenitic oolites; thickness up to 200 m.
Distribution.—Only in SW-Moncayo.
Facies type:
C-1 Ooid Limestone.—Oosparite, well-sorted, partially with pelletoids, coated-grains, echinodermal lumachelle.

Pozalmuro Calcareous Sandstone Formation.
Formación Areniscas Calizas de Pozalmuro

Type locality.—Madero area east of Pozalmuro.
Limitation.—Between Lower Callovian Unconformity and Aldealpozo Fm. (cyclic lagoonal Oxfordian-Kimmeridgian) or coral-bearing calcareous oolitic sandstone (underlying the Kimmeridgian Coral Limestone).
Stratigraphy.—Callovian; limit to Oxfordian not exactly known.
Lithology.—Mostly arenites as sandstones, oolitic and peloidic calcareous sandstones, sandy-oolitic limestones; Ciria area: fosiliferous peloidic sandy limestone-marl alternations; thicknesses 35-185 m.
Distribution.—Central and W-Madero, SW-Moncayo.
Facies types:
P-1 Sandy Ooid Limestone.—Sandy oo(biopel)sparite, ooids partially quartz-cored, with some pelletoids, peloids, biogenes. Main facies in W- and central Madero.
P-2 Sandy Filament Peloid Limestone/Marl.—Coarse-silty/ fine-sandy biopelmicrite. Lower part in Ciria and Noviercas area (Madero/ SW-Moncayo).
P-1/2 Alternations of Sandy Oolitic and Sandy Filament Peloid Limestone.—

Sandy oo(bio)- to biopelmicrite. Lower part in Pozalmuro area (Madero).

P-3 Sandy Biogene Peloid Limestone/Marl.—Fine-sandy/ marly biopelmicrite, fossiliferous (ammonites, pelecypods, brachiopods). Upper part in Ciria area.

P-4 Ooid Pelletoid Calcareous Sandstone.—Oosparitic fine/medium-sandstone. Upper part in Tajahuerce-Pozalmuro area (W-/ Central Madero).

P-5 Peloid Calcareous Sandstone.—Pelsparitic Sdst. Main facies in W-Madero.

P-6 Ooid Coated-Grain Calcareous Sandstone.—Oo(biopel)sparitic sandstone. Main facies in Bijuesca area (SW-Moncayo).

P-7 Sandstone/ Quartz Conglomerate.—Intercalations in W-Madero.

Agreda Sandy Marly Limestone Formation
Formación Calizas Margosas Arenosas de Agreda

Type locality.—Around Agreda, NW-Moncayo.

Limitation.—Between Lower Callovian and Dogger/Malm Unconformities. This replace per def. the Pozalmuro Fm. east of the Olvega-Tozanzo Swell line.

Stratigraphy.—Nearly the whole Callovian.

Lithology.—Mostly silty/ fine-sandy limestone-marl alternations and finely clastic calcareous sandstones; oolitic and coarsly clastic arenaceous limestones are less frequent; thicknesses about 150-300 m.

Distribution.—NW- and E-Moncayo.

Facies types:

A-1 Quartz-free Echinoderm Lumachelle Limestone («Añavieja Member»).—Echinoderm bio(pel)microsparite, with peloids/pelletoids. Lower part in Pégado area.

A-2 Slightly Sandy Echinoderm Limestone.—Fine-sandy/ coarse-silty biomicrite/ sparite with fine echinoderm clasts. Basally in Agreda area (NW-Moncayo).

A-3 Sandy Peloid Filament Limestone.—Fine-sandy biopelmicr(ospar)ite. Lower formation part in southern NW-Moncayo (Cueva/Olvega area).

A-4 Alternations of Biogene-bearing Silty/ Fine-sandy Marl/ Limestone to Calcareous Silt-/ Finesandstone.—Bio(pel)micrite. Typically in NW-Moncayo.

A-5 Alternations as A-4 but mostly biogene-free. Typically in E-Moncayo.

A-6 Silty Filament Limestone/ Marl.—Biomicrosparite. Locally upper part.

A-7 Sandy Peloid Limestone/ Marl.—Fine-sandy/ coarse-silty bio(pel)-micr(ospar)ite. Upper part in southern NW-Moncayo.

A-8 Pelletoid Coated-grain Calcareous Sandstone.—Biopelsparitic sandstone. Local intercalations in NW-Moncayo.

A-9 Bimodal Calcareous Sandstone.—With some peloids and biogenes. NW-Moncayo.

A-10 Sandstone («Añon Member»).—Middle part only in Añon (E-Moncayo).

Zaragoza Territory (transitional region to SE-Iberian Range) (Fig. 3d).

Ricla Marly Limestone Formation
Formación Calizas margosas de Ricla

Type locality.—Ricla profile.
Limitation.—Between Upper Bajocian Ammonite Horizons and Dogger/ Malm Boundary Unconformity. The Lower Callovian Unconformity not occurred in this region, therefore no formational differentiation between Bathonian and Callovian macro-sequences is possible here.
Stratigraphy.—Whole Bathonian and Callovian; in southern part gaps in Middle to Upper Callovian.
Lithology.—Fossiliferous limestone/ marl alternations with filaments and peloids, partially sandy; thicknesses 35-140 m, increasing from SE to NW.
Distribution.—Regions W and S of Zaragoza (proposal to define the formation for the adjacent SE-Iberian because of facies similarities).
Facies types:
R-1 Tuberoidic Filament Peloid Limestone.—Biopel(tubero)micrites, quartz-free.
R-2 Filament Peloid Limestone.—Biopelmicrites, quartz-free.
R-3 Filament Peloid Limestone/ Marl.—Same, but more argillaceous.
R-4 Sandy Filament Peloid Limestone/ Marl.—Same, but with quartz.

ENVIRONMENTAL AND PALEOGEOGRAPHICAL DEVELOPMENT

The petrographical and stratigraphical facts of the studied Formations lead to the following outline of the changing facies and paleogeography during Bathonian and Callovian time in the NW-Iberian epicontinental realm (Figs. 4a-d).

During nearly the whole Upper Bajocian in great parts of the concerning territories low sedimentation rates and omission phases with hard-ground formation and faunal enrichments prevailed (the Upper Bajocian «Unconformity» with «Ammonite Enrichment Horizons». (Fig. 4a, c[1]).

Bajocian/Bathonian Boundary (after Upper Bajocian "Unconformity»). (Fig. 4a, c[2]).

At the end of the Bajocian stage the environmental conditions changed distinctively. The sedimentation rates increased or set it again. Three different shallow marine domains are formed in the NW-Iberian:

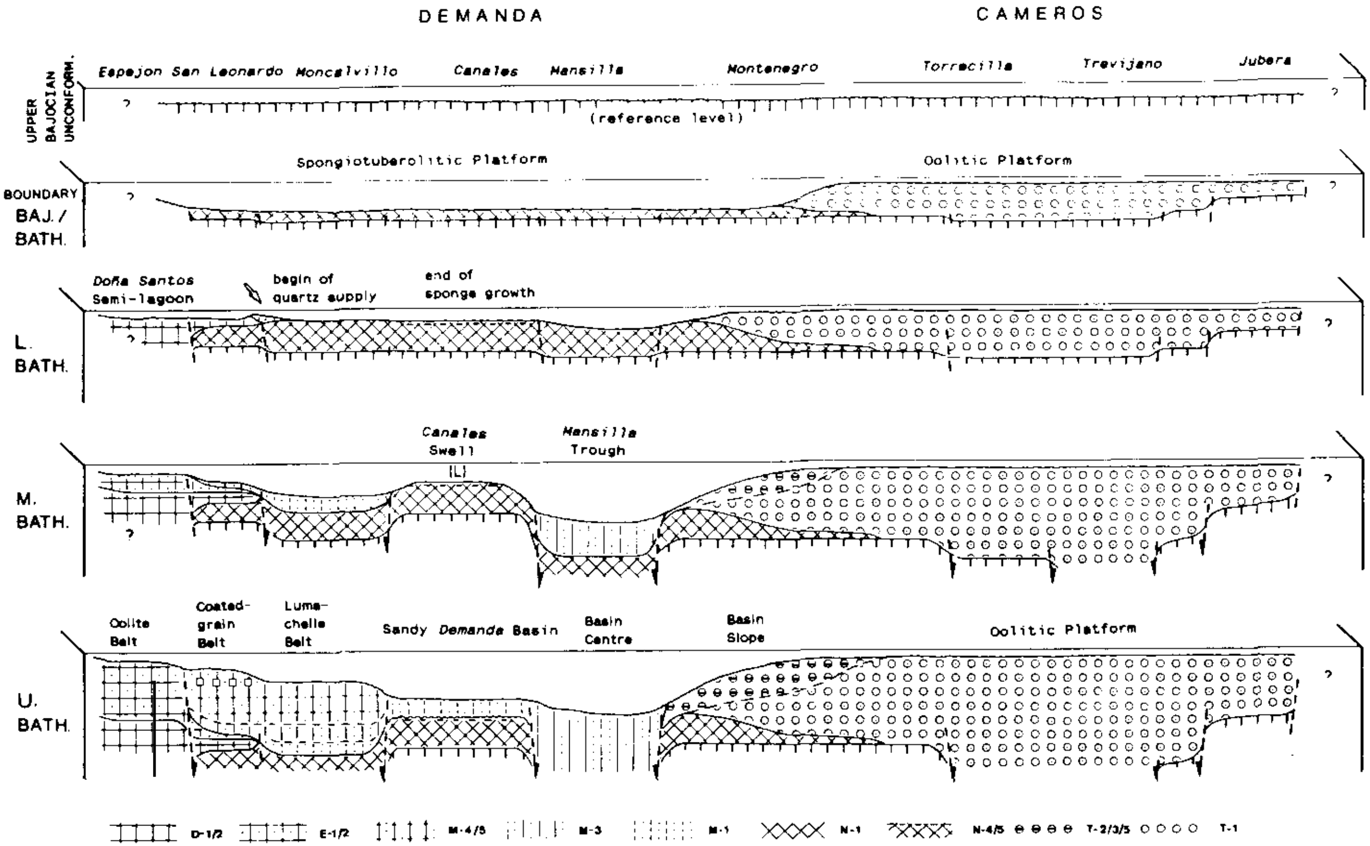

DEMANDA
CAMEROS
Espejon
San Leonardo
Moncalvillo
Canales
Mansilla
Montenegro
Torrecilla
Trevijano
Jubera
UPPER BAJOCIAN UNCONFORM.
(reference level)
BOUNDARY BAJ./BATH.
Spongiotuberolitic Platform
Oolitic Platform
Doña Santos Semi-lagoon
begin of quartz supply
end of sponge growth
L. BATH.
Canales Swell
Mansilla Trough
(L)
M. BATH.
Oolite Belt
Coated-grain Belt
Lumachelle Belt
Sandy Demanda Basin
Basin Centre
Basin Slope
Oolitic Platform
U. BATH.
D-1/2
E-1/2
M-4/5
M-3
M-1
N-1
N-4/5
T-2/3/5
T-1

Fig. 4a.

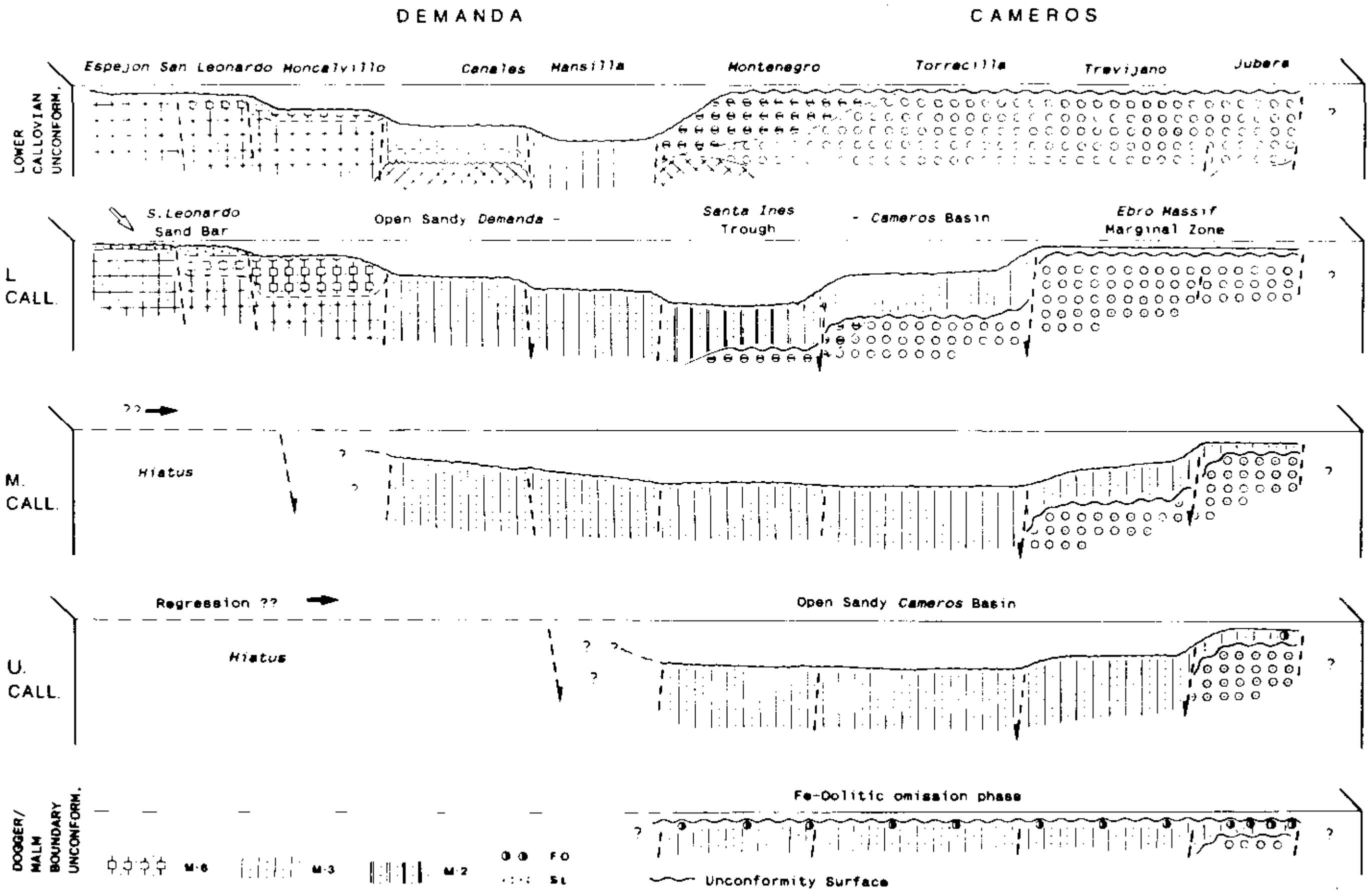

DEMANDA
CAMEROS
Espejon San Leonardo Moncalvillo
Canales
Mansilla
Montenegro
Torrecilla
Trevijano
Jubera
LOWER CALLOVIAN UNCONFORM.
S.Leonardo Sand Bar
Open Sandy Demanda -
Santa Ines Trough
- Cameros Basin
Ebro Massif Marginal Zone
L CALL.
Hiatus
M. CALL.
Regression ??
Open Sandy Cameros Basin
Hiatus
U. CALL.
Fe-Oolitic omission phase
DOGGER/ MALM BOUNDARY UNCONFORM.
M-6
M-3
M-2
FO
SL
Unconformity Surface

Fig. 4b.

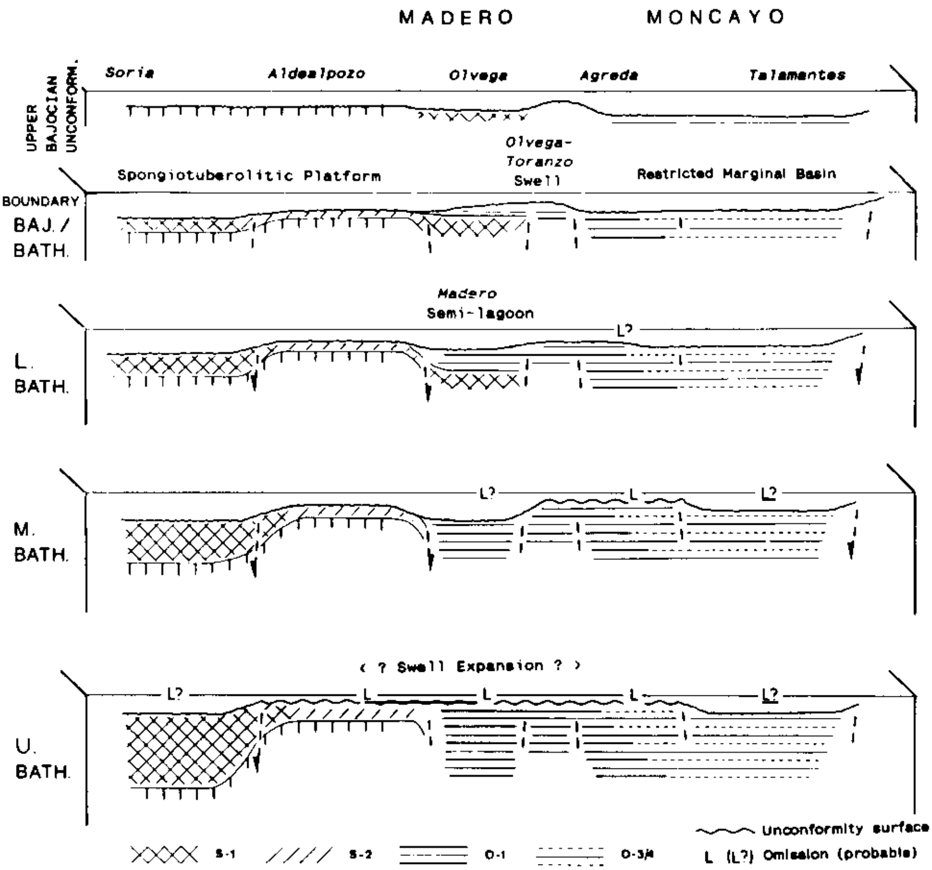


Fig. 4c.

Fig. 4.—Schematic and interpretative facial-paleogeographical cross-sections through the NW Iberian epicontinental platform during Bathonian and Callovian. For facies types see text, for the locations see Fig. 2. Subsidence differences between blocks are marked with arrows showing relative movement directions. 4a. Demanda-Cameros territory during Bathonian. 4b. Demanda-Cameros territory during Callovian. 4c. Madero-Moncayo territory during Bathonian. 4d. Madero-Moncayo territory during Callovian.

Fig. 4.—Cortes transversales esquemáticos a través de la plataforma epicontinental del NW de la Ibérica, con la interpretación facial-paleogeográfica del Bathoniense y Calloviense. Para los tipos de facies, véase al texto; para la localización de los cortes, véase Fig. 2. Las diferencias de subsidencia entre bloques se han marcado con flechas, indicando las direcciones de los movimientos relativos. 4a. Territorio de Demanda-Cameros durante el Bathoniense. 4b. Territorio de Demanda-Cameros durante el Calloviense. 4c. Territorio de Madero-Moncayo durante el Bathoniense. 4d. Territorio de Madero-Moncayo durante el Calloviense.

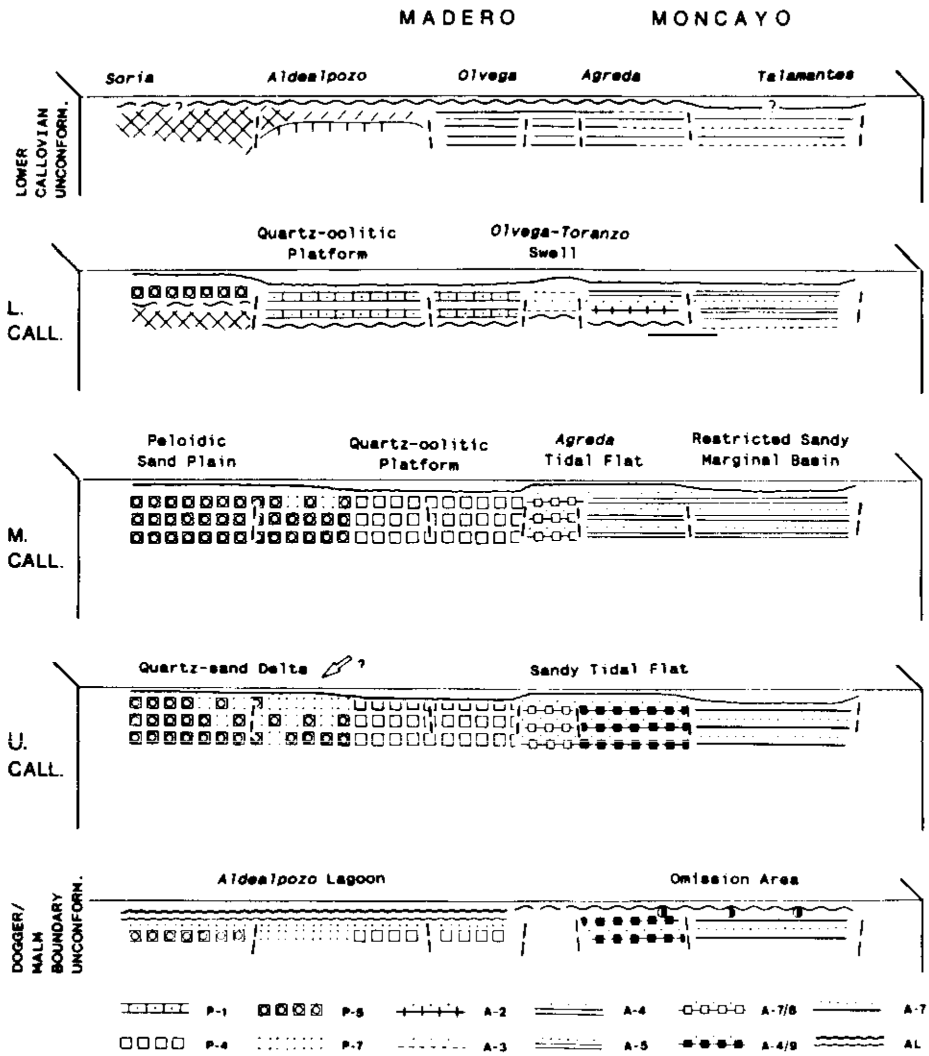


Fig. 4d.

A low-energetic «spongiotuberolitic» platform, extended between Burgos and Olvega, covering the greatest part of Demanda-Cameros and Madero regions with an isochronously beginning of biostromal sponge growth connected with an intense tuberoid formation (facies N-1, S-1).

High-energetic oolite platforms or bars started to form in edge positions of the NW-Iberian, both in the N-/NE-Cameros (T-1) and in the SW-Moncayo region (C-1) with great sedimentation rates.

A somewhat restricted, semi-lagoonal and mostly biogene-poor marginal basin lay in NW- to E-Moncayo, limited to the east from the platforms by the Olvega-Toranzo Swell, continuing similarly the previous facial conditions of the Upper Bajocian times (0-1, 0-4). The least faunal influences existed in the northern basin part, the Pegado area (0-2). Some terrigenous silt supplies are made conspicuous only in the more marginal parts in the E-Moncayo and Agreda areas (0-3/4). The sponge growth in the central Madero probably ended before the begin of Bathonian and the environment then changed also into a more abiogenic micritic one (0-1).

An open-marine and faunally rich, nearly pelagic basin were situated transitionally to the SE-Iberian realm (Zaragoza Basin) without quartz-detritic influx. In the Ricla and Aguilon areas some sponge growth took place (R-1), but without contact to the Demanda-Madero spongiotuberolitic platform. The Belchite-Jaulin area remained sponge-free (R-2).

Lower Bathonian (Fig. 4a, c[3]).

During its final development the spongiotuberolitic platform partially (S-SW-Demanda) get into higher-energetic and possibly shallower influences (N-4/5) rendering its biostromal growth more difficult or impossible. The sponge environment in most of the regions (S-, SW-Demanda, SW-Cameros) ended isochronously, possibly following by a short omission phase with local erosions.

After it the sedimentation set in again with an entire different facies of a deeper subtidal quartz-detritic and peloidic basin environment (M-1). Only in the N-Demanda the sponge tuberoid sedimentation remained longer (N-1).

This facial unconformity is restricted on the Demanda regions. The Demanda basin subsidence is connected with an uplift phase of the adjacent Meseta forelands with the consequence of beginning quartz supplies. First the marginal, but fully marine SW-Demanda regions are detritically influenced. Parts of the S-Demanda, the present-day Canales Graben, remained initially as a local «Canales Swell» with possibly omitted sedimentation.

In the SW-Cameros, from Espejón/ Hortezuelos to Las Fraguas, a narrow coast-parallel zone with semi-lagoonal micritic sediments without sponge growth, alternating with reworked biogene influx were formed (D-1/2). Near Doña Santos solitary and stock corals growed. Similar abiogenic conditions encroached locally on the adjacent San Leonardo Strip during its final sponge platform development.

The oolite regions of the Cameros spread until the Montenegro/ Santa Inés area to its maximal expansion displacing the marginal sponge tuberoid sedimentation (N-1 > T-1).

Middle Bathonian (Fig. 4 a, c [4]).

The SW- and S-Demanda were now fully included into the quartz-detritic basin sedimentation. During its initial phase it is characterized mainly by less quartz and greater filament influxes (M-1), but then continuously leading to more sand percentages (M-3). In the Canales Graben area the sedimentation rates differed locally very much, the «Canales Swell» in the west and the «Mansilla Trough» in its eastern part can be separated. In the S-Demanda locally iron-oolites were formed.

In the San Leonardo Strip area the sedimentation started at once with the «normal» sandy basin facies (M-3), but soon leading to increasing quartz and lumachelle contents as sign of a more shallow position (M-4/5). In the more marginal areas of the Demanda basin, the present Duero Basin border, higher agitated near-shore bioclastic (coated-grain) and oolitic bars developped (E-1/2). In the N-Demanda the spongiotuberolitic phase continued, but with lower sedimentation rates and increasing open-marine influences (N-6).

The facial and paleogeographical conditions of the Madero-Moncayo territory is not too well to define because of the extended stratigraphic gap or the lack of guiding fauna. Middle Bathonian is biostratigraphically proved only near Noviercas with a micritic restricted environment (0-1), which total extension is unknown.

Seemingly in the areas around Olvega/Agreda/Cueva de Agreda the sedimentation came to a standstill, interpretable as an extension of the Olvega-Toranzo Swell. But a later erosion, during the Lower Callovian Unconformity phase, of primarily deposited layers can not be excluded here. In the E- Moncayo the facies likely continued unchanged (0-4).

In the W-Madero the sponge platform get regionally deminished, probably remaining with greated sedimentation rates only around Soria (S-1); near Aldealpozo sponge deposits are minimal (S-2) possibly in a swell position. On the contrary in the oolite bar area around Ciria (SW-Moncayo) the thicknesses were proportionally very high (C-1).

Upper Bathonian (up to the Lower Callovian Unconformity) (Fig. 4a, c[5]).

The S-Demanda central basin facies, including the former Canales swell area (M-1/3), get more uniform with higher sedimentation rates, while in the marginal SW Demanda-Cameros regions the terrestrial influences increased distinctively more. There three parallel facies belts are formed: first, in the SW-Demanda, with lumachelle enrichments intercalating the normal sandy basin facies (M-3/4); second, in the San Leonardo Strip and adjacent Castrovido area, a higher-energetic zone with greater supplies of quartz sand and reworked carbonate particles as aggregate- and coated-grains (M-4/5/6), including local little quartz deltas (M-7); and third, as the most near-shore, the further existing coated-grain oolite belt (E-1/2).

The shallow oolitic platform areas of the Demanda were reduced in favour of the eastward expanding deeper sandy basin. Between these two different environments the transitional «slope» facies is found around Montenegro/Santa Ines and Anguiano (T-3/4/5). Also the N-Demanda were now included in the sandy basin realm after a continuous transition from the spongiotuberolitic facies (N-6 > M-3).

In the Madero-Moncayo territory Upper Bathonian nowhere is proved; a stratigraphic gap consisted at least from Aldealpozo (W-Madero) to the Agreda area (NW-Moncayo), as a sign of sedimentary omission, supposing small quantities of later erosion. Probably only the SW-Moncayo oolites (C-1), the sponge tuberolites near Soria (S-1) and the slightly detritic micrites of the E-Moncayo (0-4) continued sedimentation until beginning of Lower Callovian.

The regression reached its maximum in Lower Callovian with a sedimentary standstill in most regions of the NW Iberian realm, from the SE-Demanda over the whole Cameros and Madero to the SW-Moncayo, connected with the formation of ferruginous crusts and hardgrounds (Lower Callovian Unconformity). On the contrary the sedimentation did not interrupt in the Demanda Basin, same as in the Zaragoza Basin as in the whole Aragonese territory.

Lower Callovian (after the Lower Callovian Unconformity) (Fig. 4b, d[7]).

In the Demanda basin the facial belts continued existing: The S-Demanda remained as the basin centre with nearly unchanged peloidic quartz-detritic sedimentation (M-3); also, the N-Demanda get adjusted to this facies. The SW-Demanda region shallowed and now came into a higher-energetic, more near-coast aggregate- and coated-grains environment (M-6); the facies obviously shifted to N-NE indicating the regressive trends. In the San Leonardo Strip and Espejón/ Doña Santos areas during Lower Callovian, or perhaps already in Upper Bathonian, a sand bar was formed parallelly to the coast line, slightly marine influenced (facies SL). The quartz sands were terminated by a ferruginous crust which formation age is un-certain.

In the SW-, N-Demanda and SW- Cameros regions at least in early Lower Callovian the preserved marine development ends. In the S-Demanda the sandy basin sedimentation continued, biostratigraphically proven, further on.

After the omission phase of the Lower Callovian Unconformity the E-Demanda and N-Cameros regions were also included in the sandy peloidic environment of the Demanda territory (M-3), then resulting a unitary Demanda-Cameros basin up to the coastal domains of the Ebro Massif.

In the most marginal zone (N-, NE-Cameros - at the present Ebro Basin border) the sedimentation set in somewhat later or with reduced rates after the omission phase. In the E-Demanda a special «Santa Ines Trough» were formed with higher subsidence and less detritic influx (M-2).

Also nearly in the whole Madero-Moncayo territory the sedimentation started after the hiatus with more or less sandy deposits. The strongest quartz sand influxes took place around Soria (P-5), likely in a very near-shore position but completely marine. In the remaining West and central Madero regions up to Olvega a shallow wave-agitated more calcareous platform spread forming quartz-cored oolites (P-1).

The thickest deposits with correspondingly high subsidence rates were sedimented in the greater part of the Madero-Moncayo territory during Lower Callovian, obviously more than in the later substages. Only the coastal areas around Bijuesca (southern SW-Moncayo) remained in that period unaffected by the great subsidences and is characterized by reduced sedimentation. The terrestrial proximity specially near Torrelapaja were significant with pure quartz sands directly after the omission phase. In contrary the Ciria area as the only part of the Madero-Moncayo territory is characterized by fauna-rich open-marine basin-like conditions (P-2/3). Possibly there were a direct connection with the facially similar Zaragoza basin.

Open-marine influences reached (A-2/3) in the beginning of the transgressive phase up to E of Olvega (NW-Moncayo). Then regressive trends asserted and lead prevailingly around Olvega-Agreda to fine-detritic alternations of a very shallow sub- to intertidal coastal plain with some endobenthonic life, named as «Agreda watt» or «tidal-flat» (A-4). The E-Moncayo remained probably somewhat deeper and less agitated by tides, but more abiogenic and restricted as a sandy marginal basin (A-5).

Only in the Pégado area primarily a locally restricted echinoderm-rich environment without any quartz influx were formed, interpreted as a «crinoid lagoon» (A-1). After an omission this region were also included in the sandy realm.

Middle Callovian (Fig. 4b, d[8]).

In the Demanda-Cameros territory sedimentation continued with the relatively uniform open sandy basin enviroment (M-3), now with an extension at least from the S-Demanda to the present Ebro Basin border. Locally different subsidences however lead to very variable thicknesses. Wether or not a (later eroded) sedimentation took place in the western regions. (SW-Cameros, N-, SW-Demanda and partially S-Demanda) during Middle Ca-llovian is uncertain, corresponding deposits are definitely missing.

Furtheron the greater part of the W-Madero were dominated by intense siliciclastic sedimentation (P-5/7). Pure carbonate-free quartz sands were spread in some areas from the W-Madero to the Pégado, probably originated from a deltaic bay of the Ebro Massif in the NE (Cervera-Fitero region). Also the quartz-cored oolite platform of the Madero get more sandy (P-4) and expanded up to the coastal area of Bijuesca (SW-Moncayo) (P-6). In contrary to these environments the Ciria area remained as a fully marine influenced basin with open faunal exchanges to the south (P-3).

In the NW-Moncayo around Agreda the «tidal flat» deposition continued (A-4). Its southern part, the Olvega/Cueva area, were influenced as well from the southern more marine environment (A-7) as from the terrestrial clastic (A-8) of the west. The E- Moncayo marginal basin stayed unchanged with abiogenic fine-detritic sediments, except a locally built sand delta at Añón (A-10)

The open-marine Zaragoza Basin came in its western part into quartz-detritic influences (R-4). In the eastern part the sedimentation ended during the Middle Callovian leading to an omission phase with iron-oolites. The general regression let the Ebro mainlands expand to SE narrowing the NW-Iberian Strait.

Upper Callovian (up to the Dogger/Malm Boundary Unconf.) (Fig. 4b,d[9]).

The real extension of the Demanda-Cameros basin to the west is unknowun for the Upper Callovian, because of the lack of the concerning deposit in its western part, including now also the S-Demanda. Unchanged quartz-detritic peloidic deposits (M-3) were formed at least from Montenegro area (SE-Demanda) to the marginal region of the Ebro Massif (NE-Cameros), *continuing until the Dogger/Malm Boundary Unconformity* phase.

The Madero-Moncayo facies got generally more regressive and is characterized by an increase of quartz detritus in connection with a shallowing of the sea. In the West and central Madero the environment changed relatively less (P-4/5). Probably about the end of the Callovian macro-sequence a mostly thin sand plain covered *all* this regions, partially also thicker-bedded sand deltas set in somewhat earlier from the N/NE (P-7).

The quartz-oolitic platform were extended comprising the regions from southern Madero to the SW-Moncayo (P-6), including now the Ciria area. To the east it did not pass over the Olvega-Toranzo Swell. More quartz sand were intercalated also in the NW-Moncayo region, in the northern more tidal Agreda area (A-4/9) as in its southern part (A-7/8). On the other hand local open-marine influences are recognizable in the E-Moncayo (A-6/7).

In accordance to the general regressive trend also the Zaragoza Basin were narrowed. At Belchite no sedimentation took place during Upper Callovian, at Aguilón lowest-rate deposits with iron-oolites were present.

Only in the Ricla area (W-Zaragoza) the open-marine and fauna-rich basin environment continued unchanged until the late Upper Callovian (R-4).

About the final Upper Callovian the regression got to its peak and the macrosequence to an end. In the whole remaining sedimentation area an omission phase followed, from late Upper Callovian to early Middle Oxfordian, with hardground and iron-oolite formation, and faunal condensations (Dogger/Malm Boundary Unconformity (cf. Benke, 1981).

The thickest iron-oolites were found in a marginal position near Jubera (NE-Cameros). In the W-Madero between Soria, Olvega and Noviercas a shallow intertidal lagoon with characteristic cycles established (Aldealpozo Formation, cf. Dragastan *et al.*, 1987, see also further Colloquium contribution).

THE FACIAL-STRUCTURAL FRAMEWORK

The facies variety of the studied formations is mainly caused by the influences of the both sides adjacent emerged mainlands and highs, as well by the internal structural framework of the depositional area.

The sedimentary territory is limited to the NE by the Ebro Massif and to the SW by the Meseta and its forelands, especially the Burgos and the Soria-Ateca Highs, forming a strait trending NW-SE, same as the present-time Iberian Range.

The internal fragmentation of the NW Iberian carbonate platform and the facies boundaries connected with it, follow lines and structures controlled by the main directions NNW/NW-SSE/SE and NNE/NE-SW. Such «lineaments» are compiled in the structure maps (Fig. 5a, b). Many of these structural elements can also be recognized yet in the present-time tectonical framework.

In the SW Cameros some NW-SE striking lineaments (BQL = Barbadillo-Quintanar L., SLL = San Leonardo L., HEL = Hortezuelos-Espejon L.) formed facies belts during Middle Bathonian to Lower Callovian. One of these lineaments get reinforced during the Wealden Basin development forming one of the main marginal faults. The Alpide Orogeny inverted this structure to the present-day San Leonardo Fault.

The East Demanda Line (EDL) separated as a N-S trending transitional zone the oolitic platform of the northern Cameros with its greater subsidences from the spongiotuberolitic one and later from the sandy Demanda Basin.

A special trough with higher subsidences formed in the Demanda Basin centre during Upper Bathonian/Lower Callovian (MTr = Mansilla Trough), shifting to the East in Middle/Upper Callovian (SITr=Santa Ines Trough).

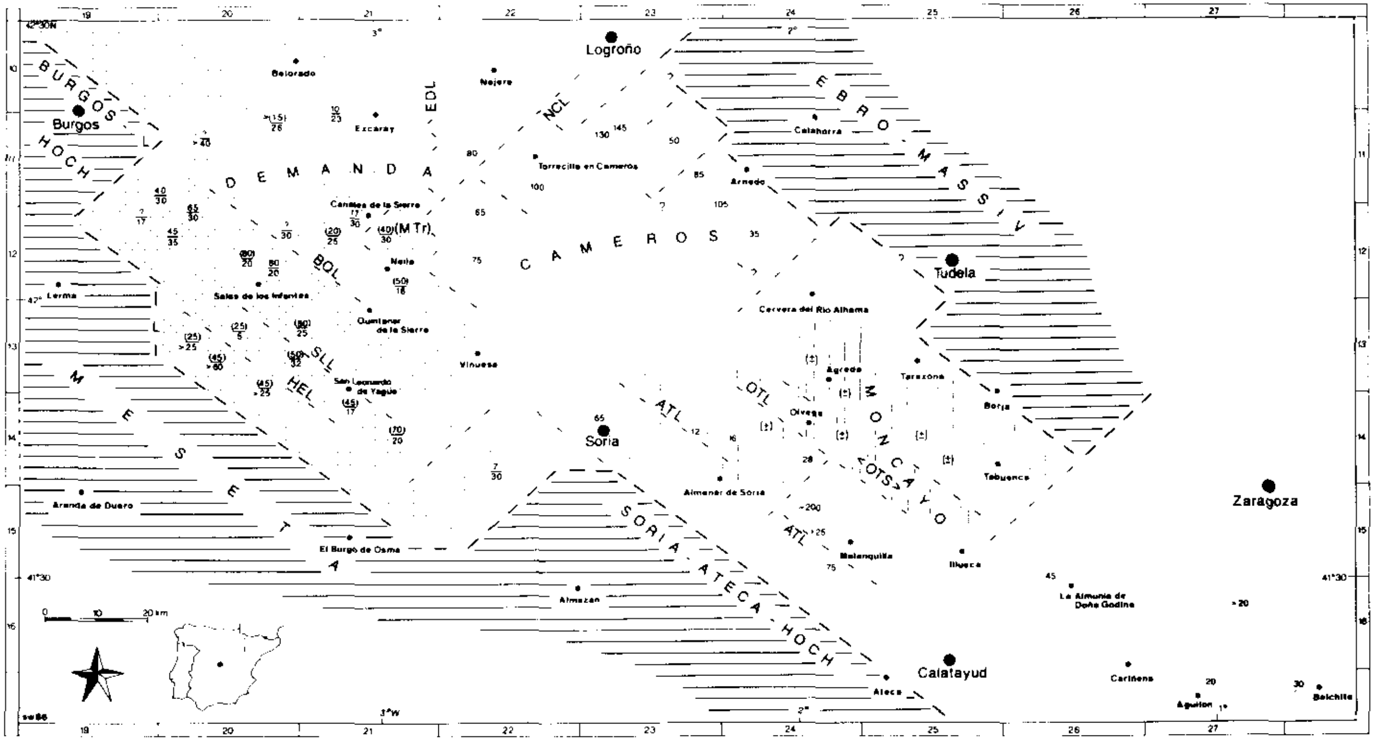
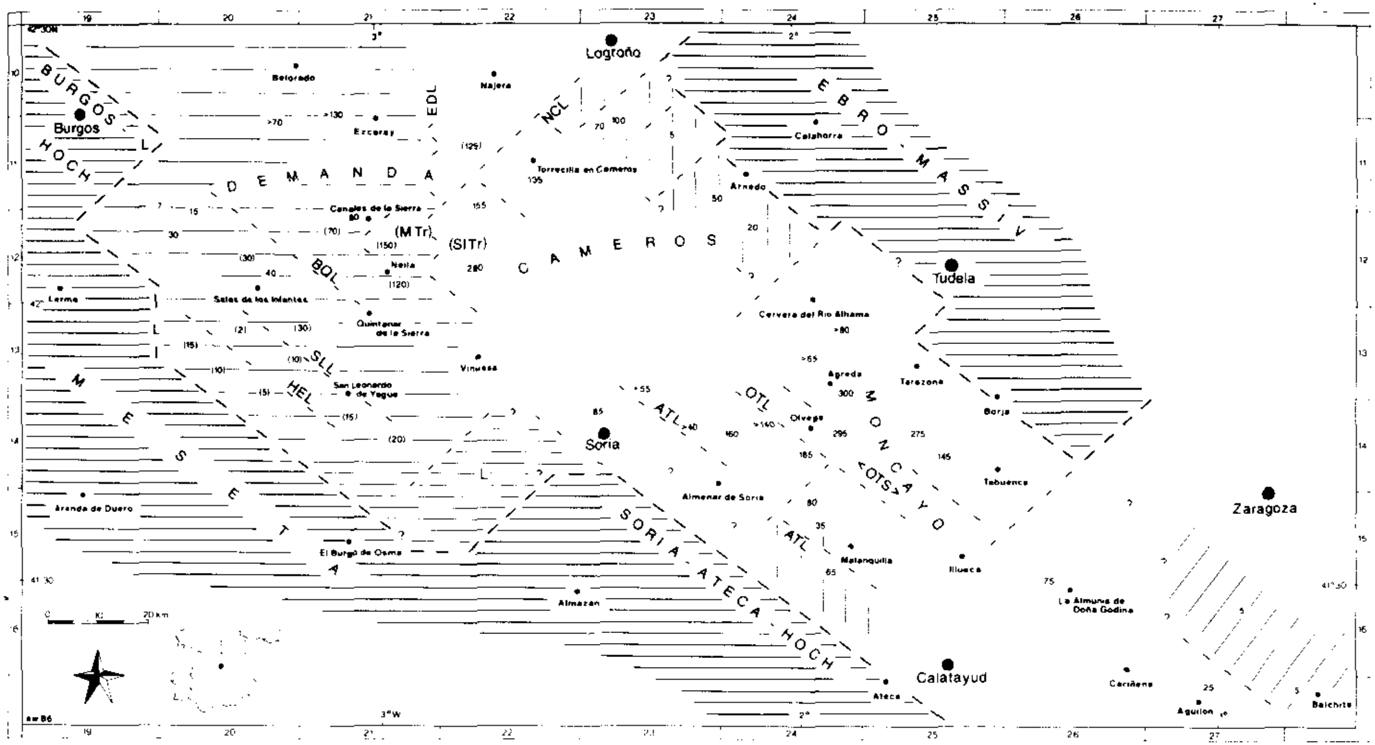

Logroño
Burgos
BURGOS HOCH
DEMANDA
EDL
NCL
CAMEROS
EBRO MASSIV
Tudela
MONCAYO
Soria
SORIA ATECA HOCH
MESETA
Zaragoza
Calatayud
Belorado
Najera
Ezcaray
Torrecilla en Cameros
Calahorra
Arnedo
Canales de la Sierra
Neila
Salas de los Infantes
Lerma
Quintanar de la Sierra
Vinuesa
San Leonardo de Yague
Cervera del Rio Alhama
Agreda
Tarazona
Olvega
Borja
Tabuenca
Almenar de Soria
Aranda de Duero
El Burgo de Osma
Almazan
Malanquilla
Illueca
La Almunia de Doña Godina
Cariñena
Aguilon
Belchite
Ateca
BOL
SLL
HEL
OTL
ATL
OTS
3°W
2°
41°30
42°30N
0 10 20 km

Fig. 5a.



Logroño
Burgos
BURGOS
HOCH
DEMANDA
EDL
NCL
CAMEROS
EBRO MASSIV
Tudela
MONCAYO
OTL
OTS
ATL
SORIA ATECA HOCH
Soria
MESETA
BOL
SLL
HEL
(MTr)
(SITr)
Belorado
Najera
Ezcaray
Calahorra
Torrecilla en Cameros
Arnedo
Canales de la Sierra
Neila
Lerma
Salas de los Infantes
Quintanar de la Sierra
Vinuesa
San Leonardo de Yague
Cervera del Rio Alhama
Agreda
Tarazona
Olvega
Borja
Tabuenca
Almenar de Soria
Aranda de Duero
El Burgo de Osma
Almazan
Matanquilla
Illueca
Zaragoza
La Almunia de Doña Godina
Calatayud
Ateca
Cariñena
Aguilon
Belchite
0 10 20 km
42°30N
42°
41°30
3°W
2°

Fig. 5b.

The region of the Ebro Basin border is characterized by a complex lineament and fault system (Jubera-Fitero Zone, Tischer, 1966). Already during Bathonian and Callovian this area, lain marginally to the Ebro Massif, was fragmentated into several blocks with different subsidences. Similarly the fault system of the North Cameros (Torrecilla-Leza Zone) were active already during the studied stages. The NE-SW striking North Cameros Lineament (NCL) later played an important role, as a main strike-slip fault of the Wealden Basin.

The central area of the Madero-Moncayo territory is characterized by the Olvega-Toranzo Swell (OTS) recognizable by an extended stratigraphical gap of different spaces of time. The omission phase ranges from Lower Bathonian up to Lower Callovian at the centre, and in the outer part starting somewhat later in Middle or Upper Bathonian. Presumably the swell expanded successively during the Bathonian and had its peak along the facies limiting Olvega-Toranzo Lineament (OTL). Its course is obviously conformable to a present main fault. Another parallel striking lineament (ATL = Aldealpozo-Torrelapaja L.) separated blocks of different facies and subsidences.

Fig. 5.—Structural framework of the NW Iberian realm with the facially recognized «lineaments» (see text) and the possible locations of the limiting emerged mainlands (Ebro Massif and Meseta with its foreland «highs»). The numbers refer to thicknesses for the Bathonian of Callowian macro-sequence respectively. 5a. Structural map of the Bathonian-Dot signature: begin of sandy facies in Lower Bathonian (closely dotted) or Middle Bathonian (widely dotted). Vertical lines: Stratigraphical gap in the Madero-Moncayo area with the centred Olvega-Toranzo swell (OTS), beginning in Lower (close lines), Middle (wide lines), or Upper Bathonian (interrupted lines), partially presumed. Double numbers refer to sandy (upper) and quartz-free (lower number) portion of Bathonian. 5b. Structural map of the Callovian. Horizontal lines: End of preserved marine facies, before Callovian (close lines), in Lower (wide lines) or Middle Callovian (interrupted lines). Vertical and diagonal lines: Presumably longer omission phases (gaps) during Lower Callovian (vertical) or Upper Callovian (diagonal) respectively.

Fig. 5.—Esquema tectónico-estructural del NW de la Cordillera Ibérica, con los «Alineamientos» reconocidos facialmente (véase el texto) y las localizaciones su-puestas de los territorios emergidos (Macizo del Ebro y la Meseta con «Altos» adyacentes). Los números se refieren a los espesores de la macro-secuencia del Bathoniense respecto a la del Calloviense. 5a. Mapa estructural del Bathoniense. Puntos: comienzo de la facies arenosa durante el Bathoniense Inferior (punteado denso) o Bathoniense Medio (punteado ligero). Líneas verticales: Laguna estratigráfica en el área del Madero-Moncayo con el Umbral de Olvega-Toranzo (OTS) situado en el centro que comienza durante el Bathoniense Inferior (líneas apretadas), Medio (líneas continuas) o Superior (líneas discontinuas), parcialmente supuesta. Números dobles: espesores de la parte arenosa (número de arriba) y parte sin cuarzo (número de abajo) del Bathoniense. 5b. Mapa estructural del Calloviense. Líneas horizontales: Final de la facies marina conservada antes de Calloviense (líneas apretadas), durante el Calloviense Inferior (líneas continuas) o Medio (líneas discontinuas). Las líneas verticales y diagonales: Fases de omisión (lagunas estratigráficas) presuntamente prolongadas durante el Calloviense Inferior (verticales) o durante el Calloviense Superior (diagonales).

CONCLUSION

The intensified facies variability during Bathonian and Callovian time in the NW-Iberian is caused mainly by two factors:

Firstly, global sea level changes gave the main sequencial rhythms leading in the shallow NW-Iberian platform to more facial diversity than in the generally more deeper and more open-marine neighbouring Cantabrian and SE-Iberian realms.

Secondly, tectonic activities set in or intensify during these stages. While during most of the Liassic and lower Dogger the depositional environments are relatively more or less uniform, the Bathonian and Callovian is characterized by an increasingly regional differentation of facies. The activities led to a structural framework of the marine platform, dividing it into several blocks with very different subsidence histories, which led consequently into the manifold environments. The same tectonic movements caused the uplift phases of the adjacent emerged mainlands which supply those huge amounts of quartz detritus into the marine realm, in the Demanda Basin beginning at Lower/Middle Bathonian and then everywhere at Lower Callovian time. The regional influenced developments overprint often the general trend of regression.

These tectonic movements lead in the following mega-cycle of the non-marine Wealden to the large Strike-slip Fault Basin with its synsedimentary marginal fault systems and its great internal subsidences and bed thicknesses. The development of the Cameros Wealden Basin is interpreted by some authors (e.g. Salomon, 1982; Wiedmann *et al.*, 1983) as connected with or caused by the main Initial Phase of the Biscay Rifting. But many structural elements of the later Wealden Basin already appeared even during Bathonian-Callovian stages, as the studied facial paleogeographical patterns indicate. So the initial phase of Biscay Spreading possibly makes themself evident already during this time.

BIBLIOGRAPHY

BENKE, K. (1981): Die Dogger/ Malm-Wende in den NW-Keltiberischen Ketten (Spanien) und angrenzenden Gebieten. Sedimentologie, Stratigraphie und Paläogeographie. (Thesis Univ. Bochum, 1980). *Facies*, 4: 95-164.

BENKE, K.; DÜRKOOP, A.; ERRENST, Ch., and MENSINK, H. (1981): Die Korallenkalke im Ober-Jura der nordwestlichen Iberischen Ketten (Spanien). *Facies*, 4: 27-94.

BULARD, P. F. (1972): Le Jurassique Moyen et Supérieur de la Chaîne Ibérique sur la bordure du Bassin de l'Ebre (Espagne).Thesis Univ. Nice, vol. I: 702 pp., vol. II: 39 pl., 100 fig.

CONZE, R.; ERRENST, Ch., and MENSINK, H. (1984): Die Ammoniten des Ober-Callovium bis Unter-Kimmeridgium in den Nordwestlichen Keltiberischen Ketten. *Palaeontographica A*, 183 (4-6): 162-211.

DRAGASTAN, O.; MENSINK, H.; MERTMANN, D., and WILDE, S. (1987): Küstennahe Sedimentationszyklen im Ober-Jura der westlichen Madero, Nord-Spanien. *N. Jb. Geol. Paläont. Abh.*, 175 (1): 377-398.

ERRENST, Ch. (1984): Der marine Malm in den nordwestlichen Keltiberischen Ketten (Spanien). *Z. Dt. Geol. Ges.*, 135: 45-55.

ERRENST, Ch. (1987): Das korallenführende Kimmeridgium der nordwestlichen Iberischen Ketten und angrenzender Gebiete. Fazies, Paläogeographie und Beschreibung der Korallenfauna. Thesis Univ. Bochum, 161 pp., (publ. in *Palaeontographica A*, in press).

GERVAIS, A. (in prep.): Das Ober-Bajocium der NW-Iberischen Ketten. Thesis Univ. Bochum.

GEYER, O. F.; BEHMEL, H., and HINKELBEIN, K. (1974): Die Grenzoolithe im Jura von Otspanien. *N. Jb. Geol. Paläont. Abh.*, 145: 17-57.

GOMEZ., J. J. (1978): Características generales del Jurásico en facies carbonatadas del sector Levantino de la cuenca Ibérica (Valencia - Castellón - Cuenca). In: *Grupo Español de Mesozóico: Guía de las excursiones al Jurásico de la Cordillera Ibérica. Dep. Paleont. & Estratigr., Fac. Cienc. Geol. Univ. Complutense*, VIII: 1-17.

GOMEZ, J. J. (1979): El Jurásico en facies carbonatadas del sector Levantino de la Cordillera Ibérica. *Semin. Estratigr., Ser. Monogr., Fac. Cienc. Geol. Univ. Complutense*, 4: 683 pp.

GOMEZ, J. J., and GOY, A. (1979): Las unidades litoestratigraficas del Jurásico medio y superior en facies carbonatadas de la Cordillera Ibérica. *Estud. Geol.*, 35: 569-598.

MENSINK, H. (1966): Stratigraphie und Paläogeographie des marinen Jura in den nordwestlichen Iberischen Ketten (Spanien). *Beih. Geol. Jb.*, 44: 55-102.

MENSINK, H., and MERTMANN, D. (1984): Diskontinuitäten im Unter-Callovium der nordwestlichen Keltiberischen Ketten. *N. Jb. Geol. Paläont. Abh.*, 167 (2): 189-223.

MENSINK, H., and MERTMANN, D. (1988): Die Geologie der Juragebiete um Olvega (Sierra del Madero, del Moncayo und de Toranzo). *Bochumer Geol. u. Geotechn. Arb.*, 30: 99 pp., with 1 geol. map. 1: 46.000.

MERTMANN, D. (1986): Die regressive Fazies-Entwicklung im Ober-Toarcium/Aalenium der NW-Iberischen Ketten, Spanien. (Thesis Univ. Bochum, 1984). *N. Jb. Geol. Paläont. Abh.*, 173; 1-46.

SALOMON, J. (1982): Les formations continentales du Jurassique supérieur - Crétacé inférieur (Espagne du Nord - Chaines Cantabrique et NW Ibriques). *Mém. Géol. Univ. Dijon*, 6: 227 pp.

SCHEER, U. (in prep.): Das Unter-Bajocium der NW-Iberischen Ketten. Thesis Univ. Bochum.

SCHUDACK, M. (1984): Die Jura/Wealden-Grenzschichten in den nordwestlichen Iberischen Ketten (Spanien). *Z. Dt. Geol. Ges.*, 135: 57-65

SCHUDACK, M. (1987): Charophytenflora und fazielle Entwicklung der Grenzschichten mariner Jura/Wealden in den nordwestlichen Iberischen Ketten (mit Vergleichen zu Asturien und Kantabrien). (Thesis Univ. Bochum, 1985). *Palaeontographica, B*, 204: 1-180.

TISCHER, G. (1966): Über die Wealden-Ablagerungen und die Tektonik der östlichen Sierra de los Cameros in den nordwestlichen Iberischen Ketten (Spanien). *Beih. Geol. Jb.*, 44: 123-164.

WIEDMANN, J., REITNER, J., ENGESER, T., and SCHWENTKE, W. (1983): Plattentektonik, Fazies- und Subsidenzgeschichte des baskokantabrischen Kontinentalrandes während der Kreide und Alttertiär. *Zitteliana*, 10: 207-244.

WILDE, S. (1988): Das Bathonium und Callovium der Nordwest-Iberischen Ketten (Jura, Spanien). Sequenzen einer sich differenzierenden Epikontinental-Plattform. (Thesis Univ. Bochum, 1987). *Bochumer Geol. u. Geotechn. Arb.*, 31: 1-222.

WNENDT-JUBER, E. (1985): Die Mikrofauna und -flora der Korallenkalke im Kimmeridgium der NW-Iberischen Ketten (Spanien). Thesis Univ. Bochum, 92 pp. (publ. in *Palaeontographica A*, in press).

Recibido: 13 marzo 1989.
Aceptado: 12 julio 1989.