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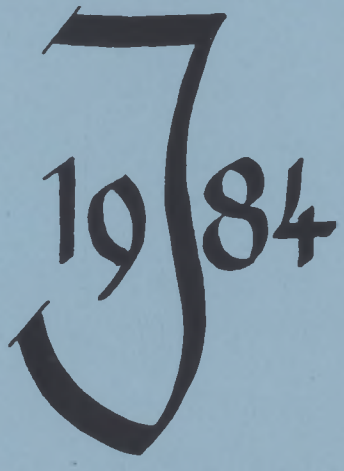
INTERNATIONAL SYMPOSIUM ON JURASSIC STRATIGRAPHY

Erlangen, September 1 - 8, 1984

Symposium volume II



Copenhagen, 1984

INTERNATIONAL SUBCOMMISSION

on

JURASSIC STRATIGRAPHY (IUGS)

INTERNATIONAL SYMPOSIUM ON JURASSIC STRATIGRAPHY

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Symposium volume II

Edited by

Olaf Michelsen & Arnold Zeiss

ISBN 87 981848 1 4
ISBN 87 981848 3 0 (Bd 1-3)

Geological Survey of Denmark, Copenhagen 1984

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MIDDLE JURASSIC AND MIDDLE-UPPER JURASSIC BOUNDARY

MIDDLE-UPPER JURASSIC BOUNDARY EVENTS-EFFECTS OF A WORLDWIDE PHENOMENON?

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MIDDLE-UPPER JURASSIC BOUNDARY EVENTS-EFFECTS OF A WORLD-WIDE PHENOMENON?

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Some attempts were recently made to explain gaps and condensattions typical of Middle-Upper Jurassic passage beds -- in terms of a net result of crises in -- clastic and carbonate sedimentation, Studies on the sequences in the Iberian Cha in and S Poland, where the record of the gaps and condensations is fairly good, - showed a geochemical anomaly and effects of advanced submarine corrosion, thus gi ving further support to the hypothesis - linking the above crisis in carbonate se dimentation with CCD rise(s) related to- intensified subaqueous volcanic activity Redeposited lithand bioclasts, often ve- ry large in size (up to c. 20 cm), appe- ared more common than hitherto inferred and some clasts display features of auto clastic breccia. Concentration of cosmic dust is usually high in the passage beds including some stromatolites, which su-- ggests an increased influx rate. Moreo-- ver, the presence of microtectites is in ferred.

Further studies should show whether or not the above findings give support - to the Callovian event of impact of lar- ge cosmic body, hypothetized recently by D.M. Raup and J.J. Sepkoski in their sche me of periodicity of extinctions. However, it should be stated that the Callovian ex tinction event may be underestimated due to an obliterating effect of several pha- es of redeposition in the latest Callovian and Early Oxfordian.

Our studies on the Middle-Upper Jurassic passage beds in Spain and Poland were mainly aimed at reconstruction of events responsible for omnipresent gaps and condensations. However, -

the recorded phenomena appeared relevant for the current discussions on extraterrestial explanations put forward for the Cretaceous-Tertiary and other bounday events (see the papers in Geol.Soc. Am. Spec. Paper 190,-- 1982/ and those on the scheme of periodicity of extinctions, recently -- elaborated by Raup and Sepkoski (1984)- see e.g. Màddox (1984)and follo-- wing papers in the same issue of Nature, Taking into account potential - value of our findings for the above discussions, we decided to present .-- the hitherto obtained preliminary results as this forum offers a chance - to receive a proper critical assessment of our data and advice, What would be also important it eventual help in further studies on reconstruction - of the events from the Middle- Upper Jurassic bcundary and, eventually, - launching a programme sithin the frame of the IGCP Project no, 199(Rare-- events in the history of the Earth (or other international project.

We may state that there is quickly growing evidence for omnipresence of stratigraphic gaps and condensations in the Middle-Upper Jurassic junction beds in the Mediterranean and adjoining regions as well as zones predestined for intense and continuous sedimentation (e.g.Viking and Central Grabens Ziegler, 1982, or Mid -Polish Trough) in Europe and other continents. Recently attempts were and made to explain these phenomena in terms - of a net result of crises in clastic and carbonate sedimentation. The for mer apperars due to advanced transgression (Meléndez et al., 1983, J. Ogg, et al., 1983 , J. Ogg, et al., 1983), leading to flood of landmases and - almost complete decrease in supply of clastic material. The crisis in carbonate sedimentation was recently explained as due to CCD rise related to the above mendioned transgression (J. Ogg et al., 1983) or the transgression and accompanying intensification in subaqqueous volcanic activity at mid-oceanic ridges (Meléndez et al., 1983). Recently we made an attempt to test the above hypotheses with reference to the results of further studies in the Iberian Chain, Spain, and on classic Callovian-Oxfordian sections in the Cracow-Czestochowa Upland (southern Poland), where condensations and gaps are fairly well evidenced (Rozycki, 1953, Malinowska-1963 Gizekewska and Wieczorek, 1976, Kopik, 1979 and others).

As it was shown in earlier paper (Meléndez et al. 1983 and references cited), in the Iberian Chain the Middle-Upper Jurassic boundary is usually fairly difficult to delineate as the passage beds are usually developped in the facies of limestones with Fe-ooids. However, detailed studies

from the last years have shown that two sections-from Pozuel del Campo -- and Ricla- are the exception. In the former section, the base of the -- boundary layer s clearly erosional (or more properly, corrosional), and the layer- infilled with redeposited materialvarying in age from the Upper Callovian to Lower Oxfordian and as a rule with Fe-Mn coatings. In - The latter it appeared possible to differentiate at least three generations of corrosional pockets infilled with limestone with intraclasts and bioclasts, mainly ammonites datable at the Upper Callovian and Lower Oxfordian. Some of the clasts are phosphatized whereas other displayFe-Mn coatings.

In the Polish sections the effects of subaqueous corrossion, first-noted by Rőzycki (1953), appear omnipresent in both the Callovian and lower parts of Oxfordian. Redeposition of clasts up to 20 cm in size and - even larger appear also more common than hitherto inferred (Kopik 1979 - and others). It should be noted that lower parts of Oxfordian. Redeposition of clasts up to 20 cm in size and even larger appear also more common than hitherto inferred (Kopik, 1979 and others). It sould be noted -- that lower parts of Oxfordian Limestones in sections from the vicinities of Czestochowa display clasts undoubtedly coming from the Callovian as - well as redeposited material of Oxfordian age. Oxfordian Clasts often display factures mineralized with Fe-Mn and other hydroxides or calcite , - not continuing in surrounding material. These and other features suggest that this may be a material of autoclastic breccias, mineralized before-redeposition. Further studies also showed that some limestone layers may be best interpreted as tempestites. The redeposition also affected fauna remains and microfauna of both Callovian and Lower Oxfordian age, resulting in significant difficulties in dating the strata. Actually, the datings may be regarded as reliable only in the case of fossils displaying deformations, i.e. those weakly diagenesed in time of final redeposition.

Geochemical analyses showed marked enrichment of both the Callovian and lower parts of the Oxfordian in the Czestochowa-Cracow area in Fe, Mn and several other metals including Ni, Co, Ree and, in the case of blue-green clays from the nodular layer even in platinium group elements. The (Fe+Mn)/Al ratio, used as an indication of the importance of hydrothermal exhalations to sediment composition (see J. Ogg, et al., 1983), appear higher than 1.0 for Oxfordian Limestones. This implicates that at least a part of Fe and Mn and other metals was derived from nondetrital sources, thus giving support for the hypothesis linking the crisis in car-

bonate sedimentation with subaqueous volcanic activity. It is not surprising as compounds from subaqueous exhalations may represent important component of ediments even at distances up to 1.000 km from active mid-oceanic ridge (Böstrom, 1977).

Analyses of samples from the Iberian Chain are still not finished-but hitherto ubtained data also implicate a marked geochemical anomaly.

Our further studies showed that the boundary layer in the southerm Polish sections and that of Ricla are characterized by unusually high concentration of magnetically separable Fe-Nispherules and other particles representing producte of ablation of meteoroids (Fig. 3) as well as, especially in the case of Ricla-most cosmic dust, i. e. aggregates below 50 Mm in size, passing through the atmosphere without melting (Brownlee, 1983. In the nodular layer stromatolite and the overlaying greenblack clay in the Czestochowa and Klobuck sections, concentration of the spherules is up to several tens or even over a hundred per 1 g. and the recorded particles are highly varing in morphology. Practically all the hitherto described types -- seem present. (We are deeply indebted to Dr. M. Zolenski of Lyndon B. Johnson Space Center, Nasa , For his helpful comments on the material, and-- advice.) .

The above mentioned high concentration of the cosmic material rise the question whether it is due to a drop in rate of sedimentation to that comparable with red oceanic clays or a catastrophic event connected with - asteroid impact as hypothetized in the case of some other boundaries. The fact that the concentration remains high also in stromatolites, i.e. usually slowly growing but, nevertheless, with certain speed growing forms, -- implicates that we are dealing here withan increased influx of cosmic material.The catastrophic explanation seem to be further supported by the above mentioned omnipresence of gaps and condensations in Europe and other continents and regions(including Central and Southern Americas and Indonesia-Jawa Island). The studies on the cosmic material, especially those recen-- tly undertaken by some of our collegues from other research centers, should give additional information on that question. Here we should also add that we cently found also some enrichment (up to 5 cosmic spherules per 1 g) in rocks embedding Lower Oxfordian peltoceratids from Chile (see Chong et - al., this volume).

The nature of the recorded gaps and codensations also seems to give further support for the catastrophic explanation. In the Polish and other sec

tions, one should note that datings of nodular layer or its equivalents -- need revision.Simply, taking into account the available evidence for subaqueous corrosion and redeposition of clasts up to about 20 cm, in size, i. e. very high agitation or water, it appears difficult to assume possibility of fossilization of any ammonite shell and the datings were usually - based on ammonites. The recorded ammonites display infill of body chamber entirely differing from cement is this layer and, When well preserved, well developed Fe-Mn or limonitic coating on their uncorroded lower side.i.e.- the features of redeposited forms. When this is the case, the age of the - youngest redeposited form may be tentatively used as indicative for bracket or time interval of formation or the layer and the eventual catastrophic - event. Taking into account the available stratigraphic record for the studied sections it might be assumed that the event has taken place after the turn or the Athleta and Lamberti (or in early Lamberti) times and before Cordatum Zone. Studies on more complete sequences should make the dating - more precise.

On Figure 2 it is shown a tentative reconstruction of events from- the turn of the Middle and Upper Jurassic as inferred for the Ricla and- Czestochowa sections. The continuation of precipitation of Fe-Mn and other metals in times of origin of stromatolites and overlaying sediments and -- continuing redeposition and origin of stormite- and tempestite-type (or-like)layers may be best explained in terms of after-effects of impacts .As - it follows from the sections on the dymanice or impacts and after-effects - (see Silver and Schultz, 1983), impact of large body should result in rejuvenation of numerous deep crustal fracture systems and eventual volcanic - activity along them. Volcanic after-effects should not cease soon, resulting in CCD level remaining high for a long time, and quakes related to - successive eruption may be the reason of the recorded redeposited autoclastic--breccia-type sediments or those representing or resembling tempestites. -- Some more quiet periods were the time of origin of layers of limestones . - which during the sucessive periods of increased volcanic activity and related quakes, became the source of clasts for the recorded sediments.

The above interpretation is tentative and any errors in interpretation are entirely the authors'. Anyway, we would like to state that discussions on the above pheomena should appear fruitful for our understanding - of the events of the Middle-Upper Jurassic boundary. This is also the case of discussions on extinctions as the above data on redeposition suggest --

that the extinction at that boundary may be greatly underestimated because of obliterating effect or the redeposition. And, redeposition, fairly easy to trace here, was, hitherto underestimated in the case of other boundaries also.

Contribution to IGCP projets
no. 199 and 171

This work has been possible thanksto a generous financial support of the Instituto de Estudios Turolenses (Teruel, Spain), and of the Rectorate of Zaragoza University, Spain.

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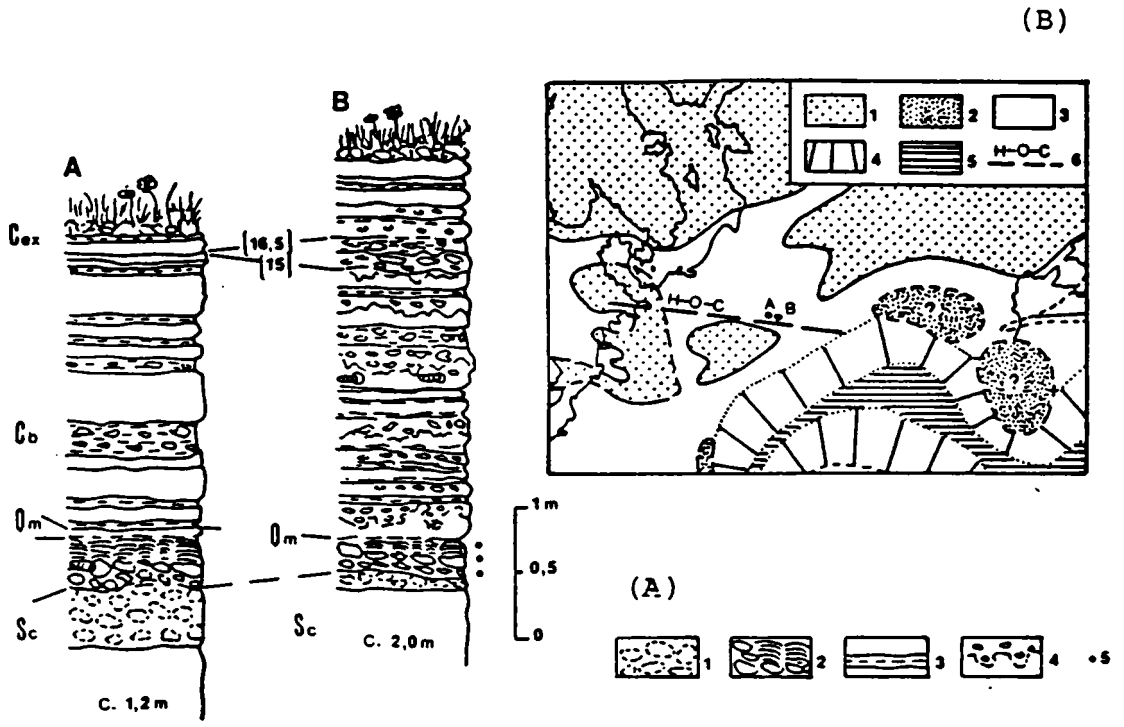

FIGURE 1

Figl Upper Callovian- Lower Oxfordian sections in the vicinities of Klobuck (k) and Czestochowa-Wrzosowa (W) (after 5-6 and others) and their location at the background of paleogeographic map for the Early and Middle Oxfordian (after J.Thierry and N. Charpy. 1982).

A;1- knobby limestones, 2- nodular layer with stromatolite at the top, 3- marls, 4- limestones with corrosional pockets infilled with material with intraclasts and traces of corrosions, 5- recorded high concentrations of cosmic Lust;, Qm-Q. mariae, Cb-C. bukowskii, Cex-C. excavatum.

B-1 - land areas, 2- epicontinental seas, temporarily emerged areas,3-epicontinental seas, 4- continental margin,5 areas with oceanic crust,6- Hamburg-(Berlin) -Odra-Cracow.

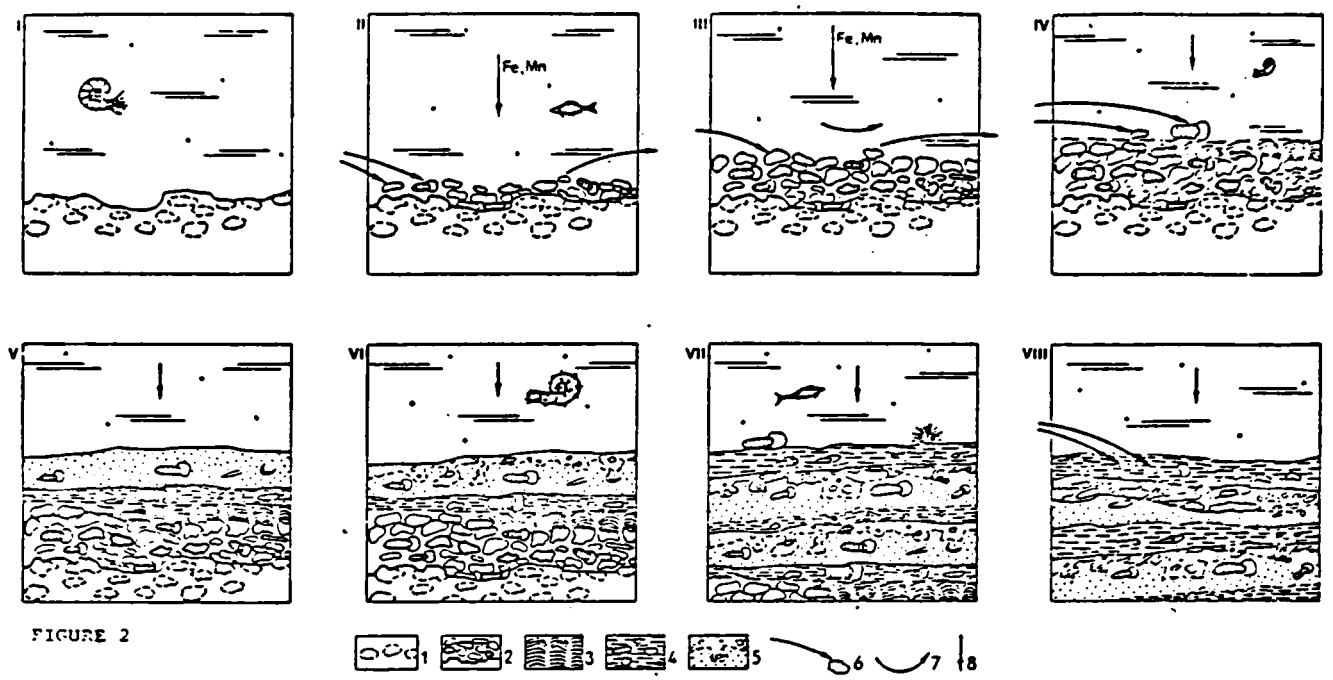

FIGURE 2

Fig. 2. Reconstruction of history of sedimentation of the Upper Callovian and lower parts of Oxfordian in the vicinities of KŹobuck and Czestochowa

1- Knobby limestones, 2- nodular layer(thick line 0 Fe-Mn coatings), 3-- stromatolites, 4- marls with litho -and bioclasts, 5- Limestones With corrosional pockets, 6- redeposition of material, 7- washing by high- energy water,8- precipitation of compounds of Fe, Mn. and other metals. I- scou-- ring and corrosion of Knobby limestones, II-III- stages in formation of - nodular layer, IV - redeposition of Callovian material after origin of stromatolite and overlaying green- black clay layer,-V- origin of basal limestone Layer, VI- scouring and corrosion of the layer (V), followed by infilling of pockets, VII-VIII- origin of successive limestone layers, accompanied by repeatance of the processes (VI) and of successive marly Layers.

BIOSTRATIGRAPHIC SUBDIVISION OF THE CALLOVIAN STAGE IN THE SUBTETHYAN PROVINCE OF AMMONITES, CORRELATIONS WITH THE SUBBOREAL ZONAL SCHEME

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BIOSTRATIGRAPHIC SUBDIVISION OF THE CALLOVIAN STAGE IN THE SUBTETHYAN PROVINCE OF AMMONITES, CORRELATIONS WITH THE SUB-BOREAL ZONAL SCHEME

E. Cariou

ABSTRACT. - A biostratigraphic scale of high resolution, founded on the Tethyan families, is defined in the Subtethyan province and correlatedwith the Subboreal zonal scheme. It has been established in the Center-West of France where the Callovian deposits are relatively complete and continuous, but for the uppermost part of the stage. Twenty three horizons of ammonites are individualized. Many biostratigraphical units present a large extent inside the Subtethyan province and some of them also in the west Tethyan realm. Further, a parallel zonal scheme based essentially on the evolution of the Tethyan Reineckeiidae can be proposed.

The Callovian series of Center-West of France figures in Europe among the more continuous and more rich in ammonites. These faunas concern both sub-Mediterranean and Mediterranean provinces. Their biostratigraphic study has permited establishment of a very detailed horizon scale of the Callovian stage (Tabl. 1). The elementary biostratigraphic unit is the horizon, defined by an association of caracteristic species. This is regionally indivisible and its geographic extension proved at least at the level of the region, that is to say over a distance of the order of 300 km (CALLOMON, 1964). 23 horizons are distinguished. Their caracteristics and also their composition are briefly reported. We can find greater details of the successive associations and of the reference sections in the early works (CARIOU, 1969, 1974, 1980).

A. THE SCALE OF CALLOVIAN HORIZONS OF THE CENTER-WEST OF FRANCE

In the successive associations, some species are more caracteristic because of their frequency or their strict localization in a horizon. They are distinguished by an asterisk. The Boreal forms are rare or absent in several levels.

I. Bullatus horizon (OPPEL, 1857 ; emend CARIOU, 1974)

**Bullatimorphites (Kheraiceras) bullatus* (D'ORB.) is very abundant, but we found also *Macrocephalites macrocephalus* ZITTEL, **M. subtrapezinus* (WAAG.), *Kamptokephalites rotondus* (QU.), **K. grantanus* (OPP.), **K. elephantinus* CORROY

English scale : Subboreal province (after J.H. CALLOMON and R.M. SYKES, 1964-1980)			Zonation of the Center-West of France : Subtethyan province			
SUBSTAGES	ZONES	Subzones	Horizons		Subzones	ZONES
UPPER	LAMBERTI	Lamberti	lacuna			LAMBERTI
		Henrici	Athletoides	XX	Poculum	
			Subtense	XIX		
			Nodulosum	XVIII		
	ATHLETA	Spinosum	Collotiformis	XVII	Collotiformis	ATHLETA
			Piveteaui	XVI		
		Proniae	trezeense	XV	Trezeense	
MIDDLE	CORONATUM	Phaeinum	Rota	XVI	Rota	CORONATUM
		Grossouvrei	Waageni	XIIIb	Leuthardti	
			Leuthardti	XIIIa		
		Obductum	Baylei	XII	Baylei	
			Villanyensis	XI		
	JASON	Jason	Richei	Xb	Tyranniformis	ANCEPS
			Blyensis	Xa		
		Medea	Turgidum	IX	Stuebeli	
			Bannense	VIII		
LOWER	CALLOVIENSE	Enodatum	Kiliani	VIIb	Patina	GRACILIS
			Boginense	VIIa		
		Calloviense	Michalskii	VI	Michalskii	
			Laugieri	V	Laugieri	
		Koenigi	Pictava	IV	Pictava	
			Rehmanni	III	Rehmanni	
	MACROCEPHALUS	Kamptus	Prahecquense	II	Prahecquense	MACROCEPHALUS
		Macrocephalus	Bullatus	I	Bullatus	

Tab. 1 - Zonation of the Callovian Stage in the Center-West of France and its correlation with the Subboreal scale.

non J.C. SOW., *"M." *sauvageti* PETITC., **Homeoplanulites subbackeriae* (D'ORB.).
Reference section : quarry of Pamproux (Deux-Sèvres), bed 1.

II. Prahecquense horizon (CARIOU, 1974)

Bullatimorphites (K.) *bullatus* (D'ORB.) has disappeared. The horizon is characterised by the abundance of large *Homeoplanulites*.

**Bomburites prahecquense* (PETITC.), **Bullatimorphites* (K.) *quenstedti* (ROEM.), *Macrocephalites macrocephalus* ZITT. and SCHL., *Kamptokephalites* aff. *kheraensis* SPATH, *K. chrysoolithicus* (WAAG.), **K. cossmanni* (PETITC.), *K.* aff. *dimerus* (WAAG.), **Homeoplanulites furcula* (NEUM.), *H. funatus* (OPP.).
Reference section : Pamproux, beds 2 to 6a.

III. Rehmanni horizon (= Petitclerci horizon, CARIOU, 1974, 1980)

The first Reineckeiinae make their apparence in large number and also the genus *Proplanulites*.

**Rehmannia rehmanni* (OPP.), **Rehm. grossouvrei* (PETITC.), **Choffatia (Subgr.) cardoti* (GEMM.), *Proplanulites* aff. *majesticus* BUCKM., *Bullatimorphites* (Kher.) sp., *Macrocephalites macrocephalus* SCHL. and ZITT.

Reference section : Pamproux (Deux-Sèvres), bed 6b.

IV. Pictava horizon (CARIOU, 1974)

Horizon of giant Reineckeiinae ; the subgenus *Chanasia* (*Hecticoceratinae*) originates.

**Reineckeia* (*Tyrannites*) *pictava* (BOURQ.), **R.* (*T.*) *tyranna* (NEUM.), **R.* (*T.*) *convexa* CAR., *Oxycerites subcostarius* (OPP.), *Hecticoceras* (*Chanasia*) *pleurocyma* PAR. et BON., *H.* (*Ch.*) *pseudochanaziense* LEM., *Macrocephalites macrocephalus* ZITT. *non* SCHL.

Reference section : Pamproux, bed 7.

V. Laugieri horizon (CARIOU, 1974)

The first *Indosphinctes* are found and the first *Oecoptychius*.

**Rehmannia laugieri* BOURQ., **Reineckeia* (*T.*) *franconica* (QU.), **Grossouvria sciutoi* (GEMM.), **Indosphinctes subpatina* (PETITC.), *I. caroli* (GEMM.), *Proplanulites trifurcatus* BUCKM., *Macrocephalites compressus* (QU.) and its forme *gracilis* (microconch), **Hecticoceras* (*Ch.*) *barbieri* (PETITC.), *H.* (*Ch.*) *pseudochanaziense* LEM., *H.* (*Ch.*) *paronai* (ZEISS), *H.* (*Jean.*) *malbosi* (ELMI), *Oecoptychius refractus* (REIN.), *Oxycerites subcostarius* (OPP.).

Reference section : Pamproux, bed 8a.

VI. Michalskii horizon (= Ardescicum subzone, ELMI, 1967)

It corresponds to the acme of *Chanasia*. The horizon is a part of the "Ardescicum" subzone (= fauna 8, ELMI, 1967).

**Hecticoceras* (*Ch.*) *michalskii* LEW., **H.* (*Ch.*) *chartroni* PETITC., **H.* (*Ch.*) *navense* ROM., *H.* (*Ch.*) *bonyi* PETITC., *H.* (*Jean.*) *anomalum* (ELMI), *Macrocephalites compressus* (QU.) and its forme *gracilis* (microconch), *Kamptokephalites* cf. *folliformis* (BUCKM.), **Indosphinctes zelleri* (PETITC.), *I. caroli* (GEMM.).

Reference section : Pamproux, beds 8b to 10.

VIIa. Boginense horizon (= horizon of Proximum a, CARIOU, 1980)

It is caracterised by the birth of number of genera or subgenera : *Reineckeia* s. st., *Collotia* (*Reineckeiinae*), *Zietheniceras* and *Hecticoceras* s.st. (*Hecticoceratinae*).

Hecticoceras boginense PETITC., *H. proximum* ELMI, *H.* (Z.) *pseudolunula* (ELMI), *H.* (*Jean.*) *girodi* BON., * *Paralcidia mamertensis* (WAAG.), *Collotia oxyptycha* (NEUM.), *Reineckeia turgida* CAR., *Rehmannia freii* (JEAN.), *Indosphinctes roberti* (PETITC.), *I. choffati* (PAR. et BON.), *Choffatia poisoti* (PETITC.), *Grossouvria chanaziense* MANG.

Reference section : Pamproux, bed 11.

VIIb. Kiliani horizon (= horizon of Proximum b, CARIOU, 1980)

Indosphinctes and *Choffatia* are very frequent with new species. The subgenus *Lunuloceras* (*Hecticoceratinae*) originates.

Hecticoceras proximum ELMI, *H.* (*Ziet.*) *kiliani* PETITC., *H.* (Z.) *striatulum* (ELMI), *H.* (*Lunuloceras*) sp., *H. (*Ch.*) *hartmanni* ZEISS, *H.* (*Jean.*) *perlatum* ZEISS, *I. *joffrei* (LEM.), *I. *pseudopatina* (PAR. and BON.), *I. rusticus* SPATH, *I. roberti* (PETITC.), *I. *patina* (NEUM.), *Choffatia prorsocostata* (SIEM.), *Ch. leptonata* SPATH, *Grossouvria cheyensis* (PETITC.), *G. revoli* (PETITC.), *Reineckeia spinosa* JEAN., *Collotia pamprouxensis* CAR., C. *oxyptycha* (NEUM.), *Macrocephalites boonei* PETITC., M. *lamellosus* (SOW.), *Kosmoceras* (Z.) *enodatum* (NIK.).

Reference section : Pamproux, beds 12 to 16.

VIII. Bannense horizon (CARIOU, 1974)

Hecticoceras s.st. has disappeared. Hecticoceratinae macroconchs (*Chanasia, Zietheniceras*) of large size are found. Among the *Reineckeiinae*, the subgenus *Loczyceras* is individualized.

Hecticoceras (*Ch.*) *bannense* ELMI, *H.* (*Ch.*) *hartmanni* ZEISS, *H. (Z.) *couffoni* R. DOUV., *H.* (Z.) aff. *alternans* ELMI, *H.* (Z.) *karpinskyi* (TSYT.), *H.* (*Lunuloceras*) sp., *Kamptokephalites tumidus* (REIN.), *Macrocephalites lamellosus* (SOW.), *Indosphinctes drevermanni* (TILL), *Grossouvria steinmanni* (PAR. et BON.), *Reineckeia anceps* (REIN.), *R. stuebeli* STEINM., *Rehmannia* (*Loczyceras*) *segestana* (GEMM.), *Collotia discus* (BOURQ.), *Kosmoceras* (Z.) *medea* (CALL.).

Reference section : Pamproux, beds 17-18.

IX. Turgidum horizon (= Medea horizon, CARIOU, 1980)

The subgenera *Putealiceras, Rossiensiceras, Sublunuloceras* (*Hecticoceratinae*) appear.

Hecticoceras (*Ch.*) *turgidum* LOCZ. succeeds *H.* (*Ch.*) *hartmanni* ZEISS, *H. (Z.) *karpinskyi* TSYT., *H. (Z.) *alternans* ELMI, *H. (*Rossiensiceras*) *loczyi* ZEISS, *H.* (*R.*) *metomphalum*, *H.* (*R.*) *rossiense* TEISS., *H.* (*Putealiceras*) *arkelli* ZEISS, *H.* (*Put.*) *krakoviense rectangulare* TSYT., *H. (*Subl.*) *gerardi* PETITC., *H. (*Lunuloceras*) *calloviensis* ROM. et LEM., *"*Paralcidia" alberti* (R. DOUV.),

Phl. lachati PAR. et BON., *Ch. subbalinensis* (SIEM.), *Indosphinctes* sp., *Rehmannia* (L.) *segestana* (GEMM.), *Rehm. (L.) reissi* STEINM., *Rehm. (L.) britannica* ZEISS, *Reineckeia stuebeli* STEINM., *R. anceps* (REIN.), *Collotia discus* (BOURQ.), *Kamptokephalites tumidus* (REIN.), *Kosmoceras* (Z.) *medea* (CALL.).

Reference section : Pamproux, bancs 19 to 22.

Xa. Blyensis horizon (= horizon of Jason a, CARIOU, 1980)

The Macrocephalitidae disappear. The horizon is marked by the birth of new species.

Hecticoceras (Ch.) aff. *turgidum* LOCZ., *H.* (R.) *pseudocracoviense* TSYT., *H.* (R.) *laubei* (NEUM.), *H.* (R.) *metomphalum* BON., *H.* (L.) *lahuseni* TSYT., *Phlycticeras cristagalli* (D'ORB.), *Phl. pustulatum* (REIN. ; D'ORB.), *Choffatia subbalinensis* (SIEM.), *Indosphinctes* sp., *Grossouvria evoluta* MANG., *Reineckeia anceps* (REIN.), *R. anceps elmii* BOURQ., *R. tyranniformis* SPATH, *Rehmannia* (L.) *blyensis* BOURQ., *R.* (L.) *hungarica* (TILL), *Rehm.* (L.) *greppini* (OPP.), *Rehm.* (L.) *balusseaui* CAR., *Collotia multicostata* (PETITC.), *Kosmoceras* (Z.) *jason* (REIN. ; D'ORB.).

Reference section : quarry of Doux (Deux-Sèvres), bed 3b.

Xb. Richei horizon (= horizon of Jason b, CARIOU, 1980).

The genus *Flabellisphinctes* (*Pseudoperisphinctinae*) is individualized but it is not frequent. The majority of the species of the preceding horizon are found, but in addition of new species.

Rehmannia (L.) *richei* (FLAM.), *Rehm.* (L.) *intermedia* (BOURQ.), *Reineckeia fehlmanni* JEAN., *Flabellisphinctes* sp., *Okaites polonicus* (SIEM.), *Indosphinctes planus* TILL, *Hecticoceras* (Z.) *janus* ZEISS, *H.* (Z.) *sarasini* TSYT., *H.* (*Brightia*) *difforme* TSYT., *Phlycticeras suevicum* (QU.), *Kosmoceras* (Z.) *jason* (REIN. ; D'ORB.).

Reference section : Doux, beds 3b, 4.

XI. Villanyensis horizon (CARIOU, 1974)

The index species has been chosen because of its great frequency but its stratigraphic range is not restricted to the horizon. The genus *Flabellisphinctes* and certain Hecticoceratinae (*Lunuloceras*, *Rossiensiceras*, *Brightia*) are abundantly represented. The genus *Erymnoceras* is found for the first time.

Flabellisphinctes villanyensis (TILL), *F. variabiliferus* (LOCZ.), *Choffatia neumayri* (SIEM.), *Grossouvria kontkiewiczi* (SIEM.), *Reineckeia anceps* (REIN.), *R. anceps elmii* BOURQ., *R. tyranniformis* SPATH, *R. fehlmanni* JEAN., *Rehmannia* (L.) *intermedia* (BOURQ.), *Rehm.* (L.) *corrugis* (BOURQ.), *Collotia gigantea* (BOURQ.), *Hecticoceras* (L.) *prealpinum* ZEISS, *H.* (L.) *sinuicostatum* (ZEISS), *H.* (B.) *leii* TSYT., *H.* (B.) *nodosum* (QU.), *H.* (B.) *tenuinodosum* ZEISS, *H.* (R.) *pseudonodosum* TSYT., *Kosmoceras* (Z.) *obductum* (BUCKM.), *Erymnoceras* s.st.

Reference section : Le Grand-Breuil (Deux-Sèvres), quarry Les Moulins, beds 49 to 68.

XII. Baylei horizon (CARIOU, 1974)

The *Erymnoceras* s.st. becomes abundant and the subgenus *Erymnocerites* is differenciated, but it is rare. The first bituberculate Reineckeiinae (subgenus *Loczyceras*) appear. In addition of the species of preceding horizon are found : *Rein.* cf. *polycosta* KUHN, **R. crassivenia* (BOURQ.), *Rehmannia* (*L.*) *crassicostata* (LOCZ.), *Rehm.* (*L.*) *vesuntiana* (BOURQ.), **Erymnoceras baylei* JEAN. (microconch *in* BAYLE, 1878, pl. 54, fig. 1, holotype; macroconch the evolute form figured by JEANNET, 1951, taf. 36, fig. 3 for example, wrongly attributed to the D'ORBIGNY species), *E. triplicatum* (TILL), *E.* (*Erymn.*) *argoviensis* JEAN., *Flabellisphinctes villanyensis* (TILL), *Okaites calloviensis* (LOCZ.), **Hecticoceras* (*Orb.*) *schloenbachi* TSYT., **H.* (*R.*) *subnodosum* TSYT.

Reference section : Le Grand-Breuil (Deux-Sèvres), Les Moulins, beds 69 to 73.

XIIIa. Leuthardti horizon (= horizon of Waageni a, CARIOU, 1980)

It is caracterised by the frequency of the subgenus *Erymnocerites*. The index species of the Leuthardti subzone (CARIOU, 1974) is localised in this horizon.

**Erymnoceras* (*Erymn.*) *leuthardti* JEAN., **E.* (*Erymn.*) *argoviensis* JEAN., *E. coronatum* (BRUG.;D'ORB.), **Rehmannia* (*L.*) *rudis* (BOURQ.), **Rehm.* (*L.*) *theobaldi* (BOURQ.), *Reineckeia fehlmanni* JEAN., *Grossouvria leptoides* (TILL), *Hecticoceras* (*R.*) *multicostatum* TSYT., etc. .

Reference section : Poitiers (Vienne), quarry of Les Lourdines, beds 7 to 10.

XIIIb. Waageni horizon (CARIOU, 1974 ; = horizon of Waageni b, CARIOU, 1980)

The *Erymnocerites* probably has disappeared ; the genus *Distichoceras* appears.

**Choffatia waageni* (TEISS.) frequent, *Flabellisphinctes* aff. *villanyensis* (TILL), *Collotia spathi* (BOURQ.), **Hecticoceras* (*Z.*) *angulatum* TSYT., **H.* (*Z.*) *bituberculatum* TSYT., *H.* (*Put.*) *subrossiense* TSYT., *Distichoceras* sp., *Erymnoceras coronatum* (BRUG.;D'ORB.) succeeds *E. baylei* JEAN. The index species of the Coronatum zone is distinguished by more involute coiling and a section which is very depressed until close of the growth.

Reference section : Poitiers (Vienne). Les Lourdines, beds 12 to 16.

XIV. Rota horizon (CARIOU, 1974)

The *Distichoceras* become numerous associated with new genera and subgenera (*Rollieria, Pseudopeltoceras, Orionoides*). The bituberculation appears at the same time in the *Reineckeia* and *Collotia* (*Reineckeiinae*). The genus *Erymnoceras* continues.

Rehmannia (L.) rota (BOURQ.), *Rehm. (L.) jeanneti* (ZEISS), *Reineckeia* nov. sp. with two rows of tubercules , *Collotia gaillardi* (ROM.), *Pseudopeltoceras* aff. *chauvinianum* (D'ORB.), *Orionoides* sp., *Distichoceras zeissi* THEOB., *D. pasdejeuensis* (GER.and CONT.), *Paralcidia (Rollieria)* aff. *greii* (JEAN.), *Hecticoceras (L.) michailowense* ZEISS, *H. (Subl.) gigas* (QU.), *H. (R.) regulare* TILL, *Kosmoceras* cf. *fibuliferum* (BUCKM.), *K. (Z.)* cf. *zugium interpositum* (BUCKM.), *Erymnoceras* sp. juv.

Reference section : quarrry of Pas-de-Jeu (Deux-Sèvres), bed 4.

XV. Trezeense horizon (CARIOU, 1969)

It corresponds to an important renewal of ammonite faunas. There are found new genera and subgenera : *Peltoceras, Hamulisphinctes, Taramelliceras* s.st. The abundance of *Pseudopeltoceras* and large *Hecticoceratinae (Sublunuloceras, Orbignyiceras, Putealiceras)* is notable. *Erymnoceras* has disappeared.

Hecticoceras (O.) trezeense (GER.and CONT.), *H. (Subl.)* aff. *dynastes* (WAAG.), *H. (R.) uhligi* TILL, *H. (Put.) trilineatum* (WAAG.), *Taramelliceras taurimontanus* ERNI, *Distichoceras bicostatum* (STAHL). *Horioceras baugieri* (D'ORB.), *Orionoides termieri* GER. and CONT., *O. monestieri* GER. and CONT., *Hamulisphinctes hamulatus* BUCKM., *Binatisphinctes giganteus* GER. and CONT., *Pseudopeltoceras famulum* (BEAN.), *Peltoceras athleta* (PHILL.), "*Collotia nivernensis* BOURQ., *Rehm. (L.) horrida* CAR.

Reference section : Pas-de-Jeu (Deux-Sèvres), beds 5-6.

XVI. Piveteaui horizon (CARIOU, 1974)

Among the new forms appearing, some are localised in this horizon.

Orionoides piveteaui GER. and CONT., *O. lanquinei* GER. and CONT., *Peltoceras regularis* GER. and CONT., *Collotia odysseus* (MAY.), *Paralcidia (Rollier.) pattei* (GER. and CONT.), *Kosmoceras (Z.)* cf. *kuklikum* (BUCKM.).

Reference section : Montreuil-Bellay (Maine-et-Loire), beds 5 and lower part of 6.

XVII. Collotiformis horizon (BOUQUIN and CONTINI, 1968 ; CARIOU, 1969)

It corresponds to the maximum frequency of the bituberculate Reineckeiinae.

* *Collotia collotiformis* (JEAN.), *C. falloti* (GER. and CONT.), *C. fraasi* (OPP.), *C. oxyptychoides* (SPATH), *Orionoides raguini* GER. and CONT., *O. cayeuxi* GER. and CONT., *Peltoceras retrospinatum* GER. and CONT., *Hecticoceras (P.) intermedium* (SPATH), *H. (O.) hirtzi* (COLL.), *H. (Subl.) dynastes* (WAAG.), *H. (S.) nodosulcatum* LAH., *Kosmoceras geminatum* (BUCKM.), *K.* aff. *spoliatum* (QU.).

Reference section : Montreuil-Bellay (M. et L.), bed 6 (upper part).

XVIII. Nodulosum horizon (CARIOU, 1974)

It is marked by several new genera or subgenera : *Pseudobrightia* (Hecticoceratinae), *Mirosphinctes*, *Properisphinctes* (Perisphinctidae), *Euaspidoceras* (Aspidoceratidae). The Reineckeiidae are less frequent.

**Distichoceras nodulosum* (QU.), *D. bicostatum* (STAHL), *Hecticoceras* (*O.*) *frederici* ZEISS, **H.* (*R.*) aff. *daghestianum* (NEUM.), *H.* (*? Neocampylites*) *secula* (SPATH), *Paralcidia* (*Roll.*) *couffoni* GER. and CONT., *Taramelliceras globulus* (QU.), **Orionoides anguinus* SPATH, *Mirosphinctes* sp., *Properisphinctes* aff. *latilinguatus* (NOET.), *Euaspidoceras ferrugineum* JEAN., *Collotia* sp. juv., *Kosmoceras compressum* (QU.), *K. tidmoorense* ARK., etc...

Reference section : Pointe du Grouin du Cou (Vendée), beds 51 to 70.

XIX. Subtense horizon (CARIOU, 1980)

In Poitou the appearance of the subgenus *Poculisphinctes* coincideswith the arrival of the first boreal *Quenstedtoceras*. Aspidoceratinae and large *Pseudobrightia* (Hecticoceratinae) are numerous.

**Peltoceras subtense* (BEAN.), **Euaspidoceras hirsutum* (BAYLE), *E.* cf. *ferrugineum* JEAN., *Properisphinctes latilinguatus* (NOET.), **Orionoides poculum* (LECK.), *Hecticoceras* (*Pseud.*) *subpunctatus* (SPATH), **H.* (*Put.*) *thirriai* PETITC., *Distichoceras freii* (JEAN.), *Q. henrici* DOUV., etc...

Reference section : Montreuil-Bellay (M. et L.), bed 8.

XX. Athletoides horizon (CARIOU, 1980)

The subgenus *Putealiceras* (Hecticoceratinae) is abundant ; some species are new. The Pachyceratinae are not rare. The horizon is also caracterised by less known large Perisphinctidae of a strong oxfordian affinity.

**Peltoceras athletoides* LAM., **Euaspidoceras ferrugineum* JEAN., **Hecticoceras* (*Put.*) *douvillei* (JEAN.), *H.* (*P.*) *puteale* (LECK.), *H.* (*P.*) *mathayense* KIL., *H.* (*Subl.*) *inerme* (R. DOUV .), **Pachyceras lalandeanum* (D'ORB.), *Orionoides* (*Poc.*) *poculum* (LECK.), *Quenstedtoceras praelamberti* (R. DOUV.), *Perisphinctidae* as *Properisphinctes*, *Kosmoceras tidmoorense* ARK.

The Callovian of Poitou is incomplete at the top. The break seems to correspond the deposit of beds H3-H5a of Marnes de Dives, in Normandy (DOUVILLE, 1912).

B. ZONATION TABLE OF SUBTETHYAN CALLOVIAN

The value of this scale of horizons transcends beyond the regional level, because of the very wide distribution of the ammonite species within the west Tethyan realm. In fact, it has already been proved that number of horizons defined in the Center-West of France have wide geographic extension (CARIOU, 1980). This is the reason why these are raised to the status of subzone (Tab. 1). By

SUBSTAGES	Subboreal province		Subtethyan province and tethyan province *pro parte*	
	ZONES	Subzones	Subzones	ZONES
UPPER	LAMBERTI	Lamberti	?	LAMBERTI
		Henrici	Angustilobata	
	ATHLETA	Spinosum	Collotiformis	ATHLETA
			Odyseus	
		Proniae	Nivernensis	
MIDDLE	CORONATUM	Phaeinum	Gaillardi	CORONATUM
		Grossouvrei	Spathi	
		Obductum	Gigantea	
	JASON	Jason	Multicostata	ANCEPS
		Medea	Discus	
LOWER	CALLOVIENSE	Enodatum	Pamprouxensis	GRACILIS
			Oxyptycha	
		Calloviense	Laugieri	
		Koenigi	Pictava	
			Rehmanni	
	MACROCEPHALUS	Kamptus	Prahecquense	MACROCEPHALUS
		Macrocephalus	Bullatus	

Tab. 2 - Parallelism between the Subboreal scale of *Kosmoceratidae* and a parallel subtethyan scale found essentially on the evolution of the tethyan family *Reineckeiidae*.

the way, I must specify that since 1980, I have noted the large extension of the horizons of Rehmanni and Pictava up to Portugal.

The subzones are regrouped in zones in the zonation table which can be applied not only to the Subtethyan province but also in part to the large west Tethyan realm. The utilisation of the very classic Anceps zone as exact Tethyan equivalent of the Subboreal Jason zone seems necessary since *Reineckeia anceps* (REIN.) has been redefined (CARIOU, 1980). This zone must be accepted in a sense more restricted than originally defined by OPPEL (1857), because the range of this common species of wide distribution in the Tethyan realm. It seems possible to propose subdivision of the Anceps zone into Stuebeli subzone and Tyranniformis subzone, equivalent to the Boreal Medea subzone and Jason subzone. Further, in the absence of Boreal *Quenstedtoceras* in the Tethys and the different composition of ammonite faunas for comparison, it is desired to replace in the future the index *Quenstedtoceras lamberti* (SOW.) by a Tethyan form.

CORRELATION WITH THE SUBBOREAL SCHEME

The important probleme of correlation persists at the base of the Callovian, because of the very marked differenciation in ammonite faunas of Subtethyan and

Subboreal provinces. At the beginning of the top of Lower Callovian on the contrary, the stratigraphic correlation between the two provinces becomesmore easy because of the southward extension of Subboreal Kosmoceratidae.

A PARALLEL ZONAL SCHEME BASED ON THE EVOLUTION OF THE TETHYAN REINECKEIIDAE

The Subboreal zonal scheme, excepting at the base and the top of the stage, is found on the evolution of a single ammonite family Kosmoceratidae. In a major part, it is a homochronologic scale. The recent revision of the Reineckeiinae (CARIOU, 1980) shows that it is possible to present a parallel Subtethyan scheme, based essentially on the evolution of this subfamily (Tab. 2) and more particulary on the development of the genus *Collotia* appearing at the top of the Lower Callovian. At the beginning of this level, the correspondance with the Subboreal scheme is more easy and it is remarkable to note that the precision in dividing the Callovian is comparable with either of the family. This parallel zonation brings to light the chronostratigraphic value of Reineckeiinae. Because of the frequency and the wide distribution of the species, this ammonite subfamily shall permit good stratigraphic correlation within the large Tethyan realm. However, in spite of the great interest, this parallel scale may not supersede the zonation defined by the successive species associations. This type of scale presents in fact two advantages from comparison with a homochronologic scale : it is sometimes more precise ; the biostratigraphic units are more helpful for identification because of great number of taxa which these are composed of.

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Acknowledgments: The author is thankful to Dr. Jai Krishna, Banaras Hindu University (Varanasi), for the English translation of this paper.

PROPOSALS TO THE DEFINITION OF THE BASE OF THE UPPER BAJOCIAN

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PROPOSALS TO THE DEFINITION OF THE BASE OF THE UPPER BAJOCIAN

Gerd Dietl & Giulio Pavia

Basing on CALLOMON's (1965) explanations favouring a clear typological definition of a stratigraphical unit, it shall be tried to reduce the still existing correlation problems by a definition of the lower boundary stratotype of the Upper Bajocian.

Before you will do such a step you have to pay attention to the following aspects: 1. A defined limit should not cut up a homogeneous bio-horizon; 2. If possible the new defined limit should not be too far away from the till now used limits; 3. Another precondition is of course that the knowledge of the new introduced stratigraphical unit is actual and extensive; 4. Furthermore we need many good informations from many different countries to choose the best section for definition of a stratigraphical unit. Only by taking care of these aspects there is a chance that the new proposal will be accepted by the majority of the colleagues.

All these points are given for our new proposals about the lower limit of the Upper Bajocian. Our proposal is that the Upper Bajocian and also the niortense Zone (= subfurcatum Zone see DIETL 1981) should begin with the bench no. 281 in the section of Chaudon, Alpes-Haute-Provence/SE-France (PAVIA 1973: tab. 2; 1983: 244 and fig. 1 in this paper). The ammonite fauna occurring in that bench no. 281 is marked by the first occurrance of Caumontisphinctes (C.) diniensis PAVIA and consequently it shall be named as diniensis Horizon. The type-bench of this bio-horizon has delivered until now the following ammonite association:

C. (C.) diniensis, ?Caumontisphinctes garnieri, C. (Infraparkinsonia) sp., Teloceras coronatum, Teloceras "blagdeni", Teloceras sp., Normannites orbignyi, Leptosphinctes sp., Cadomites lissajoui, Oecotraustes genicularis, Oppelia flexa, Strigoceras pseudostrigifer, Lytoceras and Phylloceras.

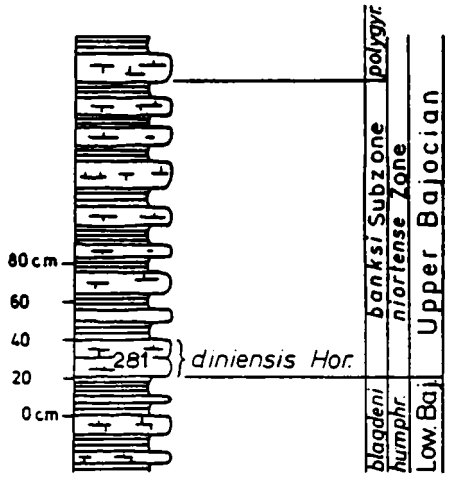

Fig.1. Section of Chaudon, near Digne, Alpes-Haute-Provence/ SE-France, showing the bench no. 281 with the diniensis Horizon with which begins the niortense Zone (= subfurcatum Zone) and therefore the Upper Bajocian (partly taken from PAVIA 1973).

Comparisons with other areas show that a similar or nearly identical faunal association occurs e.g. in SW-Germany (DIETL & HUGGER 1979; DIETL 1980) what makes the chronostratigraphical correlation with the section of Chaudon possible. It is remarkable that we can find the diniensis Horizon (fig. 2) here in a very different facies (ferrugineous oolitic limestone) in contrast to the facies of Chaudon where dark limestones and marls are dominating. Very typical for the diniensis Horizon is the ammonite association of Caumontisphinctes (C.) diniensis together with ?Caumontisphinctes garnieri and Teloceras coronatum which occur in SW-Germany too (see fig. 3). In the section of Oborne/S-England, described by PARSONS (1976), ?Caumontisphinctes garnieri and Teloceras coronatum are not mentioned.

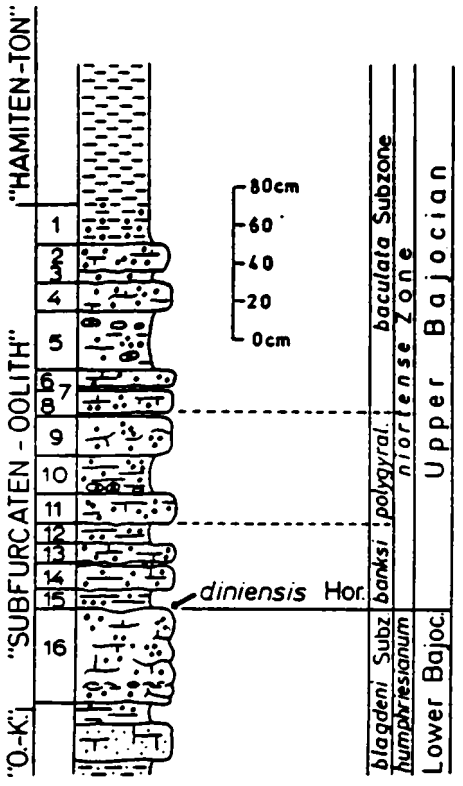

Fig.2. Section of the "Subfurcaten-Oolith" from Bisingen-Zimmern, SW-Germany, showing that the diniensis Horizon is restricted to the surface of the bench no. 16. Abbreviation: "O.-K." = "OSTREEN-KALK".

Therefore the correlation is less sure there. But PARSONS (1976) described from S-England that there Caumontisphinctes (C.) diniensis and Teloceras banksi occur together in the same layer. In SW-Germany Teloceras banksi occurs a little bit later in a layer above the diniensis Horizon (see DIETL & HUGGER 1980). In the section of Chaudon/SE-France, Teloceras banksi, the index-fossil of the basal subzone of the niortense Zone, the banksi Subzone, hasn't been found until now. After this short demonstration the diniensis Horizon may be hence accepted

to characterize the base of the banksi Subzone and therefore the base of the Upper Bajocian.

			Chaudon near Digne/Basses Alpes, SE-France: PAVIA (1973; 1983)	Bisingen-Zimmern/Swabian Alb, SW-Germany: DIETL & HUGGER (1979), DIETL (1980)	Oborne, S-England: PARSONS (1976)
UPPER BAJOCIAN	niortense (subfurcatum) Zone	banksi Subzone	bench no. 281 = type bench of the diniensis Horizon: Caumontisphinctes (C.) diniensis, ?Caumontisphinctes garnieri, C. (Infraparkinsonia) sp., Cadomites lissajoui, Leptosphinctes sp., Oecotraustes genicularis, Oppelia flexa, Strigoceras pseudostrigifer, Teloceras coronatum, Teloceras "blagdeni", Teloceras sp., Lytoceras and Phylloceras	surface of bench no. 16 = diniensis Horizon: Caumontisphinctes (C.) diniensis, ?Caumontisphinctes garnieri, C. (Infraparkinsonia) sp., Leptosphinctes sp., Normannites sp., Teloceras coronatum, Teloceras sp.	bed no. 5b = ?diniensis Horizon: Caumontisphinctes (C.) diniensis, Caumontisphinctes (C.) aplous, C. (Infraparkinsonia) phaulus, Leptosphinctes davidsoni, Chondroceras tenue, Cadomites (C.) cf. humphriesiformis, Teloceras banksi, Teloceras cf. blagdeni
LOWER BAJOCIAN	humphriesianum	blagdeni			

Fig.3. Table showing the correlation at the base of the diniensis Horizon, basal niortense Zone, between SE-France, SW-Germany and S-England.

Beside the definition of the base of the Upper Bajocian it is also necessary to discuss the subdivision of the complete Bajocian. Our proposal here is that the often used Middle Bajocian mainly only including the humphriesianum Zone should not be used any longer. We propose to divide the Bajocian in only two parts. The Lower Bajocian with the discites, laeviuscula, sauzei and humphriesianum Zone and the Upper Bajocian including the niortense (= subfurcatum), garantiana and parkinsoni Zone. The majority of the colleagues is already using this subdivision of only two parts and we hope that the other colleagues too will use it in this way in the future.

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THE DOGGER - MALM BOUNDARY IN WESTERN EUROPE

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THE DOGGER - MALM BOUNDARY IN WESTERN EUROPE

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Abstract : The areas with thick Lower Oxfordian deposits (Mariae zone) are well limited in Western Europe. This is the result of an old structural framework - strongly reactived just after the Paucicostatum horizon - which control the sedimentation. The influence of this «tectonic crisis» on the ammonite faunas is demonstrated.

Introduction –

In Western Europe the deposits of Lower Oxfordian age seem to be scattered at random. Therefore, in the recent paleogeographical reconstructions, this period has been either neglected or included in the deposits of Middle Oxfordian age. The aim of this research is to show that the distribution and nature of the sediments were controled by a structural framework, of a tectonical origin, which plays strongly at the Dogger - Malm boundary.

I – The sedimentary changes at the Dogger - Malm boundary in Western Europe

1 — Elements of datation

It is my opinion (D. Marchand, 1979) that the Paucicostatum horizon is-by definition - the first Lower Oxfordian horizon. It is to be distinguished from the underlying Lamberti horizon (D. Marchand, in press) by :
- the presence of *Cardioceras paucicostatum* Lange
- the lack of Kosmoceratinae
- the apparition of the first true *Peltoceratoïdes* s.l. with double latero-ventral tubercules.

There above, I perceive the Scarburgense horizon (D. Marchand, in press) characterized by :
- the presence of *Cardioceras scarburgense* (Y et B)
- the presence, sometimes in abundance, of Taramelliceratinae and Lissoceratidae, two tethysian groups which are seldom or lacking in the underlying horizons.

2 — Isochrony of sedimentary changes

In numerous areas of Western Europe the Dogger - Malm boundary is characterized by an abrupt change in the nature of the sediments. They may be 3 cases.

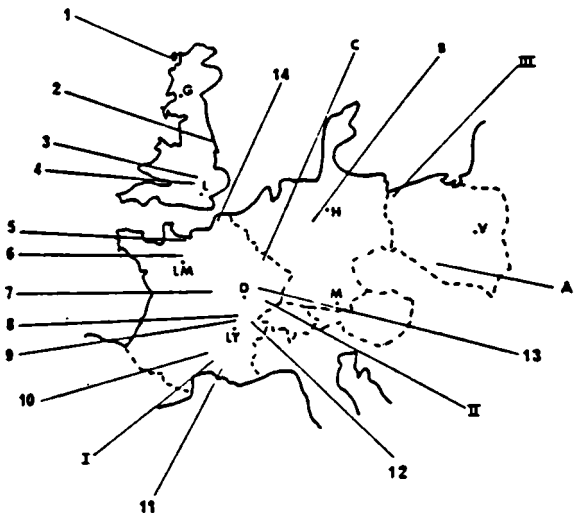


Fig. 1 –
1 - Staffin Bay, île of Skye ; 2 - Osgodby Nab , Yorkshire ; 3 - Woodham, Buckinghamshire ; 4 - Milbrook section, Bedfordshire ; 5 - Villers-sur-Mer,Normandy ; 6 - Mamers, Sarthe ; 7 - Chateauneuf-sur-Cher, Cher ; 8- Tournus, Saône-et-Loire ; 9 - Macon, Saône-et-Loire ; 10 - Meyrueis, Lozère ; 11 - Aix-en-Provence, Bouches du Rhône ; 12 - Arvières, Ain ; 13 - Blancheville, Haute-Marne ; 14 - Boulonnais.
A - Chrzanow-Wodna (Boreholes) ; B -Schleptruper Egge, Wiehengebirge ; C - Ardennes ; I - Viols-le-Fort, Hérault ; II - Liesberg, Jura Balois ; III - Pomeranie (boreholes) ;D - Dijon ; G - Glasgow ; H - Hannovre ; LM - Le Mans ; LY - Lyon ; M - Munich ; V - Varsovie.
(I've visited most of the sections and studied all the ammonite faunas with the help of M. M. Arnaud,R. Ardaens, A. Buisson, JH. Callomon, S. Debrand-Passard, R. Enay, R.A. Gygi, G. Lablanche, W. Lange, B. Laurin, A. Lebert, J.M. Magniez, L. Malinowska, T. Pelissié, B. Peybernes, M. Rioult, J. Thierry, J. Turner, JK. Wright).

1st exemple (fig. 2, n° 7). In the neighbourhood of Chateauneuf-sur-Cher (Cher, France) the Upper Callovian (Lamberti z., Lamberti s.z.) is present through alternated layers of marls and marly limestones where *Quenstedtoceras lamberti* (Sow.) and *Kosmoceras spinosum* (Sow.) can be found. In the uppermost 2 meters of this serie, the Kosmoceratinae are lacking and *Cardioceras paucicostatum* Lange can be found in abundance. Above them, suddenly, appear marls with pyritic fossils (marnes à Creniceras renggeri) which display *Cardioceras scarburgense* (Y and B) a species, which is under certain variants, already known as part of the *Cardioceras paucicostatum* Lange species. This is evidence that the change in sedimentation was instantaneous from a geological point of view. The same phenomenon occur also in areas where the marls with pyritic fossils develop above a marly limestones formation.

2nd exemple (fig. 2, n° 2). In the neighbourhood of Scarborough (Yorkshire), J.K. Wright showed (1968, 1978) that the Upper Callovian (Lamberti z., Lamberti s.z.) is always characterized by limestones (less than 1 m) full of ferruginous oolites (Hackness Rock). Above, there may exist (J.K. Wright, 1978) a thin layer of marls with ferruginous oolites which has produces *C. paucicostatum* Lange. All this formation is topped with thick marls which include at the bottom *C. scarburgense* (Y and B) and scarce Taramelliceratinae. The same abrupt change in the nature of sediments (marls lying on ferruginous oolites limestones or micritic ferruginous limestones) can be found in others areas.

3rd exemple (fig. 2, n° 11). Vauvenargues (eastern Aix-en-Provence) The Upper Callovian is characterized by marls with pyritic fossils whose top includes *Quenstedtoceras lamberti* (Sow.) and *Kosmoceras* cf. *spinosum* (Sow.). This formation is topped with more carbonated deposits (2 - 3 m) which includes 2 thin layers (0,30 m thick) of grey marly limestones full of *Cardioceras paucicostatum* Lange and Hecticoceratinae; Kosmoceratinae are missing. There above came a thick formation (marls with pyritic fossils) whose basis is related to the Scarburgense horizon. This succession of facies is known in others areas.

3 — Sedimentation again : an isochronic phenomenon

In several areas in Western Europe (fig. 2), one notice that the Callovian carbonated deposits stop at the basis of the Upper Callovian (Athleta z., Trezeense s.z.). They are topped with marls, with or without pyritic fossils, which start in the Scarburgense horizon either directly or through a thin layer of marls with ferruginous oolites dating back to the Paucicostatum horizon.

4 — Sedimentation break : an isochronic phenomena

In the areas where the Upper Callovian exists, but where the Lower Oxfordian (Mariae z.) is lacking, or poorly preserved, one notice that the sedimentation stops at the same time in the whole of the Western Europe. So in Burgundy, the Mariae zone, when it exists, is represented by thin limestones with ferruginous oolites (0,10 m), always lenticular, which include a fauna from the Scarburgense horizon. Likewise in Poland (Holy Cross Mountains), the deposits of Mariae age, always very thin, can be chiefly related to the Scarburgense s.z. Eastern Bâle (Argovie), the sedimentation stops with the Scarburgense horizon and starts again with the Cordatum s.z. In the eastern part of the French Jura, as in the Causses (D. Marchand and al 1983) or Provence (D. Marchand 1984, in press), the sedimentation abruptly stops above the Paucicostatum horizon. In areas with no sediments of Mariae age, the sedimentation either stops at the top of Middle Callovian or during the Upper Callovian.

II – Structuration and sedimentation

In the Lower Oxfordian we notice that the areas where the Mariae zone exists can be divided in two main groups. In the first one, the sedimentation is important (deposits over 10 m thick) whereas in the second one it is limited or lacking (deposits under 1 m thick). Those two main groups, very well individualized during the Scarburgense horizon, are not so clear before. The isochrony of this phenomenon on such a wide area as Western Europe implies a major cause which can only have, in my opinion, a tectonical origin. What can support this hypothesis ?

b - The Delphino - Helvetique basin

In the northern part of this basin (fig. 3), there is an area - which begin to be distinct during the Upper Callovian - («gouttière Burgonde» , D. Contini 1969) where the Lower Oxfordian is about 20 m thick (marls and marly limestones). On both sides, the deposits are scarce, thin and more often lacking.

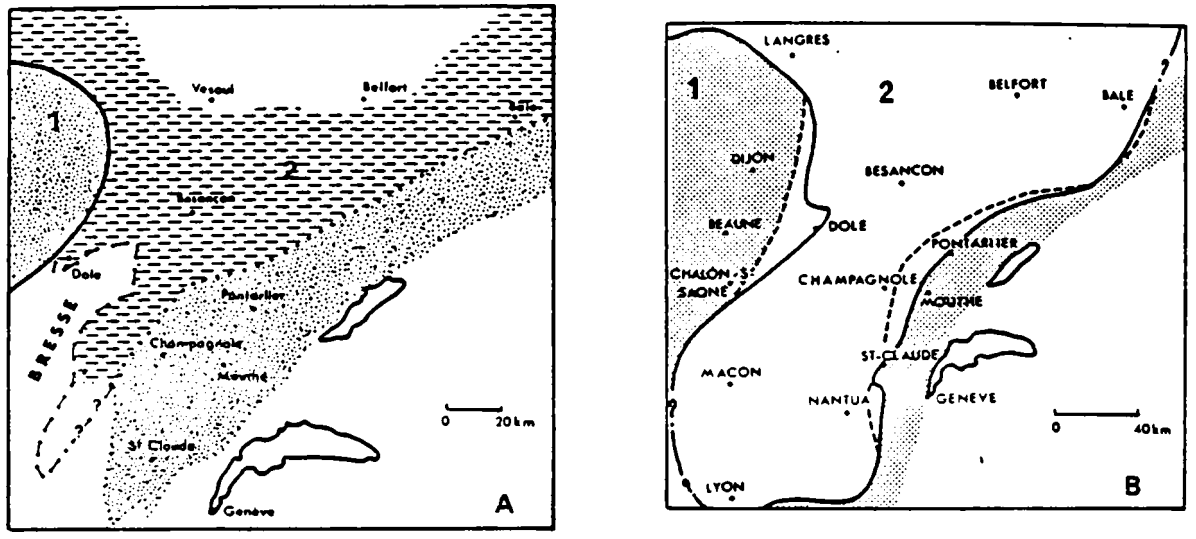


Fig. 3 — Septentrional Jura (adaptated from D. Contini 1969)

A - Upper Callovian : 1 - Gap, thin marly limestones with ferruginous oolites or micritic ferruginous limestones ; 2 - Marly limestones.
B - Lower Oxfordian : 1 - Gap or thin and lenticular deposits (limestones with ferruginous oolites common) ; 2 - Marls with pyritic fossils (Renggeri marls).
—— Renggeri marls limit (Mariae zone), – – – – «Couches à spherites» limit (Cordatum zone).

In the southern part of this basin we notice that the complex set of faults, which limite to the west the «sillon Rhodanien», has played a very important part at the Dogger - Malm boundary. In the west side one notice Middle Oxfordian deposits lying on Middle Callovian sediments. In the east side the sedimentation is continue.

These two examples (but other are known) show that during the Mariae zone the meeting points between the areas with deposits on the one hand and these without or scarce sediments on the other hand are always abrupt. These contact lines known everywhere in Western Europe at the some moment are always closely related with major faults.

2 — Synsedimentary movements

The exemples I've just given are supporting the thesis of a connection between an old structuration and sedimentation. Other examples show, quite definitively in my opinion, that there was synsedimentary movements at the Dogger - Malm boundary.

a - Yorkshire (fig. 4)

In 1978, J.K. Wright gave a synthetical section of the deposits from the Middle Callovian till the Lower Oxfordian. On this section one can observe that at Roulston Scar (but in reality along a N 120 structure) the deposits of Bukowskii s.z. age (Cordatum z.) are lying on the Middle Callovian. Immediately east of this structure, the deposits are thick and the sedimentation continuous at the Dogger - Malm boundary since the Paucicostatum horizon is there, in several places. Moreover, the thickness of the marls (which start during the Scarburgense horizon), is increasing from east to west to reach a maximum close to this N 120 structure. Of course this suggests a synsedimentary movement (listric fault ? or graben) all the more so as this phenomenon can be found again southwest of the gap area. This interpretation is strengthened by the proximity of the Market Weighton Axis, whose influence on the Jurassic sedimentation is undisputed (B. Ziegler, 1980).

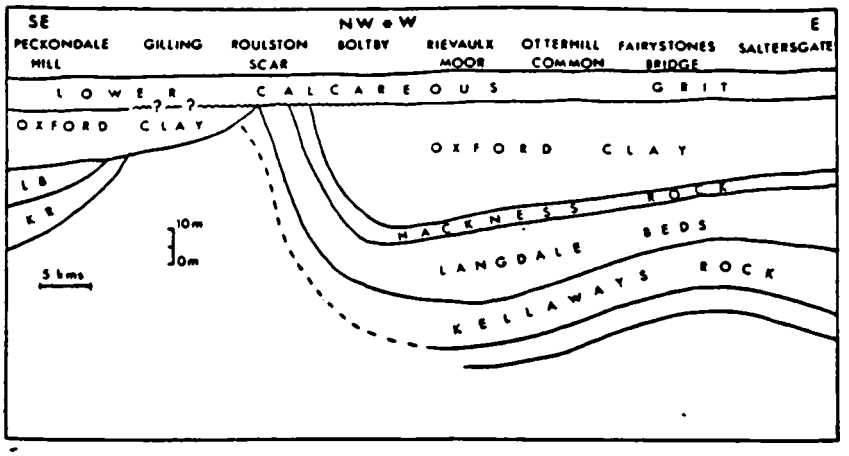


Fig. 4 — Diagrammatic reconstruction of the Callovian Western Scarborough (Vale of Pickering), Yorkshire (from J.K. Wright 1978, fig. 4).

b - Eastern Berry (France)

A similar phenomenon can be found in the Cher department. There, the marls with pyritic fossils (Mariae zone age) reach their highest thickness close to the Seine - Sennely fault. Further east, going to the Sancerre - Saincoins fault, no deposits. This arrangement of the sediments, very similar to the one described by J.K. Wright, would therefore connected with a listric fault or a graben.

c - The Chrzanow graben (fig. 5)

To the west of Cracovie, the Mariae zone is almost always missing (R.A. Tarkowski, 1983), sometimes even, the Middle Oxfordian lies on the Upper Callovian. However there is one exception : the Chrzanow area (Wodna) where the boreholes (that I was able to study thanks to L. Malinowska and W. Brochwicz - Lewinski) showed that the sedimentation (marly limestones) was continuous at the Dogger - Malm boundary (Lamberti, Paucicostatum, Scarburgense horizons are presents). Since these marly limestones are lacking beyond the limits of the present graben, we can assert that this area was tectonically active during the Mariae zone.

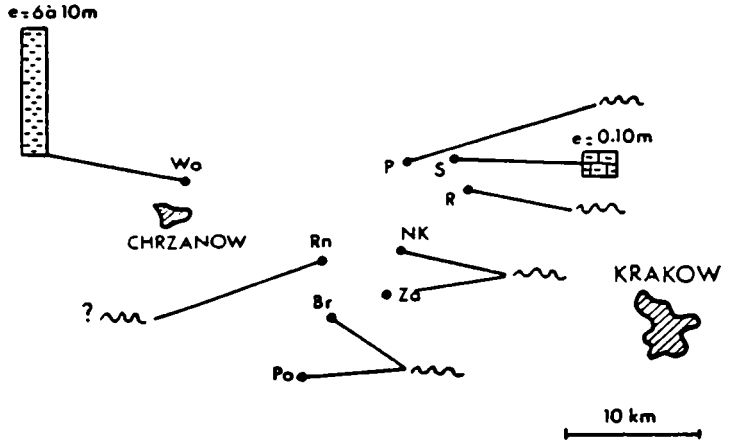


Fig. 5 — Western Krakow area (adaptated from S.Z. Rozycki, R.A. Tarkowski, M. Gizejewska, B.A. Matyja, L. Malinowska and revised D. Marchand). Br - Brodla, NK - Nova Krystyna, P - Paczoltowice (marly limestones with glauconit), Po - Podleze, R - Radwanowice, Rn - Rudno, S - Szklary, Wo - Wodna (blackish marly limestones), Za - Zalas, ~~ Gap.

d - Conclusion

From all the data given in this chapter, three points are to be emphasized.

— The tectonic control of the sedimentation during the Lower Oxfordian (Mariae z.) is connected with an old tectonic framework which begin to play again during the Upper Callovian before becoming very obvious at the Paucicostatum - Scarburgense boundary.

— These synsedimentary movements haven't been active very long since their strong influence on the sedimentation can no longer be noticed beyond the Mariae zone as is shown by J.K. Wright's studies.

—Some structures, appeared during the Mariae zone, will play a major part during the tertiary.

III – Ammonites faunas and synsedimentary movements

During the Lamberti zone, the Cardioceratinae (ammonites of boreal origin) spread as for as the northern margin of the Tethys. During that period - Paucicostatum horizon included - the Cardioceratinae abound and are almost always associated (but in various proportions) with Hecticoceratinae, Perisphinctidae, Kosmoceratinae and Euaspidoceratinae. Starting with the Scarburgense horizon, the Taramelliceratinae et Lissoceratidae (ammonites of tethys origin) suddenly appear, sometimes in so large quantities, that they produce what I've called drastic fauna changes. How can these facts be interpreted ?

1 — Distribution of Western Europe ammonites during the Scarburgense horizon (fig. 6)

The quantitative analysis of ammonites populations shows that one cannot observe gradual changes from the north to the south (D. Marchand 1983). However, if one take these faunal spectrums back into the paleogeographical and sedimentological background of that period, clear correlations become obvious. If the Taramelliceratinae and Lissoceratidae abound, and are sometimes dominating - in the marls with pyritic fossils - , on the other hand, in the areas with thin lenticular carbonated deposits, they are scarce (Taramelliceratinae) or absent (Lissoceratidae). The same thing happens in the areas where the Scarburgense horizon is represented by thick marly limestones (Chrzanow, French Prealpes) or «gaize» (Ardennes, France). Two exceptions however : in Scotland, as in Northern Poland, the marls with or not pyritic fossils only include Cardioceratinae ; on the west margin of the Delphino-Helvetique basin, the ammonite faunas are richer in Phylloceratidae.

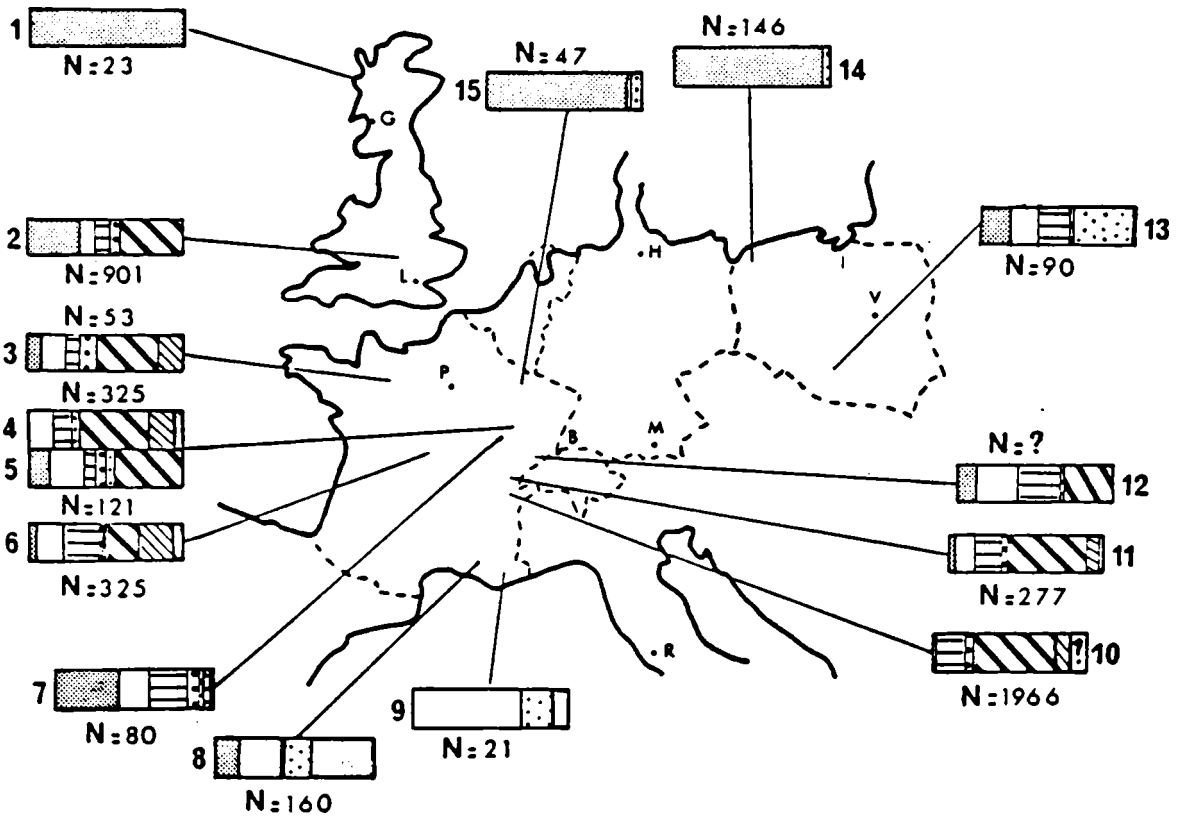
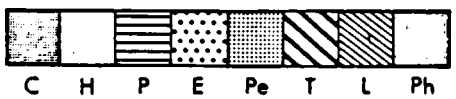


Fig.6 – Faunals spectrums in differents outcrops in Western Europe (Lower Oxfordian, Mariae zone, lower part of the Scarburgense sub. zone). 1 - Blacks marls ; 2 - 3 - 4 - 5 - 6 - 8 - 10 - 11 - 12 - 14 - Marls with pyritic fossils ; 7 - Marls with ferrouginous oolites ; 9 - Grey marls ; 13 - Marls and marly limestones ; 15 - «Gaize». B - Bâle, G - Glasgow, H - Hannovre, L - Londres, M - Munich, P - Paris, R - Rome, V - Varsovie 2 - From W.J. Arkell 1939 ; 3 - Sample of collection (Nancy University) ; 10 - 11 - R. Enay's collections ; 12 - From B. Ziegler 1967 ; 13 - 14 - Boreholes (Geological Museum, Varsovie).



C - Cardioceratidae, H - Hecticoceratinae, P - Perisphinctidae, E - Euaspidoceratinae, Pe - Peltoceratinae, T - Taramelliceratinae, L - Lissoceratidae, Ph - Phylloceratidae.

N = number of specimens.

Therefore, everything seems to prove that during the Scarburgense horizon the distribution of the ammonites is connected with paleoenvironments and that the drastic fauna changes have localy something to do with the synsedimentary movements (S. Debrand-Passard, D. Marchand 1979, D. Marchand 1983).

2 — A paleoexperiment (fig. 7)

Between the Seine - Sennely and Sancerre - Sancoins faults the sediments of Lamberti z. are every where and provide large amounts of ammonites. Thanks to these favorable conditions, it has been easy to show that the differents ammonite populations were homogeneous. Starting with the Scarburgense horizon, the marls with numerous pyritic fossils are known only in the western part of this area. In comparison with the Lamberti fauna, two major differences must be noticed.

— The presence in abundance of the Taramelliceratinae and Lissoceratidae which were previously scarce or lacking.

— Western, the Cardioceratinae are scarce but not eastern. A the opposite, Taramelliceratinae and Lissoceratidae are scarce eastern but numerous western ; these changes are gradual.

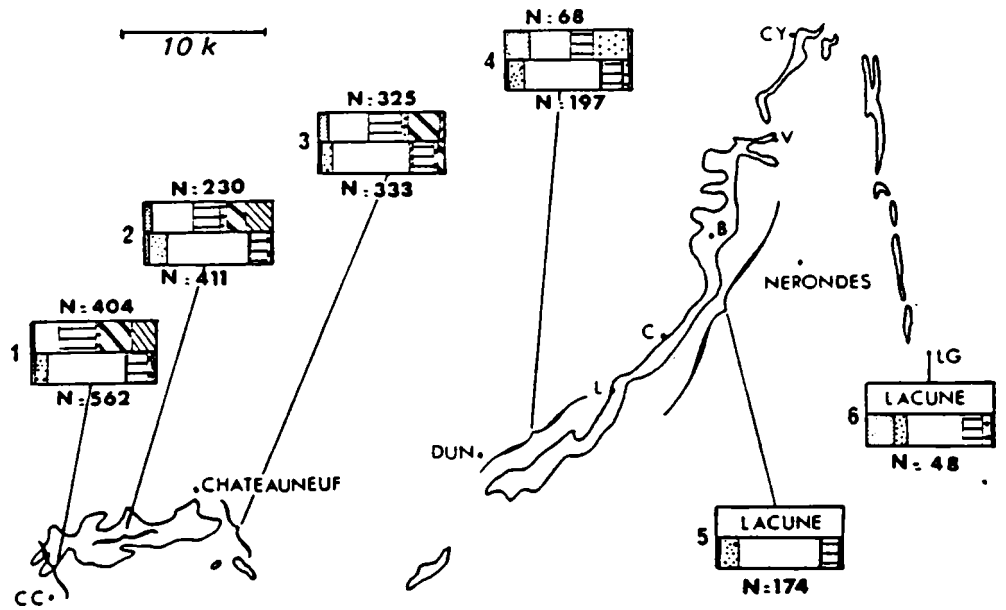


Fig. 7 — Faunals spectrums (ammonites) in the department of Cher (France) during the Upper Callovian (Lamberti zone, Lamberti sub. zone, inferior diagramms) and the Lower Oxfordian (Mariae zone, Scarburgense sub. zone, Scarburgense horizon ; upper diagramms).
B - Bengy-sur-Craon, C - Cornusse, CC - La Celle-Condé, CY - Couy, L - Lantan, LC - La Guerche, V - Villequiers



C - Cardioceratinae, K - Kosmoceratinae, H - Hecticoceratinae, D - Distichoceratinae, P - Perisphinctidae, E - Euaspidoceratinae, Pe - Peltoceratinae ; T - Taramelliceratinae ; L - Lissoceratidae.

N = number of specimens.

If one have had a listric fault, it seems logical that the tethysian ammonites, which were adapted to deep open environments, abound close to the fault where the theory can assumes deeper water. The large amount of nectobenthic ammonites as Cardioceratinae towards the east, where the theory can assumes shallower water, supports this interpretation.

IV – Conclusions

The detailed study of the Dogger - Malm boundary in Western Europe shows that the distribution of the sediments is not hazard but is connected with an old structural framework reactiveted by,certainely, a distensive tectonic.The reality of this tectonical stage is proved by numerous phenomena which are all in agreement.

— Areas with thick deposits are joinded with areas without or limited sedimentation ; between the both, major faults.are present.

— Isochrony of changes in sedimentation process in the whole of Western Europe.

— Synsedimentary movements connected with listric faults ? or graben structure.

— Drastic changes in ammonites faunas in tectonically active areas.

This structural framework, which is very active at the Mariae zone basis (Scarburgense s.z.) will play again, but not so strongly, during the Cordatum zone before losing any influence in the upper part of the Middle Oxfordian.

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AALENIAN - BAJOCIAN BOUNDARY AT BEARRERAIG, ISLE OF SKYE, SCOTLAND

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AALENIAN - BAJOCIAN BOUNDARY AT BEARRERAIG, ISLE OF SKYE, SCOTLAND

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Abstract

The Aalenian - Bajocian boundary is well exposed in a thick sequence of silty shales at Bearreraig, Isle of Skye, with fossiliferous nodules occurring through more than 25m of strata. Concavum Zone (Aalenian) ammonites, mainly referable to the dimorph pair Graphoceras limitatum (M) - carbatinum (m), occur up to 8·8m above the base of the Udairn Shale Member. From 11·5m to 22·8m above the base Hyperlioceras occurs, the macroconch morphotype evolving from incisum through mundum to walkeri and the microconch (not synchronously) from rotabilis through aspera to contorta. These are placed in the Discites Zone (Bajocian) after comparison of Bearreraig with other relatively complete sections, and discussion of the present status of definition of the Aalenian - Bajocian boundary. In ammonite morphology there is a distinct change to a more defined flatter venter, with a more prominent keel.

The stage boundary is also marked at Bearreraig by a change in composition of the benthic fauna, with bivalves Nuculoma variabilis, Mesomiltha lirata and Grammatodon inaequivalvis predominant in the Concavum Zone, replaced by Mytiloceramus polyplocus in the Discites Zone. There is no obvious change in lithology, but calcitic nodules occur in the Concavum Zone and mainly sideritic nodules in the Discites Zone.

INTRODUCTION

The Middle Jurassic of the Hebrides (or Minch) Basin of N.W. Scotland is a thick predominantly clastic sequence, the lower part of which (Bearreraig Sandstone Formation, mainly of Aalenian-Bajocian age) is marine (Morton 1965, 1983a). Bajocian ammonites and stratigraphy have already been described (summarised in Morton 1976). The purpose of this paper is to give details of the sequence across the Aalenian - Bajocian boundary at the most accessible and fossiliferous locality. This is at Bearreraig Bay, c.10km north of Portree on the

east coast of the Trotternish Peninsula, Isle of Skye (Fig. 1). The present status of definition of the boundary will also be discussed with particular reference to where it should be placed in the Bearreraig sequence.

The Aalenian - Bajocian boundary lies within the Udairn Shale Member, which is exposed in a steep partly grassy slope south of Bearreraig Bay and in the stream section below the main waterfall. The succession described below is a composite one from these localities (see Fig. 1 for details). The section is not quite continuous (in accessible outcrops) and fossils do not occur at all levels, but because of the thickness of strata the locality gives a good reference section for the base of the Bajocian Stage. The abundant ammonites are predominantly graphoceratids, with sonniniids in higher strata, but hammatoceratids are rare.

OCCURRENCE OF AMMONITES

In the relevant part of the succession fossils occur almost entirely in early diagenetic nodules scattered irregularly through the silty shales, and occasionally in some of the slightly harder more calcareous beds. Most of the nodules are crowded with fossils which are extremely well preserved (especially in the lower part). Ammonites, bivalves, land plant fragments and belemnites are most abundant, with some vertebrate and arthropod fragments and rarer gastropods, scaphopods and echinoderm fragments.

The ammonites are mainly juveniles, many of which can be recognised as probably macroconchs or microconchs because of slight differences in morphology, but others could be either. Adult microconchs with lappets are also common, but larger (? adult) macroconchs are rare. This is almost certainly an original feature of the composition of the fauna rather than due to preservation. For further details and for discussion of the occurrence of pathological deformity see Morton (1983b).

In general within each nodule the ammonites almost certainly belonged to a single population of one dimorphic species, but in some there appear to be two dimorphic species of graphoceratid represented. The faunas will be illustrated and taxonomy discussed elsewhere but for present purposes the ammonites are referred to the nearest morphological "species" and dimorphic status as macroconch (M) or microconch (m) indicated. For convenience dimorph subgenera are used with the following pairings : *Graphoceras* - M *G.* (*Graphoceras*), m *G.* (*Ludwigella*) ; *Hyperlioceras* - M *H.* (*Hyperlioceras*) including *Toxolioceras* etc., m *H.* (*Reynesella*) including *Braunsina* etc.

DETAILED SEQUENCE

The succession is described in ascending order, from near the top of the Ollach Sandstone Member to 25m above the base of the Udairn Shale Member. For details of higher ammonite faunas see Morton (1976). The figures in brackets below are grid references for localities and height above or below the base of the Udairn Shale Member for ammonite faunas.

A. BEARRERAIG POINT (NG51815272)

Ollach Sandstone Member

Bed 25. Soft medium-grey fine-grained silty sandstone with occasional calcareous nodules 2·0m

FAUNA (i) from 1·35m above base (-1·5m) -

m G. (Ludwigella) aff. robustum

m G. (Ludwigella) sp. indet. (large body chamber frag. with lappets)

m G. (Ludwigella) sp. nov. ? (very small smooth lappets)

Bed 26. Hard light grey calcareous sandstone, forming prominent feature at top of low cliff 0·85m

Basal beds of Udairn Shale Member not exposed.

B. SHALLOW GULLY 300m SOUTH OF POINT (NG51865245)

Top of Ollach Sandstone Member

Udairn Shale Member

Bed A. Soft dark grey shales with some calcareous nodules 1·80m

Bed B. Slightly harder more calcareous band 0·60m

Bed C. Soft dark grey silty shales 0·70m

Bed D. Slightly harder calcareous silty shale 0·25m

Bed E. Soft dark grey silty shales with calcareous nodules 1·00m

FAUNA (ii) from near middle (+3·5-4·0m) -

M G. (Graphoceras) limitatum

m G. (Ludwigella) carbatinum

Bed F. Slightly harder more calcareous band 0·10m

Bed G. Soft grey silty shales with small calcareous nodules 0·90m

FAUNA (iii) from just above middle (+5·0m)

M G. (Graphoceras) limitatum

m G. (Ludwigella) carbatinum

?M G. (Graphoceras) debile (very small nearly smooth)

Bed H. Prominent harder more calcareous silty shale 0·20m

FAUNA (iv) from this bed (+5·4m) -

M G. (Graphoceras) aff. concavum (larger involute)

M G. (Graphoceras) limitatum

m G. (Ludwigella) carbatinum

Bed I. Soft grey silty shales with scattered calcareous nodules 3·50m

FAUNA (v) from 0·7m above base (+6·2m) -

M G. (Graphoceras) limitatum

FAUNA (vi) from 2·4m above base (+8·0m) -

M G. (Graphoceras) limitatum

m G. (Ludwigella) carbatinum

FAUNA (vii) from 3·2m above base (+8·8m) -

M G. (Graphoceras) v-scriptum (moderately large)

M G. (Graphoceras) limitatum

m G. (Ludwigella) carbatinum

?M G. (Graphoceras) debile } (small with fine ribbing

?m G. (Ludwigella) sp. A (Buck.) } projected onto venter)

Eudmetoceras amplectens

Gap between sections approx 0·70m

C. NEAR BOTTOM OF PIPELINE (NG51705271)

Bed J. Soft medium-dark grey silty shales with a few scattered reddish-brown nodules 2·75m

FAUNA (viiia) from 2·5m above base (+11·5m) -

M H. (Hyperlioceras) incisum

m H. (Reynesella) rotabilis

?M H. (Hyperlioceras) micca

m H. (Reynesella) sp.

FAUNA (viiib) from same level (+11·5m) -

M H. (Hyperlioceras) mundum

m H. (Reynesella) rotabilis

?M H. (Hyperlioceras) micca

m H. (Reynesella) sp.

Bed K. Slightly harder silty shale with elongate large siderite nodule 0·25m

FAUNA (ix) from this bed (+12·65m) -

M H. (Hyperlioceras) mundum

M H. (Hyperlioceras) furcatum

m H. (Reynesella) aspera

?M H. (Hyperlioceras) micca

Bed L. Soft medium-dark grey silty shales 1·00m

Gap between sections approx 0·50m

D. BED OF BURN, 15-20m UPSTREAM FROM BEND (NG51635271)

Bed M. Dark grey micaceous silty shales with medium-sized calcareous nodules 2·00m

FAUNA (x) from 1·4m above base (+15·65m) -

M H. (Hyperlioceras) sp. (large fragment)
M H. (Hyperlioceras) aff. walkeri
m H. (Reynesella) aspera
Euaptetoceras sp.
Euhoploceras sp. juv.

Bed N. Band of large elongate calcareous nodules 0·15m

Bed O. Dark grey micaceous silty shales with some small siderite nodules 2·00m

FAUNA (xi) from 1·2m above base (+17·6m) -

?m H. (Reynesella) sp.

No gap between sections

E. LOWEST EXPOSURE IN WEST BANK OF BURN, NEAR BEND (NG51635272)

Bed P. Medium-dark grey micaceous silty shales with occasional sideritic nodules up to 20cm diam., some fossiliferous 2·67m

FAUNA (xii) from 0·3m above base (+18·7m) -

M H. (Hyperlioceras) aff. walkeri
m H. (Reynesella) aspera

FAUNA (xiiia) from 1·3m above base (+19·7m) -

M H. (Hyperlioceras) walkeri
m H. (Reynesella) aspera

FAUNA (xiiib) from same level (+19·7m) -

M H. (Hyperlioceras) sp.
m H. (Reynesella) aspera

FAUNA (xiva) from approx. 2·0m above base (approx +20m, slightly higher than given in Morton 1976) -

Euhoploceras (E.) ? dominans

FAUNA (xivb) from same level (approx +20m) -

M H. (Hyperlioceras) sp.
m H. (Reynesella) aff. contorta
Euhoploceras (E.) marginata

FAUNA (xv) from 2·6m above base (+21·0m) -

M H. (Hyperlioceras) walkeri

Bed Q. Harder partly nodular band with purplish-weathering surface 0·15m

Bed R. Medium-dark grey silty shales, highly micaceous, weathering with white skin and brown-red along joints, few small (to 5cm) siderite nodules 3·67m

FAUNA (xvi) from 1·6m above base (+22·8m) -

M H. (Hyperlioceras) walkeri

m H. (Reynesella) contorta

F. BED OF BURN, APPROX. 45m ABOVE BEND (NG51625266)

Also part of Bed R

FAUNA (xvii) from approx. same level as (xvi) (+22·8m) -

M H. (Hyperlioceras) walkeri

m H. (Reynesella) contorta

SUMMARY OF SUCCESSION

The lithology is almost uniform except for gradual upward increase in grain size, and slight differences between beds picked out by weathering. The ammonite faunas also show little variation with time (sequence) except between beds I and J. Faunas (i) to (vii) can all be grouped as belonging mainly to one highly variable morphospecies Graphoceras limitatum (M) - carbatinum (m), and are characteristic of the upper part of the Concavum Zone (suggested as Formosum Subzone by Contini 1969, but in Bajocian). There is then an obvious morphological change to fauna (viii) especially in the shape of the venter, which becomes more clearly defined at the edges and subtabulate rather than fastigate and with a more prominent keel. Faunas (viii) to (xvii) show gradual evolution, the macroconch morphotype from Hyperlioceras incisum through mundum to walkeri, and microconchs from H. (Reynesella) rotabilis through aspera to contorta.

This pattern of ammonite change is consistent with the Eldredge and Gould (1972) model of punctuated equilibria in evolution. The morphotypes ("species") walkeri and aspera are generally regarded as characteristic of the Discites Zone, but this is further discussed below.

Coincident with the change in the ammonites is a change from calcareous to predominantly sideritic nodules, and a change in the composition of the benthic macrofauna. In fauna (vii) (typical

of the lowest part of the Udairn Shale Member) the most abundant benthic species (336 specimens counted) are Nuculoma variabilis (46·0%), Mesomiltha lirata (15·5%) and Grammatodon inaequivalvis (11·0%). A preliminary estimate (34 specimens) for the next fauna (viii) gives Mytiloceramus polyplocus (67·6%), Grammatodon inaequivalvis (8·8%), Oxytoma inaequivalve (8·8%), Nuculoma variabilis (2·9%). Preliminary data for this plus higher faunas (88 specimens) shows similar results.

AALENIAN - BAJOCIAN BOUNDARY

During the early part of the Middle Jurassic there was a transition from domination of ammonite faunas by Graphoceratidae and Hammatoceratidae (part of the typically Early Jurassic superfamily Hildocerataceae) during the Aalenian, to domination during the Bajocian by the main Middle Jurassic superfamilies Stephanocerataceae, Haploceratacеae and Perisphinctaceae. The late Aalenian and early Bajocian are characterised by the overlapping ranges of these main superfamilies.

Definition of the Aalenian - Bajocian boundary has been discussed by several authors, notably Mouterde et al. (1972) and most recently by Pavia (1983), and most of the discussion need not be repeated here. There is general agreement that the boundary should be defined by the base of the higher (Bajocian) stage (Holland et al. 1980). This in turn is defined by the basal chronozone the Discites Zone (formerly the basal subzone of the Sowerbyi Zone), following decisions at Jurassic colloquia in Luxembourg (1962, 1967).

Several ammonite genera become extinct or make their first appearance at about the base of the Discites Zone, notably extinction of Graphoceras and first appearances of Hyperlioceras (Graphoceratidae), Euhoploceras (Sonniniidae), Haplopleuroceras (uncertain affinities but possibly Tmetoceratidae), Bradfordia (Oppeliidae), Docidoceras (Stephanoceratidae) and others. However it appears that these are not exactly synchronous and there is general concensus that the best definition (at least for the standard N.W. European scale) is the first appearance of Hyperlioceras (Morton 1971, Pavia 1983, and others).

There are problems about the type species of the genus Hyperlioceras (H. discites) which is also the name species for the zone. However the zone was introduced (as hemera) by Buckman (1893) for a type horizon in the upper part of the Bradford Abbas fossil bed,

unfortunately at a late stage in his research on Inferior Oolite ammonites so that through much of his monograph Discites is not separated from Concavum. The upper part of the Bradford Abbas fossil bed is characterised by the occurrence of the Hyperlioceras walkeri-ruddidiscites group (Parsons 1974), but there is a gap below this and no clear evidence for the presence of the upper subzone of the Concavum Zone.

More complete sequences have been described by Mouterde et al. (1972) at Murtinheira (Portugal) and Marcoux (S.E. France) and by Pavia (1983) at Beaumont (S.E. France, both localities near Digne). At Marcoux and Beaumont in the Basses-Alpes there appears to be overlap of ranges of species typical of the Formosum Subzone with those typical of the Discites Zone, but in both areas ammonites are not well preserved and the true situation is not yet clear. At Murtinheira there is a gap between the last Graphoceras limitatum (typical of the Formosum Subzone) and the first Hyperlioceras (including Toxolioceras), arcuatum and incisum. As at Bearreraig H. mundum appears slightly higher, with H. cf. walkeri, but all Hyperlioceras are placed in the Discites Zone by Mouterde et al (1972).

By comparison of the Bearreraig sequence with that at Murtinheira, and following Mouterde et al. (1972) in placing the base of the Discites Zone at the first appearance of Hyperlioceras, the Aalenian - Bajocian boundary should be placed at Bearreraig between faunas (vii) and (viii), that is between 8·8m and 11·5m above the base of the Udairn Shale Member.

CONCLUSIONS

The sequence of species of Hyperlioceras found at Bearreraig is comparable with that at Murtinheira (Portugal) summarised by Mouterde et al. (1972). Hyperlioceras mundum and H. incisum appear to be earlier than the Hyperlioceras species (walkeri-ruddidiscites group) found in the type horizon for the Discites Zone, and suggest that a more refined definition of the base of the zone (and therefore of the Bajocian Stage) could be possible. Further detailed study of these and other sections is required before a basal stratotype for the Bajocian Stage is chosen.

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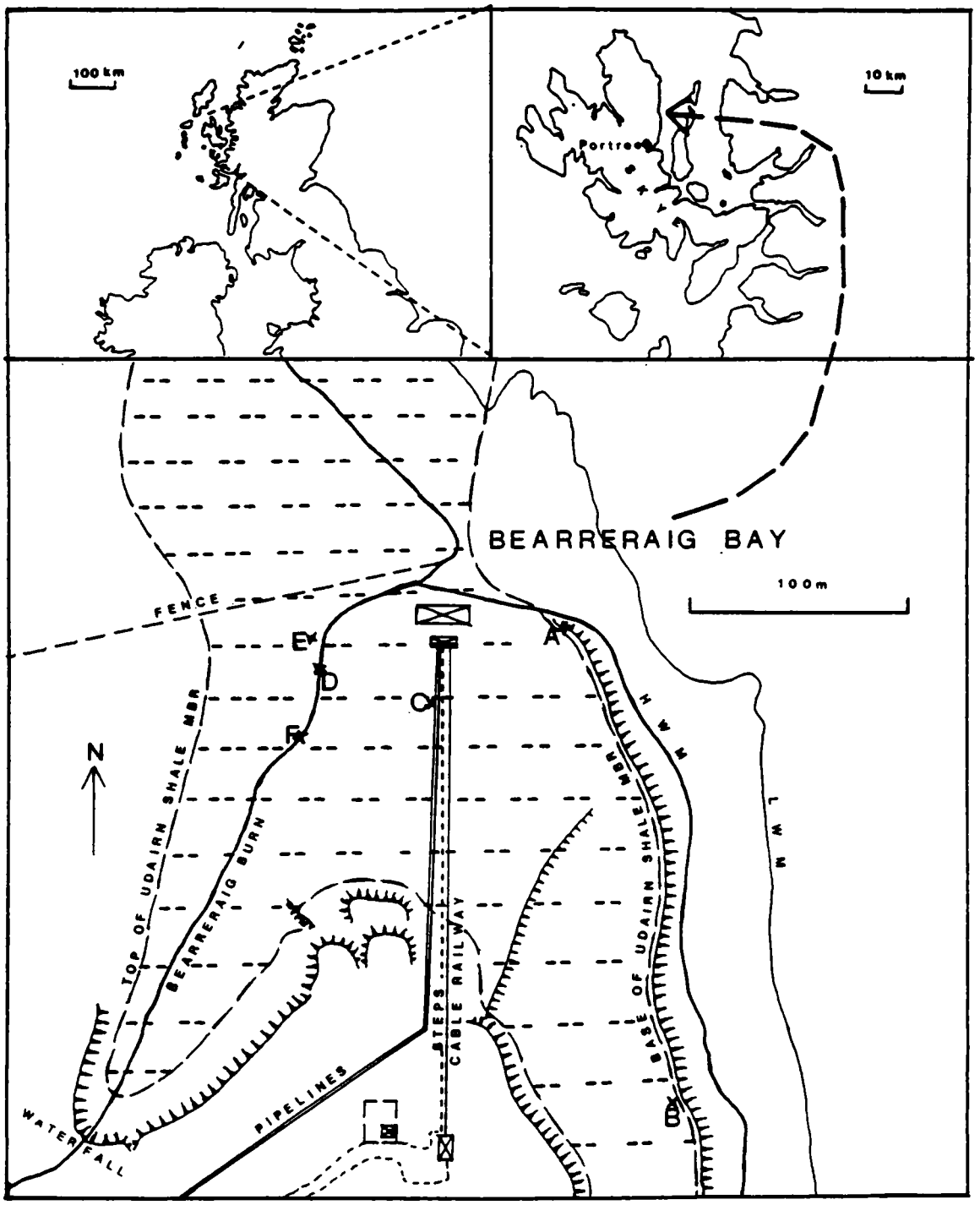

FIG. I. Location map of Bearreraig, Isle of Skye.

NEW OBSERVATIONS ON THE MIDDLE/UPPER JURASSIC BOUNDARY BEDS OF NORTHERN BAVARIA

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NEW OBSERVATIONS ON THE MIDDLE/UPPER JURASSIC BOUNDARY BEDS OF NORTHERN BAVARIA

Christel Munk & Arnold Zeiss

ABSTRACT: New observations on the boundary Middle/Upper Jurassic show the different history of the Callovian and Lower Oxfordian sediments. The Lower and parts of the lower middle Callovian of the northwestern Franconian Alb consist of grey, pyritic marls. The upper Middle and Upper Callovian were erodet, the ammonites were redeposited in a phosphoritic nodule layer at the basal parts of the Lower Oxfordian. The Callovian of the northeastern, middle and southern parts of the Franconian Alb is built up by oolitic limestones and marls (lower part) and glauconitic marls (upper part). Sediments of the Lower Oxfordian have been preserved only in a limited area. New findings of ammonites in well-cores belong to the lower part of the cordatum zone (bukowskii subzone).

1. CALLOVIAN

1.1 Review

Important contributions to clarify the ammonite succession and biostratigraphy are those of: Pompeckj (1901), Wanderer (1906), Reuter (1908), Greif (1914), C.Dorn (1916 and 1920/21), Model & Kuhn (1935), Model & Model (1937), Kuhn (1939, plates refigured in 1983), Spath (1949), Schmidtill (1953), Zeiss (1957,1961,1977), P. Dorn (1958), Kolb (1964), Sadati (1980), Pappler, Sadati & Zeiss (1982). Investigations about the microfauna (mainly foraminifera) habe been published by Kuhn (1936), Ziegler (1959) and Munk (1978). The first important report about the famous pyritic ammonites of the Callovian was given by Reinecke 1610 (see also Heller & Zeiss 1972).

However most of the older material (mainly ammonites) is no more available. Unfortunately in many cases no exact litholo-

gical sections were published and thus it is often very difficult or impossible to compare the old results with new observations. There are a lot of unsolved problems and the ammonite fauna (mainly those of the so-called "Goldschneckenfacies" (pyritic ammonites)) need urgently a revision.

1.2 Lower Callovian (fig.1,2)

The lithological differentiations of the sedimentary basin of the Bajocian and Bathonian of the Franconian Alb are continuing during Callovian times (see Munk & Zeiss 1984 fig. 26). The basin is subdivided in a more basinal facies in the northwestern parts and a more marginal facies in the northeastern, central and southern parts. The Lower Callovian of the northwestern Franconian Alb consists of grey, pyritic marls (fig.2). Only the lowermost part is somewhat oolitic. These grey marls represent the famous, so-called "Goldschneckenfacies", named after the content of "Goldschnecken" (= "golden " ammonites). The ammonites are mostly pyritic inner whorls of much larger individuals, and thus often difficult to determine. The ammonite fauna of the lowermost Callovian allows to assume, that the main part of the pyritic marls represents the middle and upper part of the Lower Callovian (koenighi and calloviensis zone). The Lower Callovian of the northeastern, central and southern parts is built up by oolitic limestones and marls and glauconitic marls in the uppermost part.

The thickness of the Lower Callovian ranges from 6,50 to 14,50m in the north and from 1 to 5 m in the central and southern districts.

1.3 Middle and Upper Callovian (fig. 2)

In the northwestern part of the Franconian Alb the pyritic facies of the Lower Callovian is continuing into the lower Middle Callovian (jason zone).The marls are usually poor in fossils but the occurence of Reineckeia (Reineckeia) aff. stuebeli Steinmann and of Ostracode No.4 ("Y"Ostracode) Lutze 1960 can be considered as typical of this horizon. In a few localities there is within the marls a bed of "breadloaf"-shaped calcareous concretions (C.Dorn 1916). It is an open problem, if the original thickness of the jason zone is completely preserved (Munk & Zeiss 1984c), as upper parts of the Middle Callovian (mainly coronatum zone in Oberlangheim und Würgau) are represented only by a horizon of

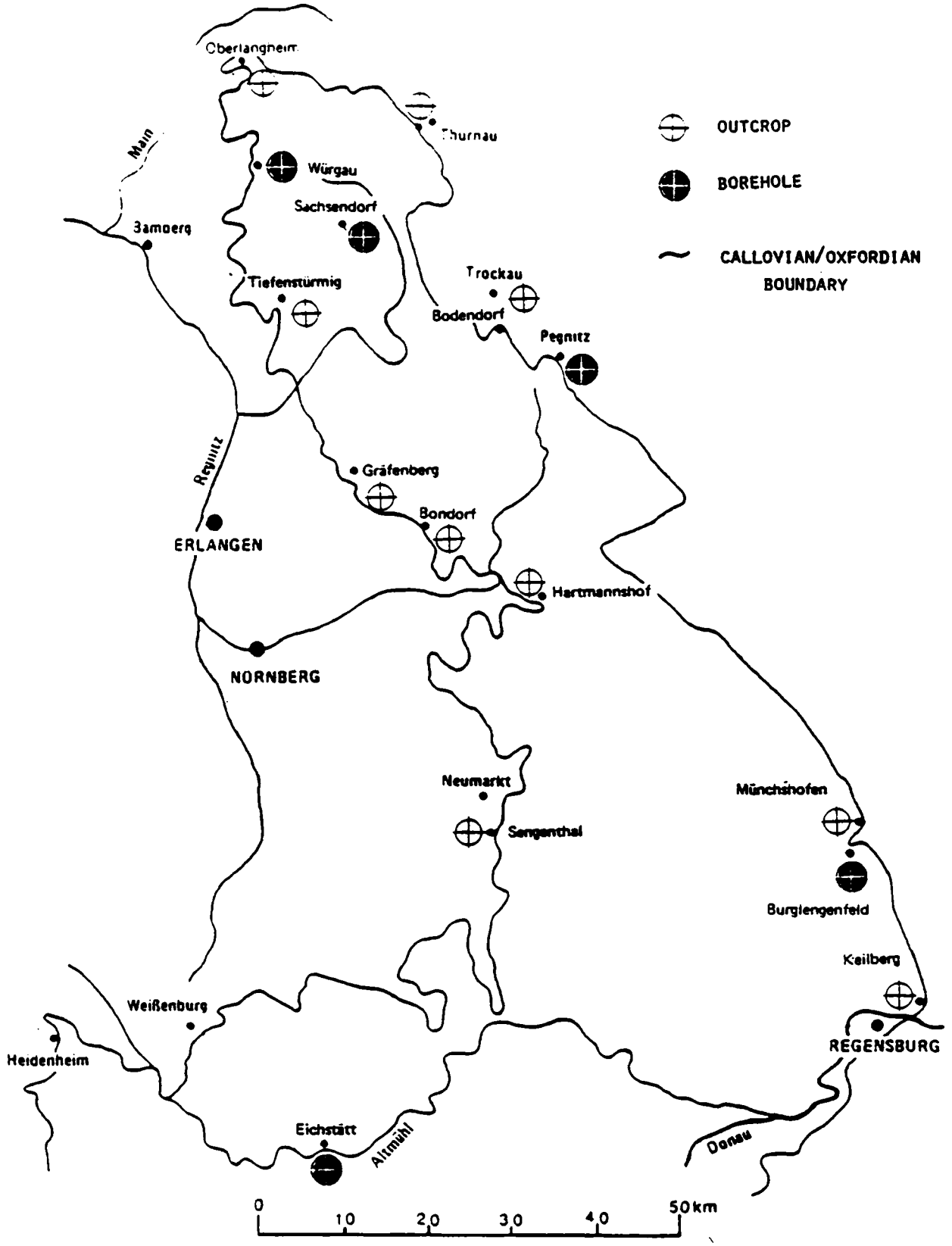

Fig.1: Distribution of outcrops and boreholes.

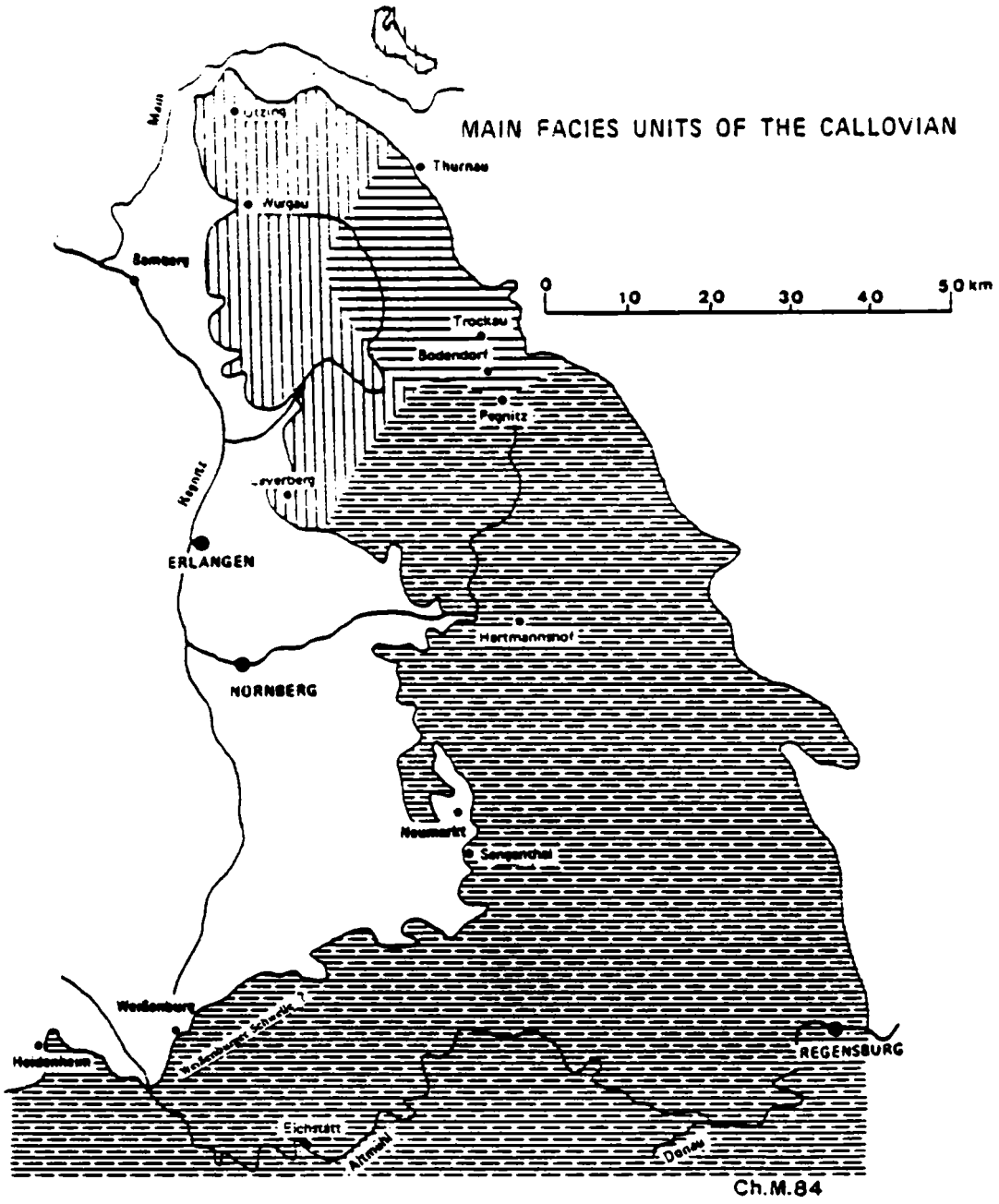

Fig.2: Facies distribution of the Callovian of Northern Bavaria (Munk 1984).

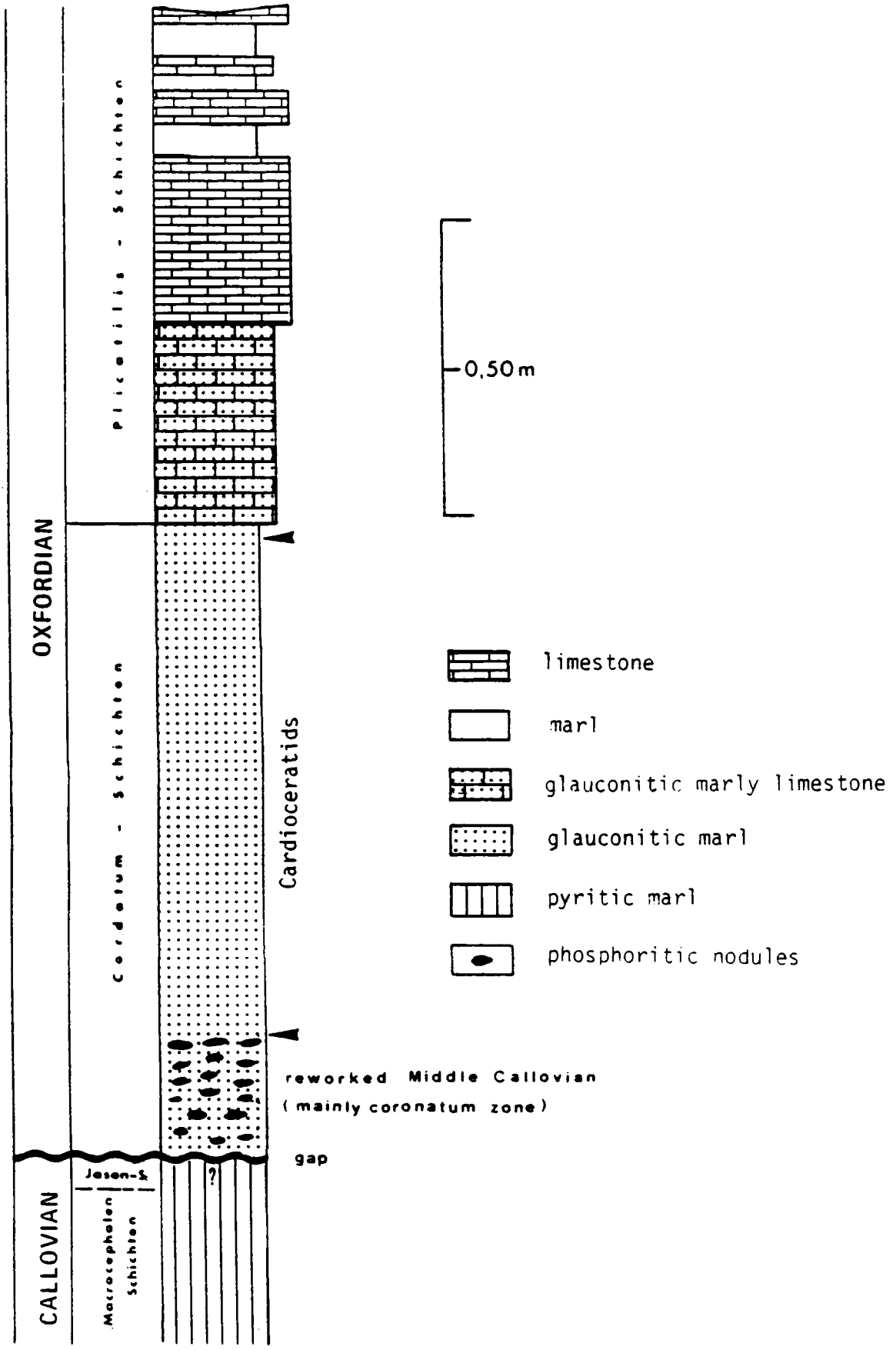

Fig.3: Section of the boreholes of Würgau (simplified after Munk 1984).

reworked and concentrated phosphoritic ammonites mostly in fragments at the basal part of the Lower Oxfordian (fig. 3). In some other localities (surroundings of Ebermannstadt, C. Dorn 1916; 1920/21) in this horizon seem to bee preserved aboye the Lower Callovian the jason, coronatum and athleta zone. It was the merit of Reuter 1908 to discover this phosphoritic layer and to recognize its palaeogeographical significance.
The upper part of the Upper Callovian (lamberti zone) is missing in the northwestern part of the Franconian Alb.
In the northeastern part (area of Bodendorf - Trockau, see fig. 2) a pyritic facies represents also the upper part of the Middle Callovian and the lower part of the Upper Callovian (Reuter 1908, Model & Model 1937). The Middle Callovian of the other parts is built up by grey marls with glauconite and phosphoritic concretions. The Upper Callovian is similar, but the marls have a higher content of glauconite. Condensation has been observed at Hartmannshof (upper calloviensis to lower coronatum zone) by Sadati (1980). The uppermost part of the Callovian (lamberti zone) is known only in a few localities (fig.4). The thickness is very low (0,17 - 0,60 m) except in the borehole of Eichstätt with 2,54m Wirth (1970).
The thickness of the Middle and lower Upper Callovian ranges from 1,30 m to 6,80 m.

2. LOWER OXFORDIAN

The Lower Oxfordian is poorly known in Northern Bavaria. Investigations habe been undertaken by Pompeckj (1901), Wanderer (1906), C. Dorn (1916; 1920/21) and P.Dorn (1958). Most of the ammonites have been put into the group of "Ammonites cordatus" by these authors.
General reviews on the distribution of the Lower Oxfordian in Northern Bavaria were given by Zeiss (1962; 1966). Due to the very scarce outcrops not much is known about the ammonites, they are rather rare and not well preserved.
Sediments of the Lower Oxfordian have been preserved only in a few localities in Northern Bavaria (fig. 4), no locality yields the complete ammonite succession of the Lower Oxfordian. The sediments consist of dark marls with muscovite, they are

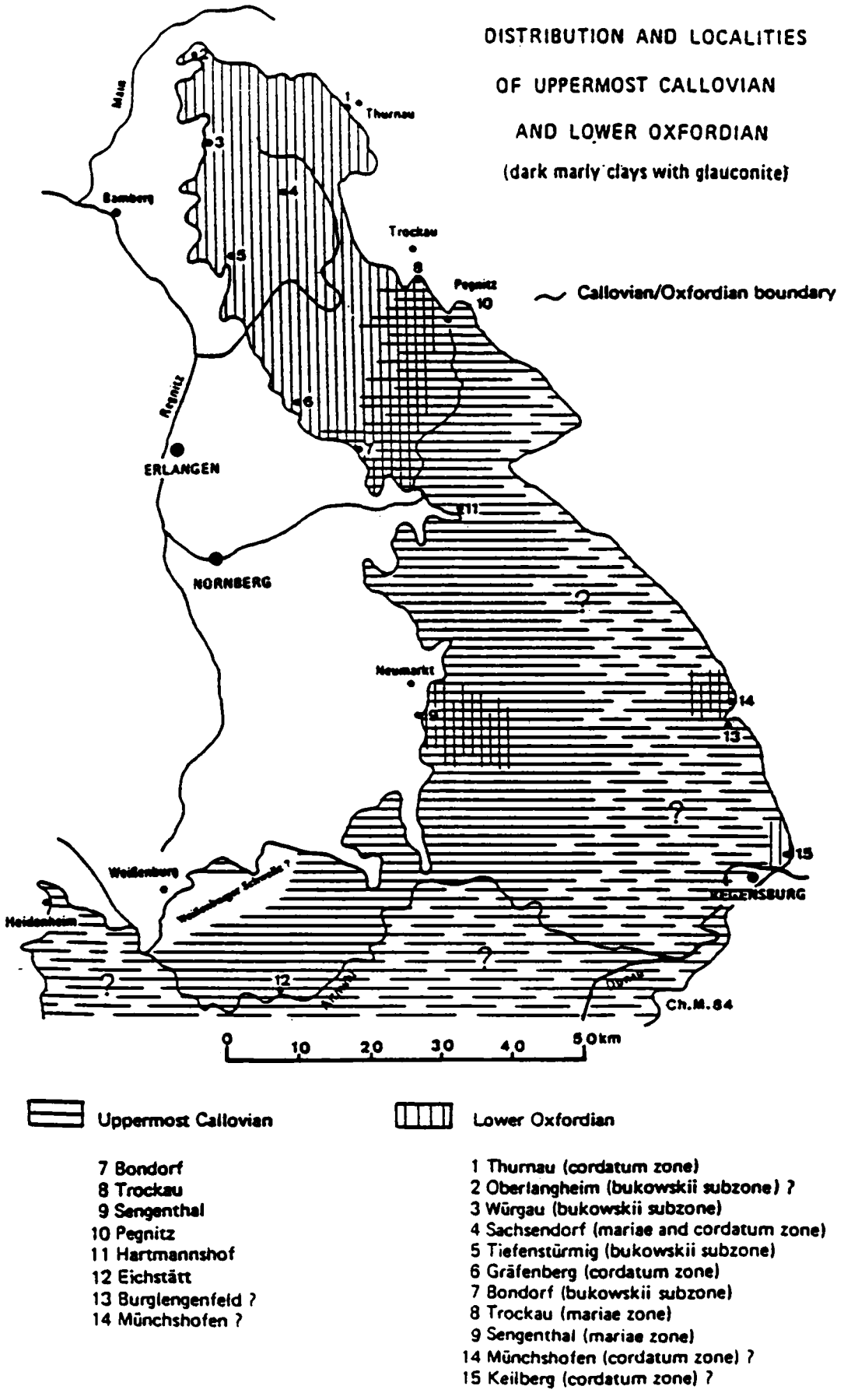

Fig.4: Distribution of the uppermost Callovian and Lower Oxfordian in Northern Bavaria (Munk 1984).

very rich in glauconite. The thickness ranges from 0,20 m to 1,20 m.
New findings of ammonites in well-cores of Würgau (wells for road building) give some new informations about the stratigraphy and ammonite succession.
The following ammonites could be isolated and determined, some of them are figured by Munk & Zeiss(1984c).
(+ figured specimen)

Cardioceras (Scarburgiceras) bukowskii Maire +
(cf. Arkell 1945, text-fig. 108/1)
Cardioceras (Scarburgiceras) cf. bukowskii Maire
(cf. Arkell 1945, text - fig. 108/6)
Cardioceras (Scarburgiceras) excavatoides Maire +
(cf. Wright 1983, pl. 20,fig.6)
Cardioceras (Scarburgiceras) reesidei Maire +
(cf. Wright 1983, pl.20,fig.4)
Cardioceras (Scarburgiceras) cf. reesidei Maire +
(cf. Arkell 1945, text-fig.108/5)
Cardioceras (Vertebriceras) aff. gracile Arkell +
(cf. Wright 1983, pl.21, fig.3-4)
Cardioceras (Vertebriceras) cf. phillipsi Arkell +
(cf. Wright 1983, pl.20, fig.8-9)
Cardioceras (Vertebriceras) sp. +
Cardioceras (Korythoceras) korys (Buckman)
(Turner 1970, pl.2,fig.N)
Cardioceras (Korythoceras) cf. korys (Buckman) +
(Turner 1970, pl. 2A, Fig.D,N)
Creniceras renggeri (Oppel) +
(Ziegler 1956, fig. 13 c-f)
Peltoceratoides sp. juv. cf. constantii (d'Orbigny) +
(Matya 1977, pl.4,fig.9)
Taramelliceras sp.
Hibolites semihastatus (Blainville)
Astarte sp.

The ammonites are typical of the lower cordatum zone, the bukowskii subzone. The fauna can be compared with the successions of Sachsendorf (Zeiss 1962), Thurnau (Zeiss 1966) and Tiefenstürmig (C. Dorn 1920/21, Zeiss 1962).
The lowermost Oxfordian (mariae zone) is only known from a few

localities (Sachsendorf (Zeiss 1962), Bodendorf-Trockau (Spath 1949), Sengenthal (Pappler, Sadati & Zeiss 1982)). It is evident, that the sediments of the Lower Oxfordian have been preserved only in a limited area of Northern and Central Franconia, the main distribution being in the Northern Franconian Alb (fig.4), north of a line running from Bodendorf to Trockau.

3. CONCLUSIONS

The history of the Callovian sediments is different in Franconia. While it may be supposed that the whole Callovian has been originally deposited - of course often only in small thickness - the later history differs: In NW - Franconia the upper Middle and Upper Callovian - at some places also lower Middle Callovian - were eroded and nothing remained as reworked, but not far transported ammonites, wich were apparently concentrated in special places of a submarine relief ; over this spread out the Lower Oxfordian in small thickness in the region between Neumarkt, Bondorf, Gräfenberg, Tiefenstürmig, Trockau and Sachsendorf. Ammonites have been yielded only by artificial outcrops or well-cores. In NE- Franconia the Callovian remained more complete and sometimes reaches into the Lower Oxfordian. But also here especially in the southern part reworked and condensed layers have been observed, but are situated within the upper Lower and Middle Callovian only. All this means strong unquiet conditions at the seaground; uplifting of parts and destruction of the sediments are influenced by tectonic movements, wich can also be observed as intracallovian faults within the quarry Sengenthal.

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MIDDLE AND UPPER JURASSIC BIOZONATION WITH COLLYRITIDAE (IRREGULAR ECHINOIDS) IN THE PARIS BASIN (FRANCE)

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MIDDLE AND UPPER JURASSIC BIOZCNATION WITH COLLYRITIDAE (IRREGULAR ECHINOIDS) IN THE PARIS BASIN (FRANCE)

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Abstract : The chronological succession of *Collyritidae* genera and species of the Paris Basin Middle and Upper Jurassic allows to establish a biostratigraphical scale parallelwith the current ammonites zonation. Its accuracy is that of a substage or sometimes a zone. When ammonites or brachiopods are absent this irregular echinoid family can provide good chronological precisions.

Introduction –

Irregular echinoids are commonly founded in Jurassic formations of the Paris Basin (France) ; in samples, well preserved specimens can be counted in tens or hundreds.Among the various groups which are present,Holectypoidea, Cassiduloidea and Disasteroidea are particularly frequent. In the previous, the family Collyritidae, known from Bajocian to Oxfordian in the whole of the Paris Basin, appears to be a good biostratigraphical tool.

The exuberance and diversity of this echinoid fauna already appeared in ancient author's monographs (Cotteau 1849 - 56 ; Cotteau 1867 - 74 ; Cotteau et Triger 1855 - 69 ; Valette 1906 - 07 ; Mercier 1932 ; etc...) but few of them had the idea to use it in biostratigraphy. For them the main target was the systematic and the description of the species and genera. Unfortunately they made some erroneous stratigraphical attributions which had been reconducted by subsequent authors (Beurlen 1934 ; Mintz 1966, 1968 ; Kier 1974) ; these had often worked on old collected specimens, even sometimes making revisions in the personal Cotteau - d'Orbigny's collections.

Methods –

Since near 10 years a little more than 2000 specimens, dispatched into about 60 samples, which size varies between 45 to 185, have been collected in classical or new outcrops in the whole Paris Basin.

The variability (including individual ontogeny) of each sample, and comparisons between one and another, have been made by mean of classical morphological studies supported with statistical tool (multivariate analysis). Preliminary results still obtained (Thierry 1974a, 1974b), are here emphazised and completed, owing tothe more consequent stock since collected. Henceforth absolutely essentiel for the best understanding of the various taxa of a living or fossil group,such a study of variability is still to day a rare thing in echinoids (Jesionek-Szymanska, 1956, 1959, 1962, 1963 ; Laurin, Marchand, Thierry, 1979).

Each sample collected have been carefully logged in time and placed upon the biostratigraphic jurassic scale of ammonites nowadays adopted. Staggered between Upper Bajocien and Middle Oxfordian the accuracy is that of a zone or even a subzone;this can be done either accordingly with the joined ammonite fauna, or that which was just below or above (fig. 1).

Furthermore, the precise geographical localization of each sample, have been accompanied with a short sedimentological study. Especially, the silt-clay-carbonates ratio and the grain-size analysis of the sediment had been noted ; these two elements appear as very important datas for explaining both some variability of the test shape and the collyritids settlements,according to the paleogeography of this west-european region (Thierry, 1984).

Such an approach, attaches importance to all facts that contribute to modify the morphology of the test : the individual ontogeny and the population variability permit to distinguish young and adult specimens, morphs and variants within a sample ; this variability may be either explained partly according to the sedimentary environment (ecomorphs) and general paleogeography (geographical subspecies) or from the stratigraphical position (chronospecies and subspecies). Thus, when all these data are known a wel thought systematic can be constructed and phylogenetic trends established : subsequently one have a sure guide to use the studied group as biostratigraphic index.

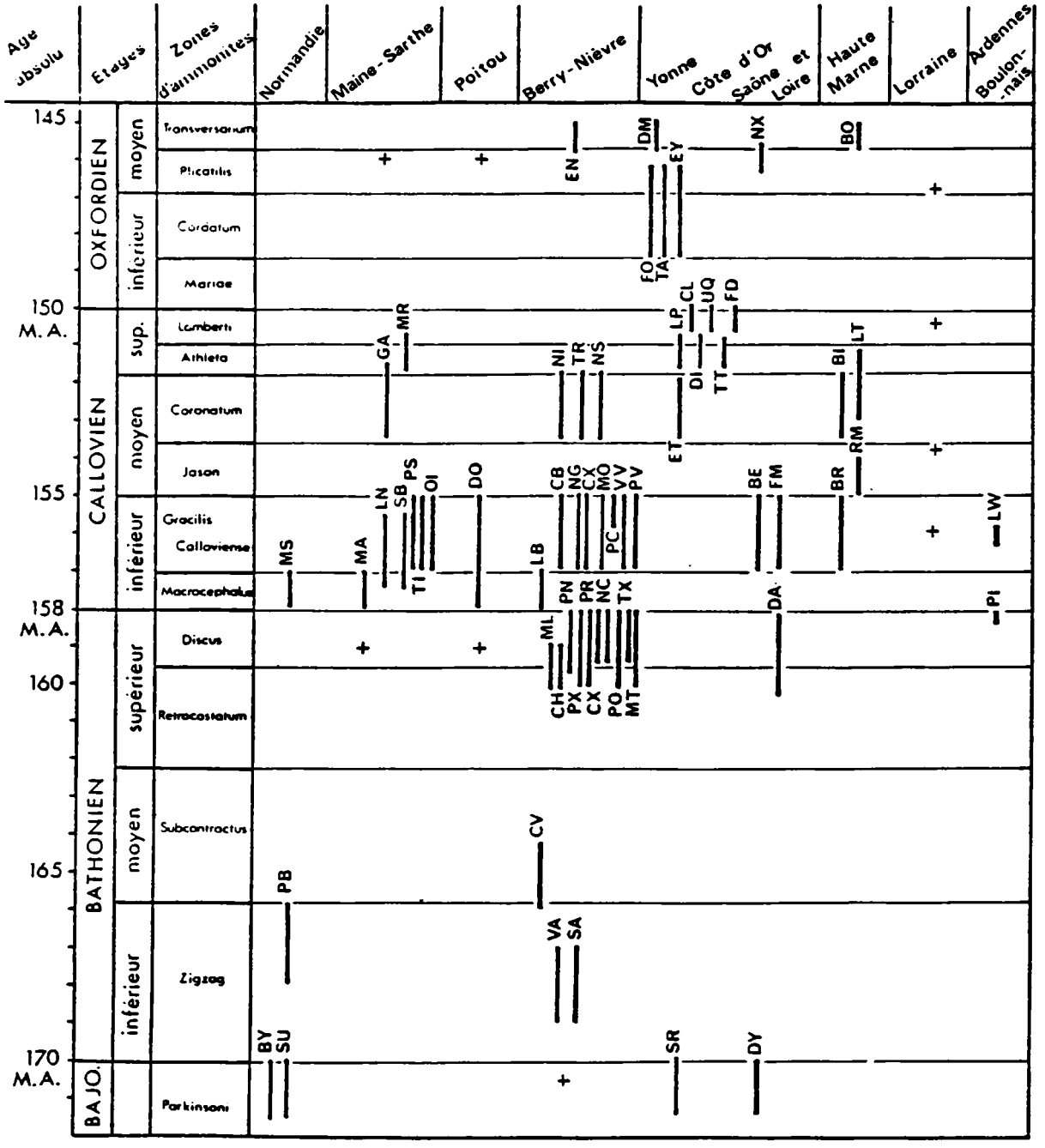

Fig. 1 — Stratigraphical and geographical distribution of the studied samples from the Paris Basin ; the crosses indicate ancient author's citations of Collyritidae without new specimens found.

Sedimentary environments and paleogeography of the Paris Basin during Middle and Upper Jurassic –

Salient sedimentary features and environmental conditions :

In the considered geographical area and whatever the chronological subdivision considered, the Collyritidae are strictly located in shallow but opened and quiet environments where carbonate sedimentation (bioclasts, lithoclasts, pellets and micrite) rises above fine or coarse detritical one (fine sands, silts and clays). The texture is more often wackestone or grainstone type, less frequently mudstone ; sediments are biomicrite or biosparite coming from the lithification of a primordial calcareous sand (grains are between 250 and 700μ). When the matrix is fairly abundant ; it is either often micritic or slightly clayish, sometimes ferrugineous. In rare cases some allochtonous oolites (oobiomicrite) or quartz sand (sandy biomicrite) can appear. The ratio between matrix and grain size has some importance about the heigh of the test (flattening or hump).

The Collyritidae totaly lack very shallow low energy and sheltered environments (internal platforms and lagoons with fine or mud carbonates) or high energy ones (bioclastic and oolitic barriers with coarse or medium sized grain sediments) as well as quiet and deeper environments (external platforms with abundant detritical muds) ; all these environments meanwhile are largely extended during this period in the Paris Basin.

Paleogeographic changes and settlement evolution of the Collyritidae fauna :

The Collyritidae settlement allows several steps correlated with transgressive periods. Appearing scarcely in Upper Bajocian they overrun gradually the basin, first in Lower Bathonian, than in Upper Bathonian, with a short recession at Middle Bathonian, which corresponds with the prevalence of unfavorable very shallow environments. Carrying on their moving forward in Lower Callovian, they have a maximum of extension in Middle Callovian, throwing back a little,once more in Upper Callovian and Lower Oxfordian. Chased out to the south of the area in Middle Oxfordian (large development of very shallow or slultered environments, often with corals buildings),they disappear from it within the substage or near the Oxfordian Kimmeridgian boundary. It is necessary to precise that Collyritidae still exist in England or in France, in the Jura mountains or more to the south (Alps, Prealps, Ardèche etc...) in Upper Oxfordian and Lower Kimmeridgian.

Evolutionary trends of Paris Basin collyritidae –

Several morphological changes or tendancies can be observed. Some of them are evidently correlated with modifications of the sedimentary environment.

— The antero-posterior length of the test increases gradually from Upper Bajocian to Middle Callovian ; a slight decrease exists in Upper Callovian and Lower Oxfordian, then, once more, an increase may be observed till Upper Oxfordian. It may be used to separate species or genera. This general increase in size is common in lineages ; one interprates this fact as a more highly adaptation of the organisms to a favorable environment. The maximum length for Collyritidae is reached in Middle Callovian with gigantic specimens ; at the same time, this family reaches its greatest geographical extension and its maximum abundance of specimens in studied sections.

— The bivium and trivium bring closer from Upper Bajocian to Upper Oxfordian. This can also be observed during the individual ontogeny : the young and small ones have a more distant bivium - trivium than the large and older specimens. Such a morphological feature can be considered as an excellent creteria (with the antero-posterior length) to separate various samples staggered in geological time. In multivariate analysis (principal componant analysis ; correspondence factor analysis ; D^2 generalized distances)it always plays the more important part on the first axis (fig. 2).

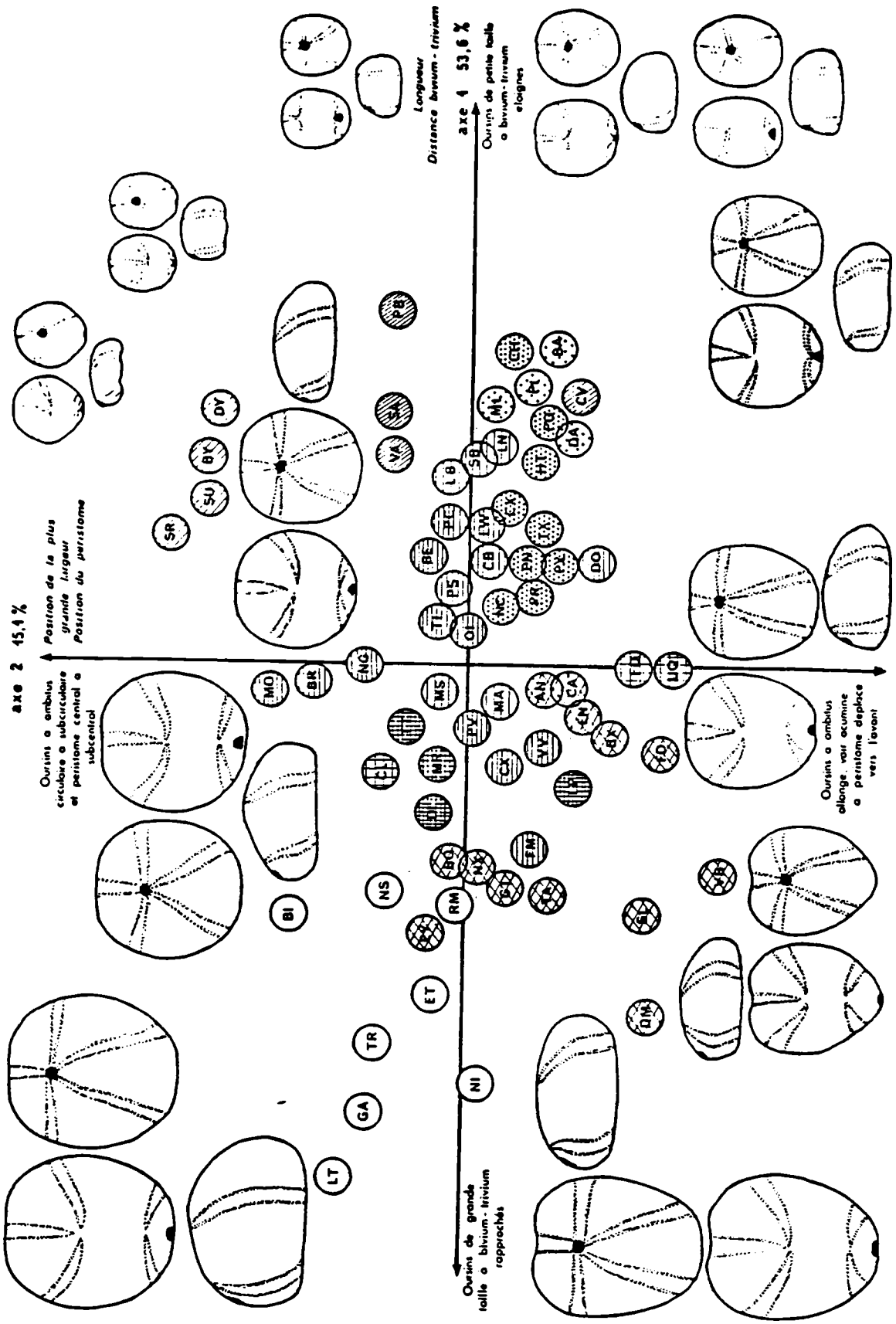

Fig. 2 — Generalized distances multivariate analysis (D^2) results : plotting on the two first canonical axis of the studied samples from the Paris Basin (five samples from the Middle Oxfordian of the Jura mountains are here added for comparison). In addition to the morphological filing samples gathered according to their stratigraphical situation : oblique lined rounds, Upper Bajocian and Lower Bathonian ; stippled rounds, Upper Bathonian ; horizontal lined rounds, Lower Callovian ; white rounds, Middle Callovian ; cross-ruled rounds, Upper Callovian ; oblique cross-ruled rounds, Lower and Middle Oxfordian.

Further more, an important morphological change occurs concerning the situation of the bivium and the periproct at the Bathonian - Callovian boundary : joined in the former they are separated in the later. This important criteria is used to discrimate *Pygorhytis - Pygomalus* genera from *Collyrites - Cardiopelta* ; it have a major consequence upon the posterior apical plates position (Jesionek-Szymanska, 1963).

— The periproct moves backward gradually into the posterior interambulacrum. Evidently supra-marginal in *Pygorhytis - Pygomalus*, it becomes step by step marginal in *Collyrites Cardiopelta*. This occurs also during the individual ontogeny where small and youngspecimens have a more supra position periproct than the large and adult ones.

Periproct progressive migration towards the posterior margin is generally interpreted as a greater adaptation to sediment swallowing (Smith, 1984). In the Paris Basin it is correlated with the extension and development of fine sediments (silty carbonate of wackstone to mudstone type).

— The peristome shifts gradually anteriorly. Central or subcentral in *Pygorhytis* and *Pygomalus ovalis*, it moves toward the anterior margin in *P. analis* and all species of *Collyrites* and *Cardiopelta*. It is a pronounced trend during the evolution of irregular echinoids that must be correlated with a change in feeding and a strongly marked unidirectional moving (Smith, 1984). Once more this morphological feature modification can be observed in the ontogeny.

— The ambitus, fairly round-shaped in *Pygorhytis* and early *Pygomalus* becomes more and more elongate and heart-shaped in late *Collyrites* and *Cardiopelta*. This modification of the general morphology can be appreciated upon the forward moving of the major breadth of the test. Some late Upper Callovian and Middle Oxfordian specimens (*Cardiopelta bicordata, C. acuta*) may have a narrowed (or acuminated) back part of the test, announcing the Upper Oxfordian species *C. capistrata*, not studied here.

Such a change in the body shape is correlated with changes in mode of life, unidirectional moving and sediment burrowing for instance. But I think that it is also related with grain size sediments : elongate (and flattened) test shape Collyritidae are more frequent in fine one.

— On the whole, the heightof the test is mostly variable, in all samples studied, showing to gether flattened and gibbous specimens with unsteady ratio. However, in some case (for instance in Upper Bajocian, Lower - Middle Callovian and Middle Oxfordian) very gibbous test largely overcome the flattened ones.

The prevalence of gibbous tests is strongly related with a coarsening of the sediment. This confirme the observations on the living species *Echinocardium cordatum* where flattened specimens are more numerous in fine, silty and clayishsands (Higgins 1972, 1974, 1976 ; Laurin, Marchand, Thierry 1979) whereas gibbous forms are in coarse sands.

— Lastly, from Upper Callovian and forward in Oxfordian time, in relation with the appearance of the lengthened and heart-shaped *Cardiopelta* test, a notch and a groove become visible on the anterior margin and ambulacrum. At the same time, the peristome is greatly shifted forward and in connection with the anterior notch through a very slight inferior groove. All these morphological changes are highly correlated and in close connection with the progressive adoption of a more fully infaunal mode of life than the first Collyritidae.

As I say above, size grain sediment has a great importance ; here the anterior groove is much more developped on flattened specimens in fine grained sediments. In *Echinocardium cordatum* (Higgins op. cit.) it is the contrary : the anterior groove is deeper in coarse sediment populations.

Stratigraphical distribution of taxas (fig. 3) –

The *Phygorhitis* lineage :

Corresponding to the family Pygorhytinae, it includes the three genera *Orbignyana, Pygohytis* and *Cyclolampas*. Only the second, with *P. ringens* was founded in Upper Bajocian (Parkinsoni zone) and Lower Bathonian (Zigzag zone ; Convergens and Macrescens subzone) ; the

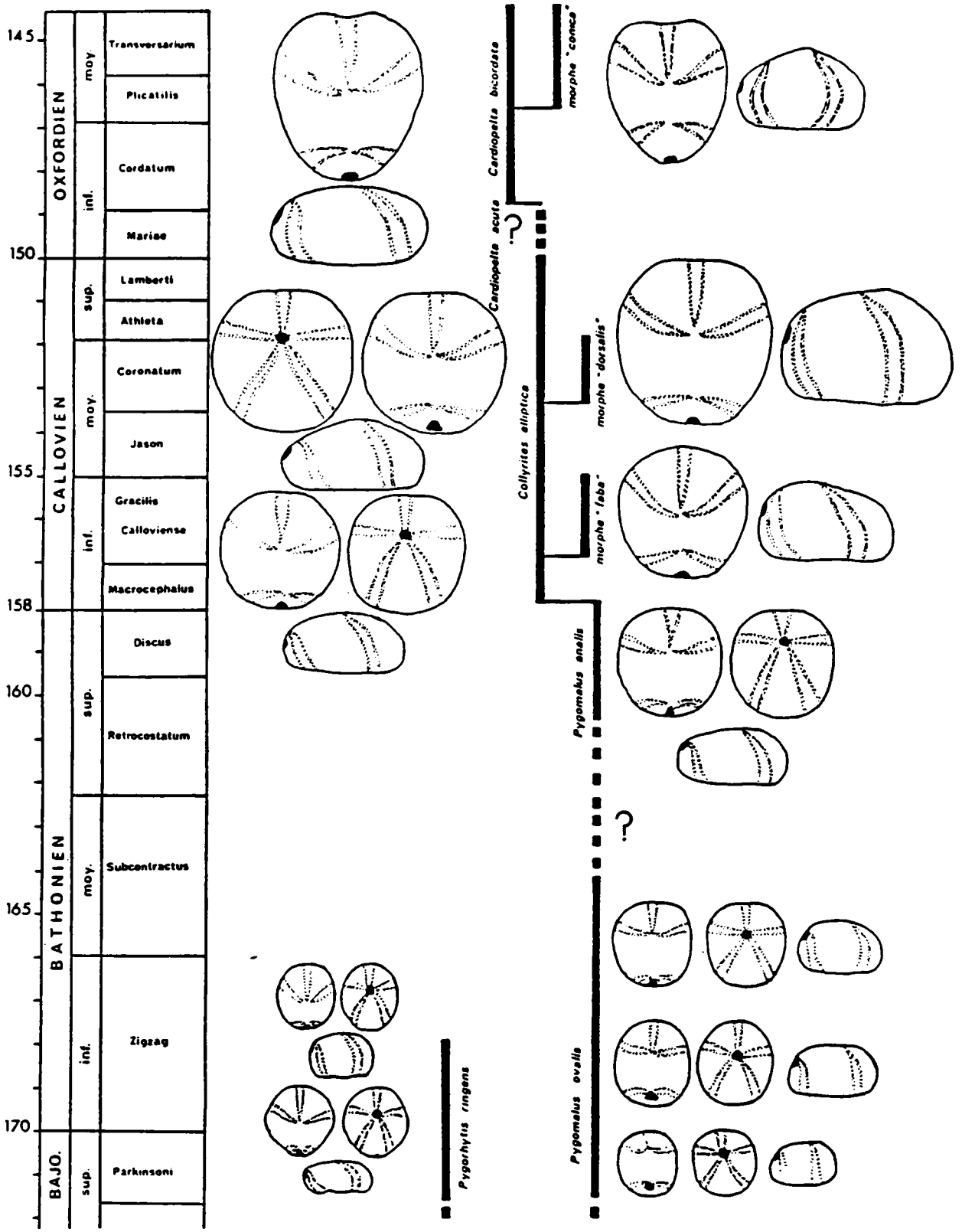

Fig. 3 — Stratigraphical distribution of the Collyritidae species and genera.

other species discribed from these levels are synonym (young specimens or variant forms). One must underline here that this genus is cited in Upper Bathonian and Lower Callovian Paris Basin by various authors (Cotteau et Triger, 1855 - 69 ; Mercier 1932) ; in spite of precise researches in the type sections of Sarthe, I never found it. *Pygorhytis*, *Orbignyana* and *Cyclolampas* (lately discovered in Upper Bajocian ; Clavel and Fournier, 1982) are the eldest Collyritidae known.

The *Collyrites* lineage :

Pygomalus, *Collyrites* and *Cardiopelta* are considered as the true Collyritinae. As I emphazised, species and generas intergrade from one another, and it is very difficult to put limits, between them.

Only one important break in the morphological features allows to separate *Pygomalus* from *Collyrites* : and can be used as a good datum line : it is the disjunction of bivium and periproct at the Bathonian - Callovian boundary. *Pygomalus ovalis* exists from Lower Bajocian (Parkinsoni zone) up to Middle Bathonian (Subcontractus zone, Subcontractus subzone). As no Collyritidae is known in the Paris Basin during the upper part of Middle Bathonian (Morrisi and Bremeri subzone) and the Lower part of the Upper Bathonian (Blanazense - Julii subzone) the distinction is easy enough with *Pygomalus analis* in Upper Bathonian (Retrocostatum - Hollandi - Discus subzones). During this time with unfavorable environments for Collyritidae, they evolve elsewhere out of the Paris Basin ; so, in fact, it is an artifical discountinuity.

Collyrites elliptica is known from Lower Callovian (Macrocephalus zone, Bullatus subzone) up to Middle Callovian (Coronatum zone) ; the distinction with the Upper Callovian (Athleta and Lamberti zones) *Cardiopelta* (or *Collyrites* ?) *acuta* is very subjective. Once more an artificial gap during the Lower Oxfordian (Mariae zone) allows a slight distinction with *Cardiopelta bicordata* in Middle Oxfordian. The typical *C. capistrata* with acuminated test is very rare in Paris Basin. The three gibbous ecomorphs *C. «faba»*, *C. «dorsalis»* and *C. «conica»* respectively in Lower Callovian (Gracilis zone), Middle Callovian (Coronatum zone) and Middle Oxfordian (Transversarium zone) can also be used as a good biostratigraphical index.

Conclusions –

The morphological changes described here do not run so fast as in ammonites or even brachiopods. In addition, as in all benthonic organisms, the sedimentary environment may interfere strongly, giving a special «morphological style» to each population studied. Nethertheless, here I claim that when one can manage such an approach I did, considering the whole fossil group in the whole sedimentary basin and showing off the space and time evolutionary trends, it is possible to use it as a biostratigraphical tool.

Now, what we must do is a same study, in others sedimentary basins, upon the same fossil group, and during the same geological period ; French Jura Mountains and Rhodanian country, Suebian, Poland, North Africa etc... may be good tests. Provisionally, it is suitable to establish a biostratigraphical distribution of the taxas parallel with that generaly adopted with ammonites. If one wants to give a name for Collyritidae biostratigraphical units, they must be «range zones». In such an anagenetic context, «phylozones» must be the best (Hedberg, 1976) : they are successive range zones where a geological serie yealds specimens which represent a segment either of a lineage or of an evolutionary trend. The most difficult which stay to be done is, as in every continuous phenomena : where can we put the limits ?

Acknowledgments –

I hope to thank the colleagues who, during several years, help me to collect the specimens : M. Rioult (Caen), A. Lebert (Mamers), J. Durand (Rennes), E. Cariou (Poitiers), J. Lorenz (Paris), J.H. Delance, B. Laurin et D. Marchand (Dijon), J. Leroux (Nancy) and A. Vadet (Boulogne-sur-Mer). I am also grateful to J.B. Marquet and D. Rousseau (Dijon) who brought into play the computer and statistical methods and to B. David (Dijon) who critically read the manuscript.

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UPPER JURASSIC AND JURASSIC-CRETACEOUS BOUNDARY

KIMMERIDGIAN AND LOWER TITHONIAN FROM THE CALANDA-BERGE AREA (IBERIAN CHAIN, SPAIN)

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F. Atrops & G. Melendez

The detailed study of upper Jurassic sections in the Calanda-Bergé-Molinos Region has led to the gathering of a fairly large Kimmeridgian Ammonites Collection. The main zones have been recognized. The successions of faunas of Ataxioceratinae, on which the lower Kimmeridgian zonation is based, appears very close to that observed in SE. France. At Platynota zone, the best characterised, the three subzones, Orthosphinctes Desmoides and Guilherandense have been recognised. Hypselocyclum zone (with Lothari Subzone), and Divisum Zone, have been, similarly, well characterised. Upper Kimmeridgian appears generally much less complete, the Acanthicum Zone being the only one always present. Locally, in some sections such as that of Val de la Piedra, the Type-Section for the whole area, the stratigraphic record ranges up to Eudoxus Zone, and even to lowermost Tithonian (Hybonotum Zone).

Despite some local peculiarities, representatives of Ataxioceratinae show great affinities with those of SE. France, and evolutive modalities and trends are the same in both regions.

I. INTRODUCTION

Many authors, among the most important A. Dereims (1898), P.F. Bulard (1972), Ph. Marin (1977), O.F. Geyer & R. Pelleduhm (1981) have remarked the existence, in the Calanda Region (N. Eastern Iberian Chain, Prov. Teruel), of a well developped, highly rich in Ammonites, Kimmeridgian succession. The main Ammonite zones, especially those of lower Kimmeridgian, have been classically recognised. Sections, however, have always been exposed and reported quite synthetically, the Biostratigraphy remaining imprecise, and the faunistic successions hardly comparable with that already established in S. Germany (Swabian-Franconian Alb) and SE. France. Therefore, we have here studied in detail numerous sections throughout the region between the localities of Bergé and Calanda (Fig. 1).

In Lower Kimmeridgian, (mainly in Platynota Zone), a fairly abundant Ammonite fauna was gathered. This has allowed to make very fine comparisons with nowadays well known successions from SE. France (Atrops 1982), - or Southern Germany, Swabian and Franconian Alb (Geyer 1961, Schairer, - 1974), with which the studied region shows the closest affinities. It is specially worth to note the good development of Desmoides, and Guilherandense subzones (i.e. Middle and Upper Platynota Zone).

Upper Kimmeridgian is similarly recognisable, though more or less - complete, and remarkably less rich in Ammonites. Lower tithonian (Hybonotum zone) appears locally present, and is here identified for the first time in Iberian Chain.

II. DESCRIPTION OF SECTIONS.

The section of Val de la Piedra in the vicinities of Calanda appears the most complete, and is here designated as type section for the region. Some other sections, though displaying an incomplete upper Kimmeridgian are, however, valuable as comparison elements with the type section, and appear as useful tools in order to establish the biozonation. In this sense these sections of Gallipuen (SW. of Alcorisa), El Cerro (SW. of Molinos), and Ermita de la Virgen de la Peña (S. of Bergé) are counted among the most important.

1.- The Val de la Piedra Section: (Fig. 2)

The Kimmeridgian from that locality has been known since Bulard - (1972, pp. 67-70; Figs. 27-28), as Morón outcrops; and are placed on the - hills dominating, at north, the Val de la Piedra Depression, just above - the road from Calanda to Mas de las Matas, along the Dam of Calanda, on - the Guadalope River. A thick series (80 m.) of lithographic limestones, with hard white marly interbeddings, gently grading upwards into thick-massive limestones, is attributed to lower Kimmeridgian by P.F. Bulard. On - the other hand, O.F. Geyer and R. Pelleduhm have recognised within this - series the Platynota, Hypselocyclum and Divisum Zones, the uppermost levels being assigned to upper Kimmeridgian (Beckeri Zone).

Upper Jurassic starts with a 5 m. thick interval of grey, often glauconitic, sponge limestones, with a rich upper Oxfordian Ammonite fauna, of Bimammatum and Planula zones. Further south (Calanda-2 section), these limestones overlay the classical Fe-oolitic level, containing lower Callovian Ammonite fauna in this region; the final levels have given some elements - characteristic of uppermost Oxfordian (Planula Zone, Galar Subzone) parti-

cularly: Orthosphinctes (Orthosphinctes) polygyratus (REINECKE), Aspidoceras (Physodoceras) circumspinosum (QUENSTEDT), Taramelliceras (Metahaploceras) litocerum (OPPEL) and Sutneria galar (OPPEL).

a) Lower Kimmeridgian:

Above the sponge limestone bank, a hardly visible marly interval, - lateral equivalent of Sot de Chera Formation (Gomez & Goy 1979), is attributed to uppermost Oxfordian, Planula Zone, by O.F. Geyer and R. Pelleduhn, with no paleontological argument but Orthosphinctes sp. This interval is followed by some 10 meters of yellow-brown limestones, more or less altered in banks 15 to 110 cm. thick, with hard, marly interbeddings 5 to 30 cm. thick (levels 10 to 33 b). This limestone series ranges in age from Platynota to Divisum Zone, ending with a distinct hardground at the top of bank nr. 33 b.

Platynota Zone: Despite the general scarcity of fauna there are good reasons to suppose that the marly interval underlying the described limestones series belongs in fact to lower-Platynota Zone (Orthosphinctes Subzone), having specially into account that the first limestone banks have given some Ammonites already characterising the Desmoides Subzone, and that the lowermost part of this same interval in the near section of Gallipuen, of a strong marly aspect, have given some scarce elements typical of Orthosphinctes Subzone.

The Desmoides Subzone (banks 10 to 16) appears well characterised - and fairly rich in Ammonites, with: S. Platynota (REINECKE) Aspidoceras - (Phys.) circumspinosum (QUENSTEDT), Asp. (Pseudowaagenia) aff microplum - (OPPEL), Taramelliceras (Metahaploceras) litocerum (OPPEL), Nebrodites - (Nebrodites) heimi (FAVRE), Orthosphinctes (Ardescia) desmoides quenstedti ATROPS, very frequent, Orth. (Ardescia) enayi ATROPS, Orth. (Ardescia) desmoides desmoides (WEGELE), Orth. (Ardescia) proinconditus (WEGELE), - Orth. (Lithacosphinctes) pseudoachilles (WEGELE), Orth. (Lithacosphinctes) aff. evolutus (QUENSTEDT) transitional form to pseudoachilles. The most - commonly recorded forms of Ataxioceratinae are those characteristic of the Enayi Horizon, recently defined in SE. France (Atrops 1982).

First representatives of Schneidia, allowing the individualisation - of Guilherandense Subzone (beds 17-19) are collected immediatly above. As in SE. France, they appear associated to numerous Orth. (Ardescia) of the desmoides group but markedly smaller in size than those of Desmoides Subzone. Atax. (Schneidia) of the guilherandense group appears specially common

in bank 19 where it constitutes the bulk of the recorded fauna. This level has given as well: Sutneria platynota (REINECKE) Aspidoceras (Phys.) circumspinosum (QUENSTEDT), Aspidoceras (Asp.) acanthicum (OPPEL), Orth. (Ardescia) nov. sp., gr desmoides (WEGELE), Orth. (Ardescia) aff. desmoides debelmasi ATROPS, Ataxioceras (Schneidia) guilherandense ATROPS, and related forms, very abundant Ataxioceras (Parataxioceras) praehomalinum ATROPS, Ataxioceras (Parataxioceras) nov. sp., Ataxioceras (Ataxioceras) striatellum SCHNEID.

Above bank 19, giving the last S. platynota (REINECKE) the series becomes markedly less fossiliferous (banks 20-27) the most common forms being Taramelliceras (Metahaploceras) which in SE. France and in the Swabian-Franconian Alb characterize still the Platynota Zone: Taramelliceras (M.) aff. rigidum (WEGELE), Taramelliceras (M.) kobyi wegelei SCHAIRER, Taramelliceras (M.) tenuisculptum (FONTANNES). Some representatives of Ochetoceras canaliferum (OPPEL) are also found, Ataxioceratinae appearing markedly scarce: - Orth. (Ardescia) schaireri ATROPS and Atax. (Schneidia) guilherandense - ATROPS are themselves characteristic of upper Platynota Zone; Orth. (Ardescia) aff. inconditus (FONTANNES), Atax. (Schneidia) aff. lusassense ATROPS, Atax. (Parataxioceras) nov. sp. aff lautum (SCHNEID) have been found in SE. France at the lower part of Hypselocyclum zone. Therefore, despite the absence of S. platynota, the levels 20-27, where the fauna shows greater affinities with that of Platynota Zone (particularly the representatives of Metahaploceras) may be here assigned to Platynota Zone though some of the recorded taxa are found in SE. France already at the base of Hypselocyclum Zone. It is, finally, worth to note the generalised absence of T. (Metahaploceras) of the strombecki (OPPEL) group.

HYPSELOCYCLUM ZONE (banks 28-30a).

It represents a quite thin interval (1 m.) with a higly abundant Ammonite fauna, the specimens being disposed in all directions within the - bed. Among the Nautiloidea it is worth to note the presence of Pseudaganides sp. Among the Ammonoidea, there have been gathered: Sutneria cyclodorsata (MOESCH), Ochetoceras canaliferum (OPPEL), Aspidoceras (Asp.) acanthicum (OPPEL), Aspidoceras (Phys.) aff. circumspinosum (QUENSTEDT), Taramelliceras (M.) aff. nodosiusculum (FONTANNES), Ataxioceras (Parataxioceras) lothari (OPPEL), very frequent, Ataxioceras (Parataxioceras) hippolytense - ATROPS, Ataxioceras (Atax.) hypselocyclum (FONTANNES), Ataxioceras (Atax.) cardoti ATROPS, Orth. (Ardescia) inconditus (FONTANNES), Orth. (Ardescia) - nov. sp., Orth. (Ardescia) nov. sp. aff. perayensis ATROPS, Garnierisphinc-

tes sp., Crussoliceras crussoliense (FONTANNES).

It is also woth to note the presence of very scarce representatives of genera Crussoliceras and Garnierisphinctes, reported as purely testimonial at the top of Lothari Subzone (Atrops 1982), and much more abundant in the Divisum Zone, They constitute in some way an assemblage typical of upper part of Hypselocyclum Zone (Lothari Subzone). However, in these levels there have been also found some forms known from the Divisum Zone, - Hyppolitense Subzone. Therefore, it cannot be completely excluded the possibility that these last levels partly belong already to Divisum Zone.

DIVISUM ZONE (bank 30 b).

This bank 25 cm. thick, which appears capped by a distinct hardground, contains, in its upper surface, a rich Ammonite fauna, clearly representative of Divisum Zone: Aspidoceras uhlandi (OPPEL), Garnierisphinctes garnieri (FONTANNES) Garnierisphinctes championneti (FONTANNES) Crussoliceras divisum (QUENSTEDT), Crussoliceras aceroides (GEYER), Aspidoceras acanthicum - (OPPEL).

b) Upper Kimmeridgian-Lower Tithonian:

Materials assigned to this stratigraphic interval form a quite thick series (50 m.), with a markedly low contents in Ammonites.

Just above level 33 b, Upper Kimmeridgian starts with a 12.5 m. thick series formed by thick marly intervals (up to 1.70 m.) with some thinner interbeddings (10-30 cm.) of irregular, highly bioturbated limestones. The - scarce collected Ammonite fauna characterizes well the Acanthicum Zone: Aspidoceras acanthicum (OPPEL), Aspidoceras (Phys.) nov. sp. aff. altenense - (d'ORBIGNY), Phylloceras sp.;Nebrodites peltoideus (GEMMELLARO), Progeronia (Hugueninsphinctes) lictor (FONTANNES), Progeronia (Huguenisphinctes) breviceps (QUENSTEDT).

This soft interval is followed by a thick series of hard, compact limestones, forming a distinct vertical cliff, with thin, flakey marly interbeddings. The lower 7 meters give an Ammonite fauna sill characterising - the Acanthicum zone: Sutneria cyclodorsata (MOESCH), Taramelliceras (Taramelliceras) pseudoflexuosum (FAVRE), and Aspidoceras acanthicum (OPPEL), - Taramelliceras (Taramelliceras) klettgovianum (WÜRTENBERGER), Sutneria eumela (d'ORBIGNY), Progeronia (Progeronia) nov sp. making it possible to individualize as well the Eudoxus Zone, (= Malm-Delta 3 and Delta 4 of the - Swabian Alb, Ziegler 1958).

A bank of thin bedded, marly limestones comes just above, giving: Lithacoceras (Subplanites) rueppellianus (QUENSTEDT), Lithacoceras (Subplanites) postrueppellianus OHMERT & ZEISS, Lithacoceras (Subplanites) aff. vicinus SCHNEID, Lithacoceras (Lithacoceras) nov. sp., Lithacoeras (Virgalithacoceras) nov. sp. aff. acricostatum OHMERT & ZEISS.

This bed represents, certainly, the level F of O.F. Geyer and R. Pelleduhn. The authors report as well the presence of Lithacoceras and Subplanites, placing that bed in the Beckeri Zone. This association in fact corresponds much better to lowermost Tithonian (Hybonotum Zone), which starts therefore in this locality with that bank.

2. SECTIONS AT THE SURROUNDINGS OF GALLIPUEN:

They are located next to the "Gallipuen Reservoir", just beside the Dam, at both sides of Guadalopillo River, near the road from Alcorisa to Bergé (Fig. 1). The profiles have been made in small ancient quarries, now abandonned.

Early references to Kimmeridgian of this region come from Bulard (1972), who reports to lower Kimmeridgian a 15 m. thick series of lithographic limestones.

The Oxfordian-Kimmeridgian transition is well exposed in section GP-1 at the right bank of Guadalopillo River: typical sponge limestones of Middle-Upper Oxfordian age are covered by a bed o.5 m. thick of brown nodulous oolithic limestone, with highly irregular upper surface. It is covered by a soft, 1.75 m. thick marly interval, lateral equivalent of the so-called "Sot de Chera Formation" (See Gomez & Goy 1979). At the top there have been recorded: Orthosphinctes (Orth.) polygyratus (REINECKE), Orthosphinctes (Orth.) polygyratus, morphotype pseudopolyplocoides GEYER, Nebrodites hospes (NEUMAYR), i.e. a typical lower Platynota Zone (Orthosphinctes Subzone) association. This interval is followed by a 15 m. thick calcareous sequence containing a rich Ammonite assemblage typical of Desmoides Subzone: Sutneria platynota (REINECKE), Aspidoceras (Phys.) altenense (d'ORBIGNY), Aspidoceras (Phys.) circumspinosum (QUENSTEDT), Orthosphinctes (Ardescia) desmoides quenstedti ATROPS, very common, Orth.(Ardescia) enayi ATROPS, Orth. (Ardescia) proinconditus (WEGELE), Orth. (Lithacosphinctes) pseudoachilles) (WEGELE).

On the left bank of the river the section may be followed as well: above the Desmoides levels, equally rich in fauna, a thick limestone series with a scarce contents in Ammonites is capped by a massive bank, ending by

a distinct hardground containing : Crussoliceras divisum (QUENSTEDT). Just below this level in the limestone beds of nodular aspect and irregular - joints, the last representatives of Orth. (Ardescia) inconditus (FONTANNES) from Hypselocyclum Zone, have been collected. Above the hardground a new, soft marly interval 12 m. thick, is covered, transgressively, by detritic material belonging to lower Cretaceous. In the lower part, a 0.85 m. thick limestone bank, again with a distinct hardground in its upper surface, - contains still a typical Divisum Zone Ammonite fauna: Crussoliceras aceroides GEYER, Crussoliceras crussoliense (FONTANNES), as well as few Nautilus and numerous Bivalves and Brachiopds (Terebratula). In its upper part, there have been collected: Progeronia (Hugueninsphinctes) breviceps (QUENSTEDT) Progeronia (Progeronia) progeron (AMMON), Glochiceras nimbatum (OPPEL), characterising already the Acanthicum Zone.

It may, therefore, be concluded that in the Gallipuen region, upper Kimmeridgian appears incomplete, the lower Kimmeridgian being much thicker (particularly Desmoides Subzone) than in Val de la Piedra section. The Guilherandense Subzone has not been undoubtedly identified; Hypselocyclum Zone, though probably present, appears markedly poor in fauna.

3. - The Sections at the vicinities of Bergé and Molinos.

Good sections of Kimmeridgian are exposed on both limbs of an anticlyne, near the Ermita de la Virgen de la Peña, southwards from the locality of Bergé. Above the Oxfordian sponge limestones, showing a distinct ferroginous-bored surface (hardground), and a soft, 20-30 cm. thick marly interval, a 5 m. thick sequence of fine shaley beige-yellow coloured, lithographic limestones has given, from the very base, a quite abundant Ammonite - fauna, characteristic of Platynota Zone (Desmoides Subzone): Sutneria platynota (REINECKE) and Orth. (Ardescia) desmoides quenstedti ATROPS, markedly abundant.

Southwestwards from the village of Molinos, near the path to Mezquita, several nice sections of Kimmeridgian materials (those of El Cerro and Loma del Pinar) are there exposed, at the side of the road. Upper Kimmeridgian usually appears, as at Gallipuen, incomplete and covered transgressi - by Cretaceous materials.

In these sections, the classical Fe-ooids level (5 cm. thick) appears just above a thick sequence of grey-white massive limestones, with no stratification joints visible, and covered by a 2.50 m. thick bank of sponge-limestones developping a clear hardground at its upper surface. It is follo-

wed by a 0.25 m. thick softer, marly interval, and then, by a 11 m. thick sequence of well bedded yellowish limestones containing a typical Ammonite faunal assemblage of Platynota Zone (Desmoides Subzone): Orth. (Ardescia) desmoides quenstedti ATROPS, Orth. (Ardescia) enayi ATROPS, Orth. (Ardescia) nov. sp. aff. proinconditus (WEGELE), Orth. (Lithacosphinctes) pseudoachilles (WEGELE), Ataxioceras (Parataxioceras) nov. sp. aff. praehomalinum ATROPS.

This calcareous series is followed by a thick sequence of massive, nodular limestones with numerous irregular surfaces, containing: Orth. (Ardescia) inconditus (FONTANNES), Ataxioceras (Parataxioceras) lothari lothari (OPPEL), Orth. (Ardescia) aff. perayensis ATROPS, Orth. (Ardescia) nov. sp., Aspidoceras acanthicum (OPPEL), from the Hypselocyclum Zone (Lothari Subzone), and may well be interpreted as the equivalent of that similarly nodulous limestones of Gallipuen, having given some scarce Orth. (Ardescia) inconditus (FONTANNES). A more tender series, 20 m. thick formed by an interbedding of marls and thin limestone layers with occasional flint nodules comes inmmediatly above. In its upper part, a grey-greenish marly limestone bed contains an abundant Ammonite fauna, characterising the Acanthicum Zone: Aspidoceras acanthicum (OPPEL), and related forms; Progeronia (Hugueninsphinctes) ernesti (FAVRE), in Quenstedt; Progeronia (Hugueninsphinctes) breviceps (QUENSTEDT); below that bank, such forms as Garnierisphinctes semigarnieri GEYER characterize the Divisum Zone. As in the Gallipuen section, the upper Kimmeridgian appears incomplete, covered transgressively by cretaceous materials, begining with a bioclastic limestone level with coarse grains of quartz.

III.- BIOZONATION

1) Platynota Zone:

It has been well characterized in all the studied sections by an abundant Ammonite fauna. The Orthosphinctes Subzone is certainly present within the marly interval covering the Oxfordian sponge limestones, though Ammonites are usually markedly scarce: Orthosphinctes (Orth.)polygyratus (REINECKE), Orthosphinctes (Orth.) polygyratus, pseudopolyplocides morphotype GEYER; Nebrodites hospes (NEUMAYR).

Desmoides Subzone, appears generally well developped, its thickness varying from one place to another: 4 m. at Val de la Piedra, 11 m. at Molinos, 15 m. at Gallipuen. Ammonites are always abundant at every level, the most common and characteristic being: Sutneria platynota (REINECKE), Aspi-

doceras (Phys.) circumspinosum (QUENSTEDT), Orthosphinctes (Ard.) desmoides quenstedti ATROPS, Orthosphinctes (Ard.) enayi ATROPS, Orthosphinctes (Ard.) proinconditus (WEGELE), Orthosphinctes (Lithacosphinctes) pseudoachilles - (WEGELE), a typical assemblage of Enayi Horizon, for the first time individualized in SE. France (Atrops 1982). The presence, at the upper part of - Desmoides Subzone, of such taxa as Orth. (Ardescia) desmoides desmoides - (WEGELE) associated to Ataxioceras (Parataxioceras) nov. sp. aff praehomalinum ATROPS makes it possible the Desmoides Horizon to be similarly present.

Guilherandense Subzone has only been recognised at Val de la Piedra section, where Atax. (Schneidia) guilherandense ATROPS and related forms appear quite common, associated, just as in SE. France, to Atax. (Ataxioceras) striatellum SCHNEID and Orth. (Ardescia) desmoides debelmasi ATROPS Sutneria platynota (REINECKE), and Aspidoceras (Phys.) circumspinosum - (QUENSTEDT) are also present. It is also worth to note the early appearance of Aspidoceras acanthicum (OPPEL).

2) Hypselocyclum Zone:

Except for the type section (= Val de la Piedra), it is normally thin and markedly poor in fauna. Hyppolitense Subzone, despite the record of the index species, is still not surely individualised. Lothari Subzone, on the contrary, is well characterised, the same association than in SE. France - having been recorded, namely: Ataxioceras (Parataxioceras) lothari lothari (OPPEL), quite common; Ataxioceras (Atax.) hypselocyclum hypselocyclum (FONTANNES), and Orth. (Ardescia) n. sp. aff. perayensis ATROPS. First Crussoliceras and Garnierisphinctes still scarce appear, as well as in SE. France (ATROPS 1982), already present in these levels.

Ataxioceras (Parataxioceras) hyppolitense ATROPS is still present. Lothari Subzone appears difficult to individualize due to its extremely reduced thickness (1 m. at Val de la Piedra Section), not to say about subdividing it into Horizons.

2) Divisum Zone:

The bulk of the fauna of this zone is formed by representatives of - Crussoliceras and Garnierisphinctes. Among the more important taxa, Aspidoceras uhlandi (OPPEL), Garnierisphinctes garnieri (FONTANNES), Garnierisphinctes championneti (FONTANNES), Garnierisphinctes semigarnieri (GEYER, Crussoliceras divisum (QUENSTEDT), Crussoliceras crussoliense (FONTANNES), Crussoliceras aceroides GEYER, Aspidoceras acanthicum (OPPEL)are specially

worth to note. Representatives of both Ataxioceras and Ardescia seem to - be already absent.

4) Upper Kimmeridgian and Lower Tithonian:

Upper Kimmeridgian is represented generally in the studied area by a tender, marly interval. Acanthicum Zone is always well characterised: Aspidoceras acanthicum (OPPEL), as well as macro and microconch representatives of Progeronia, with the species lictor (FONTANNES), breviceps (QUENSTEDT) - progeron (AMMON), ernesti (FAVRE), in Quenstedt, appear among the most common. There have also been found some scarce representatives of Sutneria cyclodorsata (MOESCH) and Taramelliceras pseudoflexuosum (FAVRE).

Eudoxus Zone may be evidenced, despite the absence of representatives of Aulacostephanus, by the record of some characteristic taxa, such as Taramellices klettgovianum (WURTTENBERGER), associated to Sutneria eumela (d'ORBIGNY) (Ziegler 1958 Hölder & Ziegler 1959). Beckeri Zone, identified by - O.F. Geyer & R. Pelleduhn, does not seem for us to be undoubtedly present. On the contrary, the here found upper assemblage well defines the lowermost Tithonian (Hibonotum Zone). The association of Lithacoceras (Subplanites) - rueppelianus (QUENSTEDT), Lithacoceras (Subplanites) postrueppelianus OHMERT & ZEISS, Lithacoceras (Subplanites) aff. vicinus SCHNEID, Lithacoceras (Lithacoceras) nov. sp. and Lithacoceras (Virgalithacoceras) nov. sp. aff. acricostatum OHMERT & ZEISS, characterizes the Hibonotum Zone, the - fail of record up to the present of representatives of Hibonoticeras being specially worth to note.

Therefore, the Kimmeridgian zonation established for both Swabian - and Franconian Alb, as well as for SE. France appears also valid for the - Iberian Chain, which may, consequently, be well regarded as a part of Submediterranean Province. As far as Betic Chains is concerned, the recorded faunistic associations are typically mediterranean in character (Olóriz, 1978), and markedly differ from these ones, the extreme scarcety of representatives of Ataxioceras being specially noteworthy.

IV) PALEONTOLOGICAL REMARKS

In the Calanda-Bergé Area the high share of representatives of Ataciceratinae during the lower Kimmedirgian, specially in Platynota Zone, makes it possible to carry out very fine correlations with coeval faunas from SE. France (Atrops 1982). Microconch representatives of Ataxioceratinace from lowermost Desmoides Subzone, i.e. Orthosphinctes (Ardescia) desmoides quenstedti ATROPS and Orth. (Ardescia) enayi ATROPS may reach, simi-

larly, a large size (over 170 mm. diameter), appearing certainly linked as well with last Orth. (Orthosphinctes) polygyratus (REINECKE), via Orth. - (Orth.) polygyratus, of the pseudopolyplocoides morphotype, GEYER .

In the same way, representatives of Orthosphinctes (Ardescia) of the desmoides group (WEGELE) display similar evolutive trends throughout Desmoides and Guilherandense Subzones towards a reduction of adult size and umbilical diameter. The same trend is also detected in, macroconch, representatives of Orth. (Lithacosphinctes) of the pseudoachilles group (WEGELE). It should be noted, however, that the observed reduction in the adult size is never so important as detected in those groups in SE. France, specially in those forms without parabolic nodes, such small-sized forms as Orth. (Ardescia) thieuloyi ATROPS or even Orth. (Ardescia) desmoides debelmasi ATROPS remaining still not found in the studied area.

Representatives of Schneidia seem, here again, to originate from those or Ardescia, of the desmoides group (WEGELE), by a reduction in umbilical diameter, several intermediate, or transtional forms having also been found. This subgenus in characterised by narrower constrictions, as well - as by the presence or ribs of the subpolyplocoid type. These ones appear, however, in the spanish representatives of the subgenus, less developped - (less numerous) than in their correlatives from SE. France. It should also be remarked the persistance, within Hypselocyclum Zone, of some representatives of Ardescia, of the desmoides group (WEGELE), contrarily to that observed in SE. France.

Similarly, it is also worth to note the early appearance of Parataxioceras at upper part of Platynota Zone, (some scarce representatives only), within populations of Ardescia of the desmoides group (WEGELE).

Therefore, and despite some local peculiarities, it may be assumed that representatives of Ataxioceratinae in both regions display the same (or similar) evolutive trends. These local differences are specially clear, in spanish representatives from Platynota Zone, displaying markedly large and thick constrictions, than "french" ones.

It should also be noted, specially as far as lower Kimmeridgian, where data are more complete, is concerned, the predominance of Perisphinctids, and the marked scarcity of Phylloceratids, Oppelids appearing always in a low share. This remark had already been made by B. Ziegler (1967, - (1980) in this same region, on the base of a less abundant material.

V) CONCLUSSIONS:

The numerous sections carried out in the Calanda-Bergé region have made it possible to characterize the main zones of Kimmeridgian. Lower - Kimmeridgian appears generally well developped and highly rich in fauna, allowing very fine comparisons with that in SE. France. Representatives of Ataxioceratinae show the same general evolutionary trends in both regions, within Submediterranean Province, throughout Platynota Zone. The three Subzones, Orthosphinctes, Desmoides, and Guilherandense, have been clearly characterised. Similarly, Hypselocyclum (specially Lothari Subzone), and Divisum Zones, have been also individualized. As far as Upper - Kimmeridgian is concerned, it is worth to note the generally good development of Acanthicum Zone. Lower Tithonian (Hibonotum Zone), has only been characterized in the most complete sections, such as Val de la Piedra. - Therefore, the Calanda-Bergé Region appears as a good reference area for the study of lower Kimmeridgian in the Iberian Chain. Evolutive modalities within Ataxioceratinae may be studied here in great detail. Consequently, the evolution of this group is actually known throughout a larger area, - which makes it possible to face the troublesome and always hard problem of geographic variation of species.

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This paper was greatly facilitated owing to a generous financial support from the Instituto de Estudios Turolenses, Teruel, Spain.

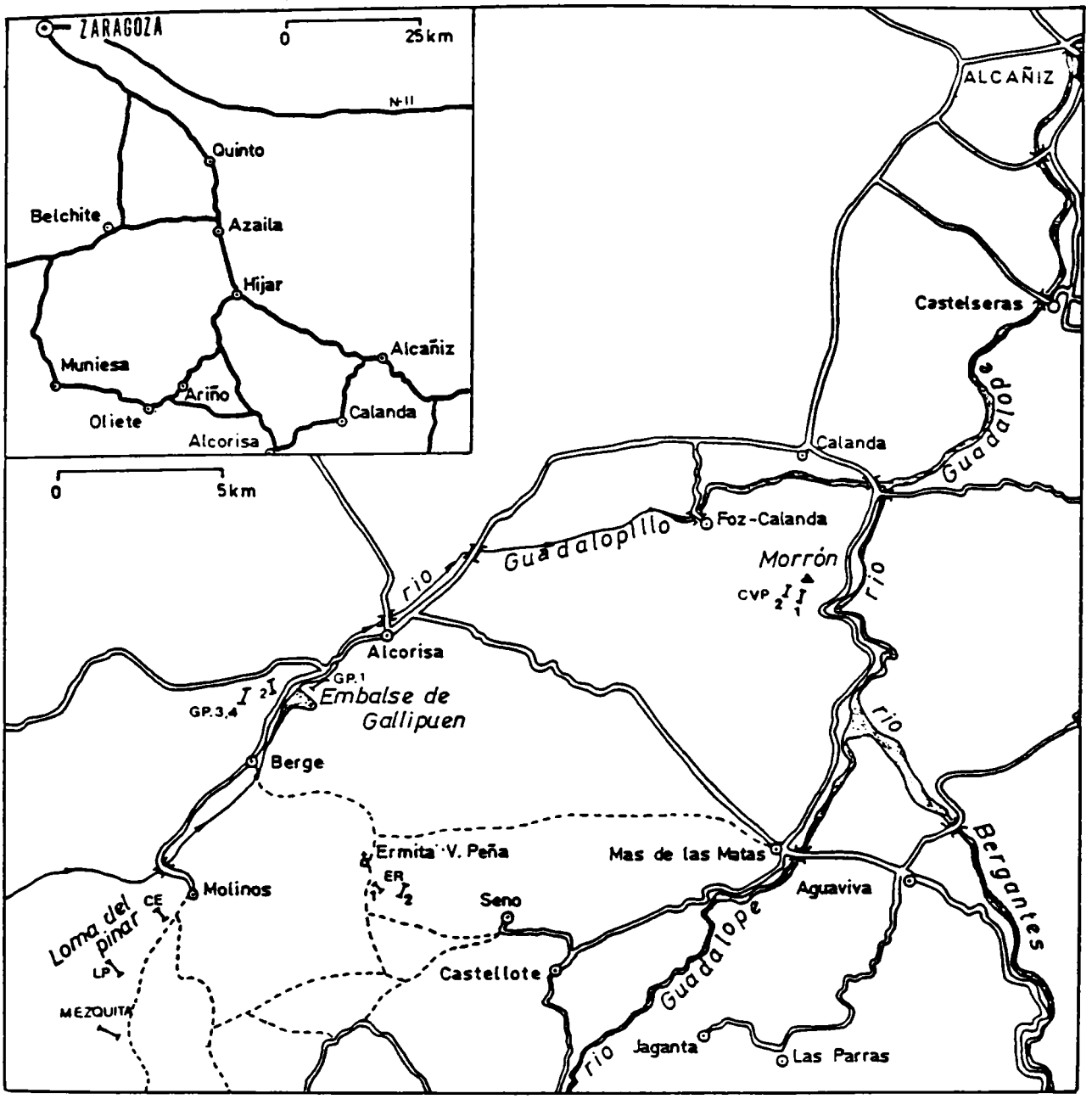

Fig. 1: Geographic frame and situation of studied outcrops.

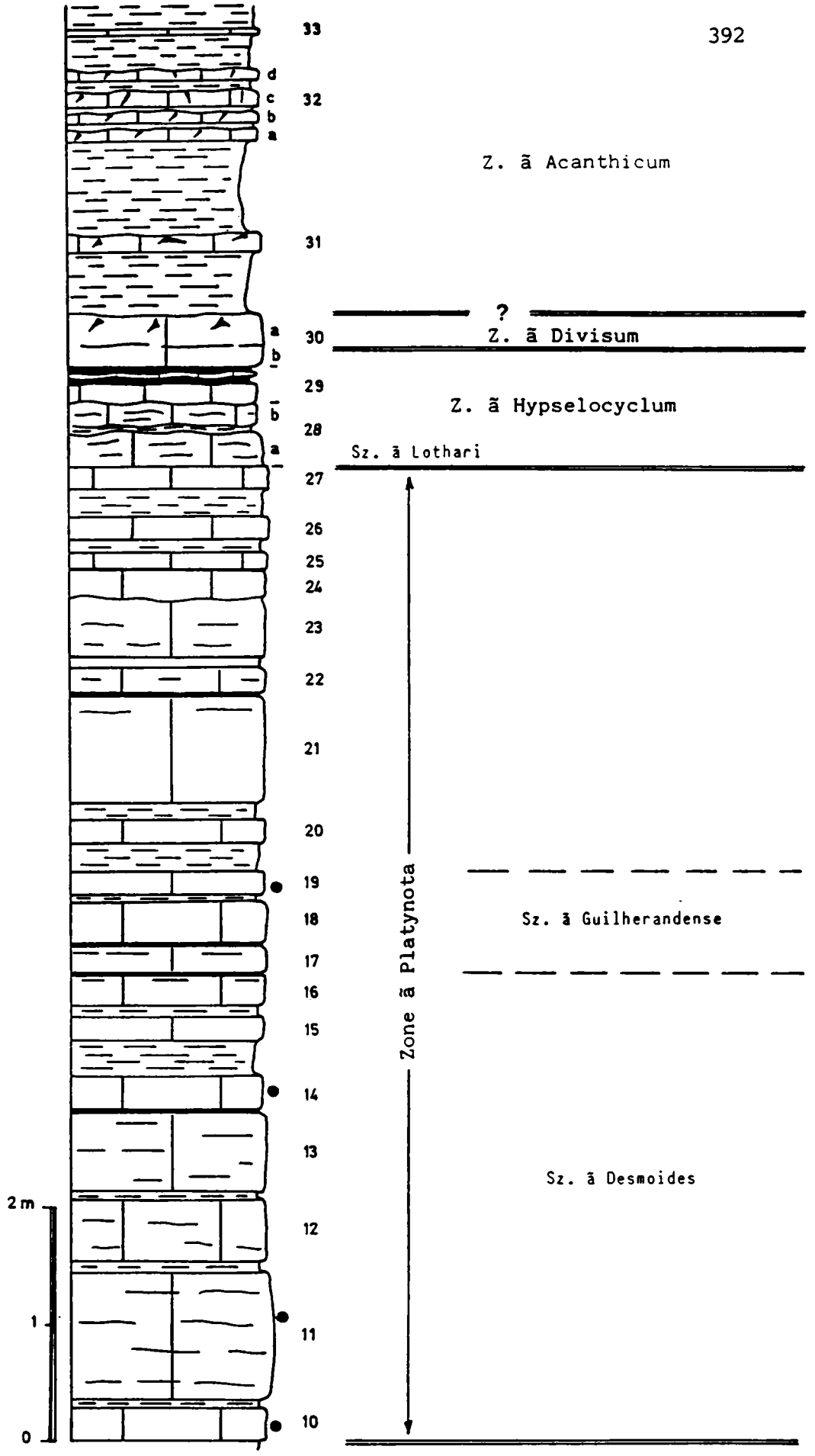

Fig. 2: The stratigraphic section at Val de la Piedra - CVP.1 - (lower Kimmeridgian, and upper, pars.).

(*): Levels with Sutneria platynota (REINECKE).

SIGNIFICATIVE MEDITERRANEAN "ASPIDOCERAS" IN UPPER JURASSIC BIOSTRATIGRAPHY

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SIGNIFICATIVE MEDITERRANEAN "ASPIDOCERAS" IN UPPER JURASSIC BIOSTRATIGRAPHY

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On the basis of paleogeographical, paleobiological and stratigraphical criteria is possible to obtain an evolutive scope of the mediterranean "Aspidoceras", and so, the taxa with higher bioestratigraphical significance. In this context the quantitative approach has been a profitable source of information.

Given this, in the present work the most significative chronological implications deduced from the application of a new systematic ordering are advanced.

According with the obtained data, a higher biostratigraphical yield in the upper Jurassic during the Kimmeridgian is recorded. Always at a level lower than that of the substage, the contributions of the different genera are the following:

- Aspidoceras: five species; four in the Kimmeridgian and one Kimmeridgian-Tithonian.

- Pseudowaagenia: three Kimmeridgian species.

- Orthaspidoceras: three Kimmeridgian species.

- Physodoceras: one Kimmeridgian species.

Two new genera appear as being good markers at the base of the Kimmeridgian and of the Tithonian.

Occasionally, the acmé of some species is considered as having biostratigraphical significance.

INTRODUCTION:

Upper Jurassic ammonites of the Betic Cordilleras, in Southeastern Spain Peninsula, have been object of detailed studies since 1973. Among published works are of special interest those of ENAY & GEYSSANT (1975), OLORIZ (1976) and

OLORIZ y TAVERA (1981), where a first biostratigraphic scheme and comments on the Tithonian association, the first stratigraphic scheme of the Kimmeridgian and detailing on lower Tithonian, within the framework of a first approximation to detailed paleontological study, and a general view of subbetic upper Jurassic with commentaries about Subbetic basin, the developed facies and quantifications on faunal association, are respectively studied.

Qualitative interpretation on Tithonian "Aspidoceratidae" findings by ENAY & GEYSSANT (1975), recent paleontological studies by OLORIZ (1976) based on the guide-lines of BUCK (1958), and quantifications of upper Jurassic "Aspidoceras" by OLORIZ & TAVERA (1981) -determining the percent participation of this component in the association- are the basis for this work.

The object of this research is to obtain a reading of the fossil record through a new systematic proposition -CHECA (1984)- and thus reaching a double effect: the obtaining of a detailed biostratigraphy, that will even allow to know intervals of maximal frequency, and the deduction of evolutionary considerations that are only outlined here. The data here collected are based upon an earlier research by the authors, especially Checa, that from 1979 has deepened on monographic studies of mediterranean "Aspidoceras". A null hypothesis on the evolutionary behaviour of this group is presently in press -CHECA & OLORIZ (1984).

The main reason that leads to refer the fossil register to a new systematic approximation originates on the needs to unify criteria, so that to interpret the dynamics of that group of ammonites, that during 15.10^6 years appears as standout component of the association within an ample differentiated paleobiogeographic distribution. On the other side, only a monographic study was allowed to reach a view without interferences, brought in by the treatments of different authors during more than a century.

METHODS:

Quantifications have decisive weight on the development of this research, thus implying directly the materials upon which work is done and its proccess of obtention, in other words, its sampling. Biostratigraphic scale turns out to be another main factor to which data will be later referred.

Material and sampling: Collections by OLORIZ (1976 and later) and CHECA (1979,

1984) have been studied, as soon as material coming from joint recollections of the authors, where special sampling technic has been carried out. As against other traditional practises, where differences in sampling deepness can be relatively frequent at different levels of a certain profil, preparations from top to bottom and successive outcrop surfaces with an approximate minimum of two square meters are prepared. These surfaces belong to rocky bodies of 10 to 15 cm. of maximal width. Consideration of maximal width implies that strata geologically differentiated have been subdivided with special attention to omission surface traces fused within other internal discontinuities or irregularities -this is specially interesting in the study of "condensed pelagic biomicrites" facies; cf. COMAS et al (1981) and MARTIN-ALGARRA et al (1983). This sampling technic not only allows for a better precission of biostratigraphical control, but it substantially improves the possibility of statistical approximation, diminishing the risk implied by punctual sampling. At the same time, simplifies the obtention of detailed sedimentological information, in any case complementary and often inevitable for a better interpretation of the fossil record.

In general, sampling has to be considered representative for it is the result of collections within profils distributed in a large geographic area, where upper Jurassic materials are geologically differentiated -areal distribution, paleotopographic location, deposit conditions, thickness... cf. OLORIZ (1976), COMAS et al (1981), CHECA et al (1983), MARTIN-ALGARRA et al (1983). A great number of samplings -950 specimens- originate from recollection carried out at the Kimmeridgian-Berriasian interval following sampling uniformity criteria. the rest has been obtained by intensifying sampling of those levels where "Aspidoceras" are more frequent and/or aboundant -Kimmeridgian to lowermost Tithonian. This has been unavailable face to a deep study of this ammonite group. As of now, terminal Oxfordian record should be considered comparatively defficient in number, even though may be evaluated as sufficiently representative given the low diversification of pre-Kimmeridgian "Aspidoceras". In summary, total collection size has been of 1.577 specimens: 1.275 Kimmeridgian; 340 Tithonian; 90 Oxfordian; 2 Berriasian.

Biostratigraphic intervals: The biostratigraphic scale of reference is that of OLORIZ (1976) and OLORIZ y TAVERA (1983), with a single modification incorporated by OLORIZ y TAVERA (1981) as far as a proposition of fruitful subdivision of Kimmeridgian, that includes the middle Kimmeridgian denomination for the interval of strata with O. uhlandi (OPPEL) -upper part of the Divisum zone- and those where the Kimmeridgian Hybonoticeras fauna develops -Beckeri

As far as Kimmeridgian, some of the known intervals show certain peculiarities that are associated to facies imposed by paleogeographic location and, more in detail, by paleotopography. The almost generalisation of Ammonitico Rosso facies where it is often difficult to differentiate strata or rock-bodies geologically individualized, does not simplify a feasible registry of great precision correlations, due to changes in thickness, coining, changes in detail in lithofacies, increase of nodulisation... Also, ammonite association characteristics imply a certain indefinition in some level when trying zonal or interzonal characterisation. This is particularly noticeable in the central sector of the Subbetic Zone for Platynota zone and middle Kimmeridgian -interval zone of Compsum and Cavouri zone. (OLORIZ, 1976, 1979; OLORIZ y TAVERA, 1981). Limitations of terminal Oxfordian are given mainly by factors associated to sedimentation. The situation is generally more favourable in Tithonian, even though difficulties are there for intrazonal subdivision, induced mainly by the conservative character of the fauna, specially Perisphictids.

As a result of the incidence of the indicated factors, it has not been possible to offer the same intrazonal yield for all recognized biozones. Intervals that have allowed for greater intrazonal biostratigraphical precision are the Strombecki an Divisum biozones, the interval zone of Compsum and the Beckeri, Hybonotum and Verruciferum biozones. Anyhow, information shown by the sampling carried out, as described, allows to foresee a high rate of precision within a short time. So far, it has been preferred to unify the expression of biostratigraphic intervals within its temporal extension, and therefore, not responding to the distribution of partial thickness. Further works have been carried to obtain a detailed thicknes correlation record.

Quantifications: Controling the number of individuals by stratum or level of reference, all registers by interval have been accounted for. Specimens that by its provenance do not allow for an accurate stratigraphical assignment, have been discharged. When material shows a register that affects a limit between zones or to a gap of time, unless it is not feasible to recognize its concrete location within the column, numerical expression has been obtained by dividing the "rough" data proportionally to percentages given by unequivocal stratigraphical register. This treatment accounts for fractionary counting that has been rounded up by excess or default -40.4 approximates 40. In nc case indetermination was greater than the substage level.

Results thus obtained have been stratigraphically selected in agreement with the systematics proposed. This way, a general view of the behaviour of the fauna studied can be provided, along the time and within each interval, at family, genus and species level. In each case, the frequency is expressed in absolute frequency figures and rigurously reflected in the lateral extension of each species within the interval studied. To graphs that exclusively include information selected from a strictly systematic point of view, data discharged in other representations have been added, provided that systematic identification were not problematic.

RESULTS:

Figure 1 shows a hystogram of absolute frequencies referred to considered stratigraphic intervals -biozones. Occasionally, subdivisions have been observed at stratigraphical intervals that reflect the possibility to obtain a greater detail of information. It also implies that the hystogram reading should account for "comparative distortion" that implies redistribution of data of a standard interval -biozone- in others of second and ever third order -this is that the hystogram will show the "falls" induced by the greatest stratigraphical precision. Maximal frequency of Aspidoceratiforms is reached at the top of lower Kimmeridgian -Divisum- as shown in Figure 1. This implies a sevenfold greater register than that of the Bimammatum zone -upper Oxfordian- where the group originates.

A small increase of approximately 3% occurs at last Oxfordian strata. Already in the Kimmeridgian -Platynota zone- frequency increases a 67% with respect to the previous record, showing previously the tendency that will reach the maximum at the Divisum zone. During middle Kimmeridgian there is a marked fall of the fauna -31% less than the maximum of Divisum zone. This tendency will keep on till the extinction of the group at the Berriasian. Results are: upper Kimmeridgian ,Beckeri zone, 41%; lower Tithonian: Hybonotum zone 50%, Albertinum zone 75%, Verruciferum zone 86%, rest of lower Tithonian 97.5%. During upper Tithonian and Berriasian decrease is greater than 99% of the maximal frequency registered in Divisum.

Given this general view it may be interesting to analize its behaviour respect to the recognized taxa at the genus level. There are eight genera belonging to two subfamilies: Aspidoceratinae (Aspidoceras and Pseudohimalayites) and Physodoceratinae (Physodoceras, Benetticeras gen. nov., Orthaspidoceras, Simaspidoceras, Pseudowaagenia and Schaireria gen. nov.).

Aspidoceratinae (fig. 2)

Genus Aspidoceras: It shows the greatest stratigraphic distribution. The maximal frequency is registered at the Divisum (Uhlandi subzone)-Compsum interval, arriving to triple its presence as related to other pre-Tithonian levels. A fall of 60% is observed at the beginning of the Tithonian as compared to its representation at upper Kimmeridgian -Beckeri zone- even though that fall is of only a 80% of the lower third of the zone. During Verruciferum the drop is of more than 80% respect to final Kimmeridgian. Following registers show decreases greater than 97%.

Genus Pseudohimalayites: The scarce number of collected sample does not allow any significant comment. It represents 25% of Aspidoceratinae and 12% of total Aspidoceratiforms at the upper part of Verruciferum, which shows the scarcity of the group already in full decadence.

Physodoceratinae (fig.2)

During upper Oxfordian -Bimammatum zone- the two basic structures of this subfamily are registered -Physodoceras and Pseudowaagenia. Before middle Kimmeridgian the basic type was Physodoceras.

Physodoceras is 85% of Physodoceratinae at Bimammatum zone. At the Planula zone Physodoceras reaches 85% and a related type -Benetticeras- the 25%. The appearance of this last type reaches its maximal representation during Platynota zone -22%- and both genera account 99% of Physodoceratinae. There may be a correlation within this subfamily, between the disappearance of Benetticeras and the maximum of Physodoceras -97%- at the Strombecki zone. At the final strata of lower Kimmeridgian -Divisum zone- two new genera are registered -Orthaspidoceras and Simaspidoceras. Again, the dominating rôle falls on one of them, Orthaspidoceras, with a 79%, while Simaspidoceras accounts for 4%. Physodoceras, that was previously the dominating one, falls to 9%. It should be remarked that the other basic structural type of Physodoceratinae -Pseudowaagenia- recuperates levels near to those registered at its origin, 12%.

An unprecedent descent of the level of this subfamily -its representation falls in a 68%- is observed at the lower part of middle Kimmeridgian: Orthaspidoceras 15% -down 94%- Simaspidoceras 6% -down 50%- and Pseudowaagenia 69% -up 100%. The first registers of Schaireria are observed, 8%. Of the structural types, only Pseudowaagenia is represented at upper Kimmeridgian. In an interval where

the subfamily increases in a 30%, Pseudowaagenia does 86% and Schaireria 14%.

During lower Tithonian results show a maximum at Hybonotum zone with 99% for Schaireria and 1% Pseudowaagenia that is in its last and scarce register. Successive descent are produced at Albertinum and Verruciferum zones, that affects in each case an approximative 40% of the subfamily, now in clear descent. For the rest of the lower Tithonian, registers are absolutely residual.

Results at the species level

Control of quantifications at a specific level shows new and numerous fluctuations of fossil record. No comments have previously been made about intra zonal results for it was understood that information could be easily obtained from the graphs presented. Several comments will be made at the species level where specific representation are needed, regarding the most relevant species studied. Numerical expression of data is shown in figure 3 and its graphic representation in figures 4 and 5.

ANALYSIS OF RESULTS:

As it was observed by sampling of the four stages analized -Oxfordian to Berriasian- (figs. 1 and 3) register is progressively increasing just to the base of Divisum. Comparing the curve of the set of Aspidoceratiforms register with the eustatic curve of HALLAM (1978) a considerable parallelism can be deduced, being quite significant considering that Aspidoceratiforms should be among the most ubiquitous ammonites respect to facies. It is to remark that both curves adjust better at lower levels than middle Kimmeridgian. From there, a certain "dissonance" is observed that has a dual interpretation. At distal environments -mediterranean fauna in general terms- where environmental fluctuations were almost not felt, it should be expected a lesser adjustment; at proximal environments -submediterranean fauna- correlation could be greater, even though "local distortions" could be frequent and therefore ecological tolerance of this group should contribute to lessen environmental effects. Quantifying, it can be seen that maximal register of the top of lower Kimmeridgian implies a sevenfold increase of Oxfordian record; for a later similar equivalent interval on the descending branch of the fossil record of Aspidoceratiforms, decrease is only 50%, thanks to the "Tithonian renovation" -Schaireria, A. zeuschneri ZITTEL group. In relation with the so called "Tithonian renovation" is to be observed the fact that occurs in a moment when at least qualitatively -after the biostratigraphic correlation of the eustatic

curve of HALLAM (1978) in ENAY (1980)- sea level reached is comparable to that of the basis of the Kimmeridgian. Given that in both cases a repetition of basic structural types is registered, ecological factors could be implied -in this sense, it should be remained that maximal transgressive occurs with maximal frequency of this group and altogether with the greater diversification of basic structural types.

At the subfamily level, results are shown in figures 1 and 3. It should be emphasized the great difference at the diversification rate. In Aspidoceratinae, a single genus -Aspidoceras- balances out the spectrum of Physodoceratinae. This can be interpreted as an evidence of structural stability produced by the subjacent ecological tolerance of this genus. Even though this seem to be so at a first glance, it implies a paradox. Is it correct to speak of ecological tolerance in a stable environment? Two previous facts are evident: 1) an environment is considered stable when, besides global data such as Temperature, salinity... no other fluctuations of environmental parameters with innovation capacity are observed -plancton or other factors determining facies; paleotopography, even though differentiated, appears not to influentiate as far as this problem is concerned. 2) ecological sensibility should have two determining factors considering the extreme terms within a continuum of interrelationship; thus, in this case -an environment without apparent oscillations- the determinant will be endogenous or of biological character, tied to inherent limitations of a given organic functional mechanism.

Therefore, it may be interpreted, given the environmental conditions of distal environments, that the structural stability of the genus Aspidoceras should be linked to its physiological requirements and that the ecological tolerance mentioned reflects its low level of requirements of the environmental parameters as related to its biological answers. This interpretation implies a hypothesis such that final typic diversification is favoured in low stress environments. It is assumed, hereafter, for any further observation, the hypothesis that Aspidoceratinae and Physodoceratinae were two ammonite groups of similar non-induced change potential.

Looking again differential diversification of Aspidoceratinae and Physodoceratinae, the following observations will be carried out preferently at the species level, even though the systematic scheme of reference can be considered as homogeneous for it is the proposal of a single author -CHECA (1984). In any case , the main object will be the behaviour of the group at the subfamily level. As a consequence, two time intervals have been differentiated,

correlationable with the eustatic curve for that period of time, and two faunal associations with its genus-specific composition as related to subfamilies studied:

	Mediterranean fauna	Subbmed. fauna	
Pre-middle Kimmeridgian	2 Ph.,1 Btt.(1),3 O.(1) 1 S.: 7 (3)	2 Ph.,2 O. 4 (0)	Physod.
	4 A.(2) 4(2)	2 A. 2 (0)	Asp.
Middle Kimmeridgian-lower Tithonian (Albertinum zone)	3 Psw.(2),4 Sch., 1 O. 8(4)	2 Psw.(1),3 Sch.(1) 1 O.(1): 6 (3)	Physod.
	5 A.(4) 5 (4)	4 A.(1) 4 (1)	Asp.

Comparison between species of intervals I and II evidences that diversification of mediterranean Aspidoceratinae fluctuates about the 60% of that reached by Physodoceratinae, being slightly greater at interval II. Within submediterranean fauna level may be reduced to the 50%. In general, submediterranean association keeps a 62% level of mediterranean diversification. Nevertheless, a deviation is observed at interval II where submediterranean diversity goes from 54% to 69%. Considering fauna that is significantly related to paleogeographic area -numbers parenthezised in table 1- it will be seen how the 15% increase of diversification of interval II appears tightly related to the existence of real endemisms in submediterranean association. On the other side, it is of great interest the different rôle of the genus Aspidoceras within the two associations studied. this should be interpreted in agreement with the hypothesis mentioned about their greater physiological limitations, now restricted by environmental stress resulting from the progressive accentuation of the eustatic fall at the submediterranean province. In this line, the lesser diversification rate of submediterranean fauna permits a better evaluation of the capacity -or volume- of the stable mediterranean environment, that offered greater opportunities for diversification than submediterranean did, regardless that at this last one areal restrictions were noticeable.

At the genus level (fig. 2) mediterranean Aspidoceras do not offer stratigraphic yield. Its maximal frequency is linked to eustatic maximum and does not correspond to the time of greater specific diversification, that occurs at the base of interval II, and seems to correlate with the moment of greater geographic dispersion. As a consequence, the importance of geographic factor on diversification may be comprehended. Pseudohimalayites appears as an anecdotic

evolutionary branch, but of greater stratigraphic significance.

Differences of shell configuration in Physodoceratinae recommends to separate two lines: Physodoceras line -Physodoceras, Benetticeras, Orthaspidoceras, Simaspidoceras- and Pseudowaagenia line -Pseudowaagenia, Schaireria. The first one is restricted to interval I and, always at a low specific diversification level, there are several differences. On the contrary, it is observed a considerable frequency fluctuation related to eustatic maximum of the top of lower Kimmeridgian. At the genus level there is no stratigraphic signification of zonal order, except in the case of Benetticeras that seems to announce the following subgroup -Orthaspidoceras, Simaspidoceras- with greater diversification. When greater diversification is shown, the influence of geographical factor is evident and emphasized stratigraphical imbalance -sub-mediterranean and ethiopian fauna- reaching eventually almost zonal significance.

The second line -Pseudowaagenia, Schaireria- shows no relevant data at interval I. the oldest forms show a progressive change at species level. Both in mediterranean association -dietli- and in submediterranean one -hermanni- smaller deviations of that tendency have been detected. Greater alterations are responsible for Schaireria emergence, where morphological oscillations are considerable. This set of forms -Schaireria- gives rise to "Tithonian renovation", where structural models -that will be commented later- of interval I are repeated, even though should be caught in mind that this repetition keeps a significate equivalent within the subfamily configuration. Similarly to older forms, it is not possible to find zonal yield at genus level and geographic factor appears not to affect but the emergence of evolutionary marginal species -Sch. episa (OPPEL).

Given the object of this work. considerations at species level are restricted to those of stratigraphic interest. In this sense, should be beared in mind total distributions and acmés (figs. 3, 4 and 5). There are great differences as far as total distributions. As a set, there is a greater proportion of longevous species -minimum three zones- of Aspidoceratinae, while species with less than a two zones distribution are more aboundant in Physodoceratinae. Anyhow it should be brought out (fig. 6) that with the exception of O. uhlandi (OPPEL), all species of both subfamilies have older registers at mediterranean associations. This explains migrational movements of this ammonite group. Generally the greater stratigraphic precission seems to concentrate on the central part of both mediterranean subfamilies distribution. Pseudohimalayites,

as always, is an exception.

The acmés consideration is observed in figures 3, 4 and 5. First of all, it should be remarked how a maximal frequency interval never reaches the duration of two zones, being restricted ocassionally to only half a zone. Also, of great interest is acmés distribution. Maximal number of species at acmé phase occurs at Divisum zone -eustatic maximum. At that time, acmés of greater size are produced. With the exception of upper Kimmeridgian and the basis of Tithonian -three species- there are never more than one species at maximal frequency phase, implying a considerable alteration of subfamily configuration. Finally, acmé location appears to be tied up to environmental behaviour -acmés tend to approximate eustatic maximum, independently of the stratigraphical distribution of species. Thus, species originated before eustatic maximum and disappearing near that event will have their acmé at the end of its evolutionary course. Its corolary is also truth.

A comment is deserved by the interval of maximal frequency occurring at lower Tithonian -Hybonotum and Albertinum zones. This is what "Tithonian renovation" is. It is a remarquable diversification phase for not only two new species originate -Sch. avellana (ZITTEL), Sch. neoburgensis (OPPEL)- but that its emergence implies total dominance in the Aspidoceratiforms spectrum. Also of great interest is shell configuration of both species. They are globular forms, tuberculate or not, a repetition of some of the oldest Physodoceratinae -Physodoceras, Benetticeras- of lower Kimmeridgian. This configuration implies a clear deviation of characteristic design within the evolutionary line of Pseudowaagenia, where they belong. Finally, the stratigraphic position of the interval where this evolutive event appears is of interest. Considering the evolutionary history of Physodoceratinae in parallel with the eustatic curve of HALLAM (1978), certain relation may be deduced in a way such that globular types of Physodoceratinae appear at distances of eustatic maximum that imply similar levels. The "repetition" of the lower Tithonian signifies the revitalisation of a line where specializing reached a high grade and the generalisation of basic types, resulting almost exclusive at the subfamily spectrum, as previously registered at lower Tithonian

CONCLUSSIONS:

a) Intensive sampling, and with the greatest stratigraphic detailing and strictness allow a quantitative approximation to evolutionary behaviour of Aspidoceratiforms.

b) As quantified, the evolutionary model excludes simultaneous generic codominance within one subfamily. For a certain structural type, acmês are out of phase within the time. At Aspidoceratiforms level, coincidence is interpreted as an expression of ecological differentiation.

c) Within the two differentiated evolutive lines of Physodoceratinae -Physodoceras and Pseudowaagenia- as far as different basic structural types, they evidence a different evolutive model within their respective acmês: diversification and specialization.

d) The wide stratigraphic distribution of mediterranean Aspidoceratiforms allows to compare the evolutive course of the group -defined as the absolute size of populations- with the eustatic curve proposed for that period of time. Also, the ubiquistic character of this fauna, gives significance to the sensible paralellism among both traces. In this sense, disagreements observed after lower Kimmeridgian are interpreted on ecological bases: scarce incidence of fluctuations at distal environments, and ecological tolerance and local paleogeographic factors at proximal environments. Another factor that punctually affects, no doubt, the design of the evolutionary course of this group is the specific diversification level. Any case, there seems to be a repercussion of the environmental volume on global size of populations.

e) Evolutionary stability of the basic structural type Aspidoceras -Aspidoceras genus- within an environment with no great fluctuations is interpreted as expression of physiological limitations. Tighly bounded to it should be considered differential diversification, in paleogeographical terms, between Aspidoceratinae and Physodoceratinae.

f) The greatest diversification in the mediterranean association positively values the stability and volume of the environment at the Aspidoceratiforms evolution. Geographical factor plays an important rôle in specific diversification at proximal environments in the associations -endemism.

g) At the genus level, stratigraphic yield is greater in groups with smaller morphological stability. In Physodoceratinae, Benetticeras, Orthaspidoceras and Simaspidoceras restrict their distribution in each case to a maximum of two zones. Within Aspidoceratinae the exception to null stratigraphical yield is Pseudohimalayites that breaks morphological stability of the subfamily.

h) At the species level, greater proportion of longevous species is found in Aspidoceratinae -binodum, sesquinodosum, longispinum, zeuschneri, rogoznicense-

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while distribution of less than two zones is more aboundant in Physodoceratinae -ziegleri, garibaldii, uhlandi, bucki, dietli. Species that offer the greatest stratigraphic precission -one biozone or less- are: Aspidoceratinae: linaresi, steinmanni; Physodoceratinae: uhlandi, bucki, dietli.

i) At the species level, the maximal frequency interval -acmé- never reaches two zones and is occasionally restricted to half a zone. Species belonging to a very stable structural type may even show a second acmé.

j) An interesting relation among the stratigraphic position of acmé of each species and the absolute frequency curve, with a sensibly parallel tracing to that of the eustatic curve, is observed. Independently of stratigraphic distribution species, acmé tends to approximate the maximum of absolute frequency of the group and, at the same time, the eustatic maximum. Coincidence of eustatic maximum with the greater number of species at acmé phase is recognized.

k) From the non-coincidence of specific acmés within a subfamily, it is deduced the considerable alteration that implies the existence of species at maximal frequency phase with regard to the internal configuration of the subfamily. In the case of the "Tithonian renovation", this effect bypasses off subfamily limits and affects all Aspidoceratiforms.

l) "Tithonian renovation" turns out to be an evolutionary event where types already tried with success during lower Kimmeridgian -structural type Physodoceras- are repeated, and that implies a deviation from the specialization line previously dominant. Agreeing with this, the earliest manifestation of globular types -Physodoceras- and its repetition -Schaireria- are registered at "distances" from the peak of Divisum zone that imply comparable eustatic levels.

m) In the mediterranean association, the stratigraphic record of a given species is always oldest than in the submediterranean one -O. uhlandi (OPPEL), whose register is coetaneous in both environments, is an exception, even though the fact that this simultaneity could be an artifact delivering from its utilisation as an element of correlation, should not be discharged. This allows to interpret migratory directions towards proximal environments.

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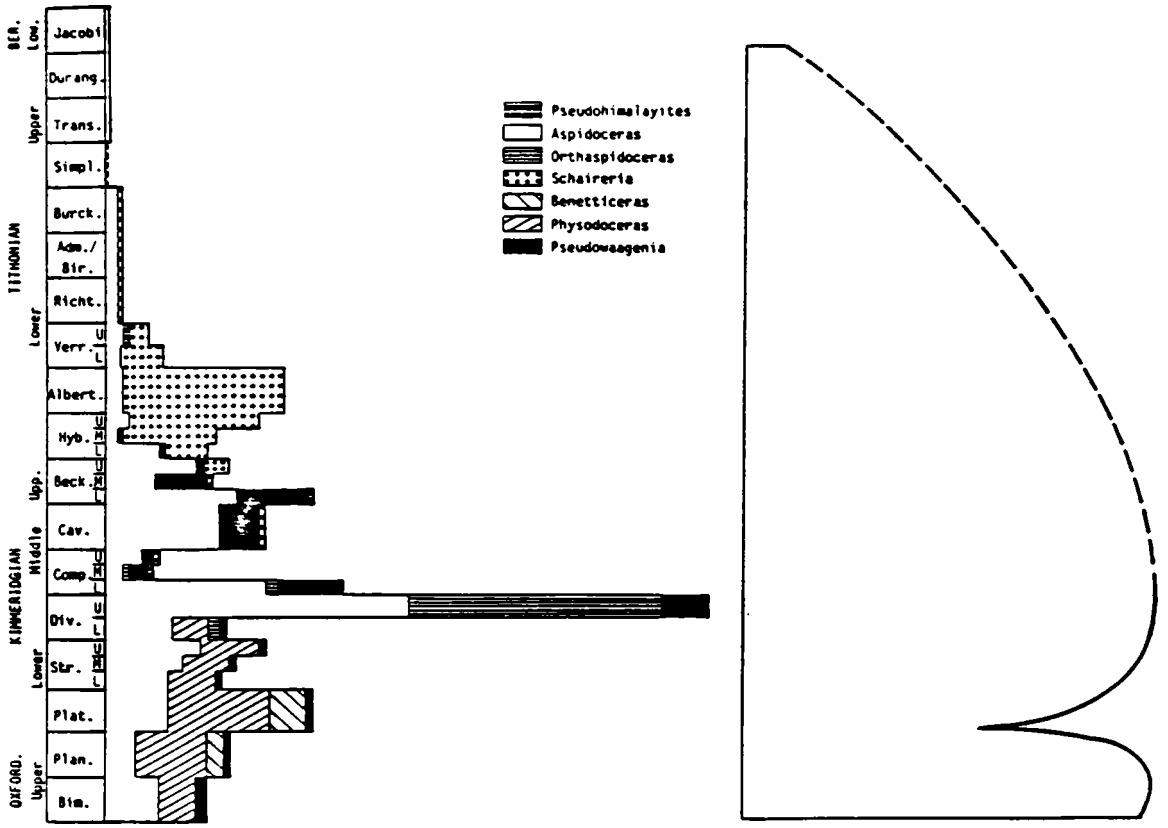

Figure 1: Hystogram of absolute frequencies at subfamily level. On the right, eustatic curve of Hallam(1978)

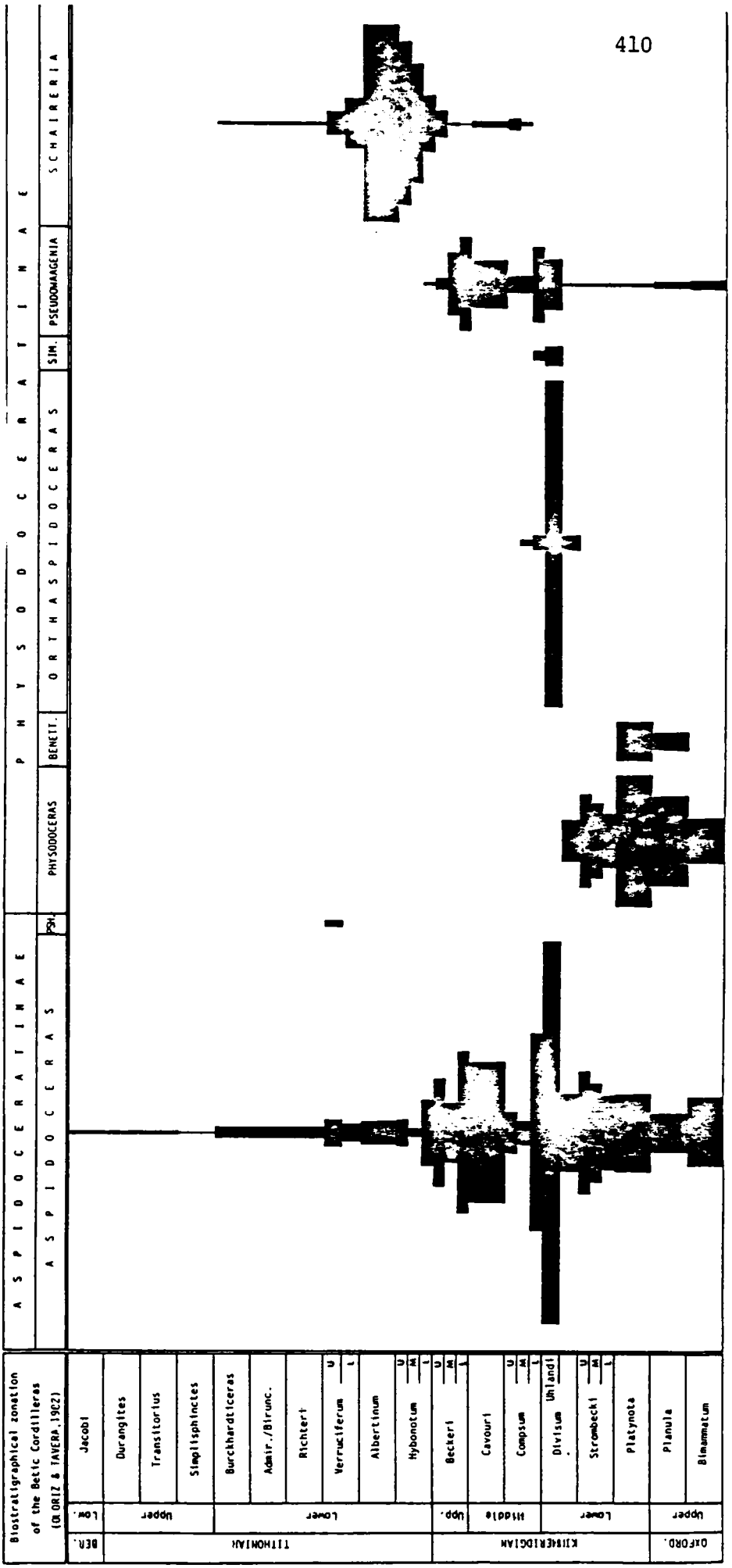

Figure 2: Quantitative record of Aspidoceratinae and Physodoceratinae at genus level.

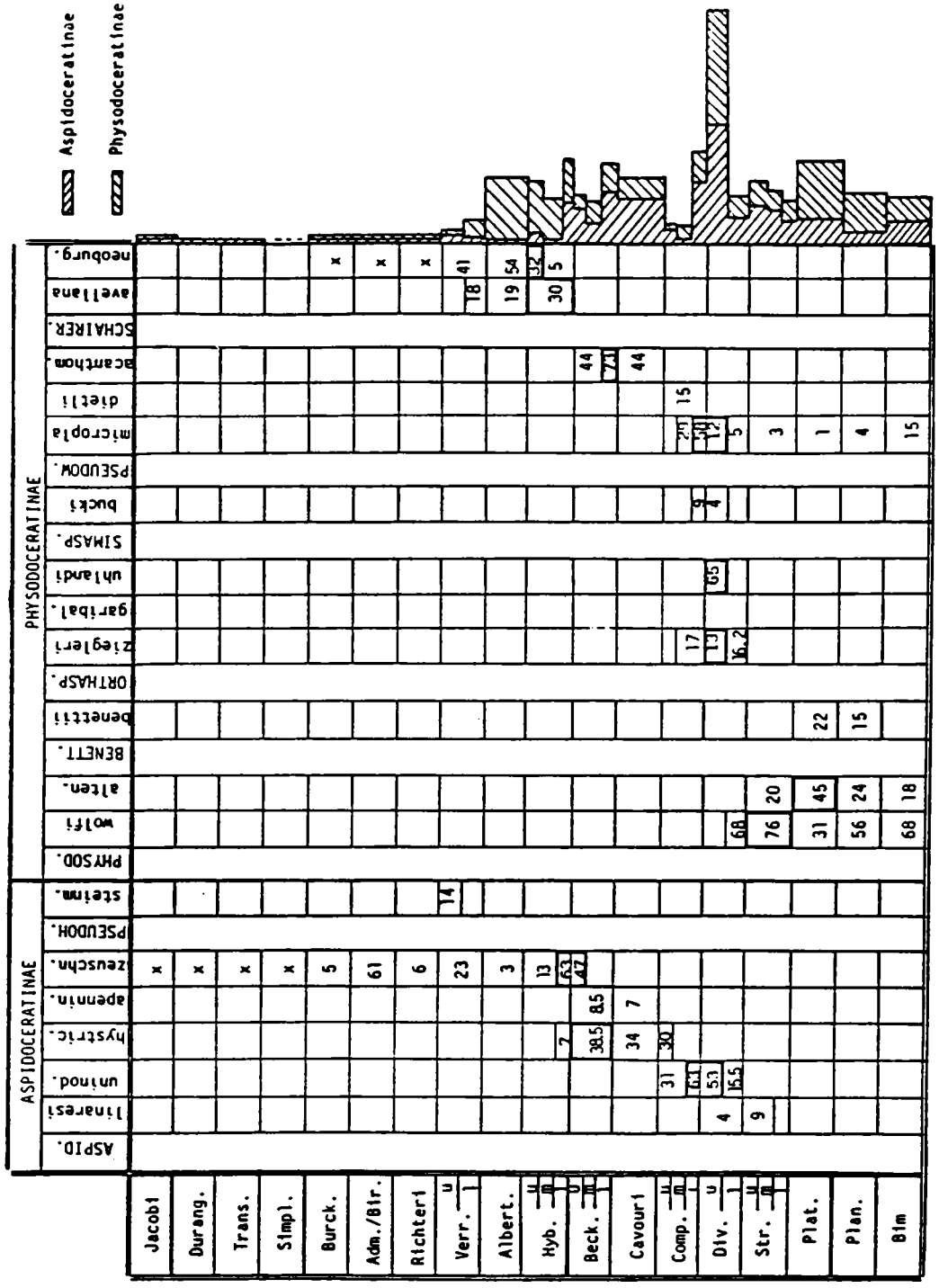

Figure 3: Control of maximal frequencies at speciel level in Aspidoceratinae and Physodoceratinae. Numbers refer to percentage within the subfamily. On the right, hystogram of absolute frequencies at subfamily level.

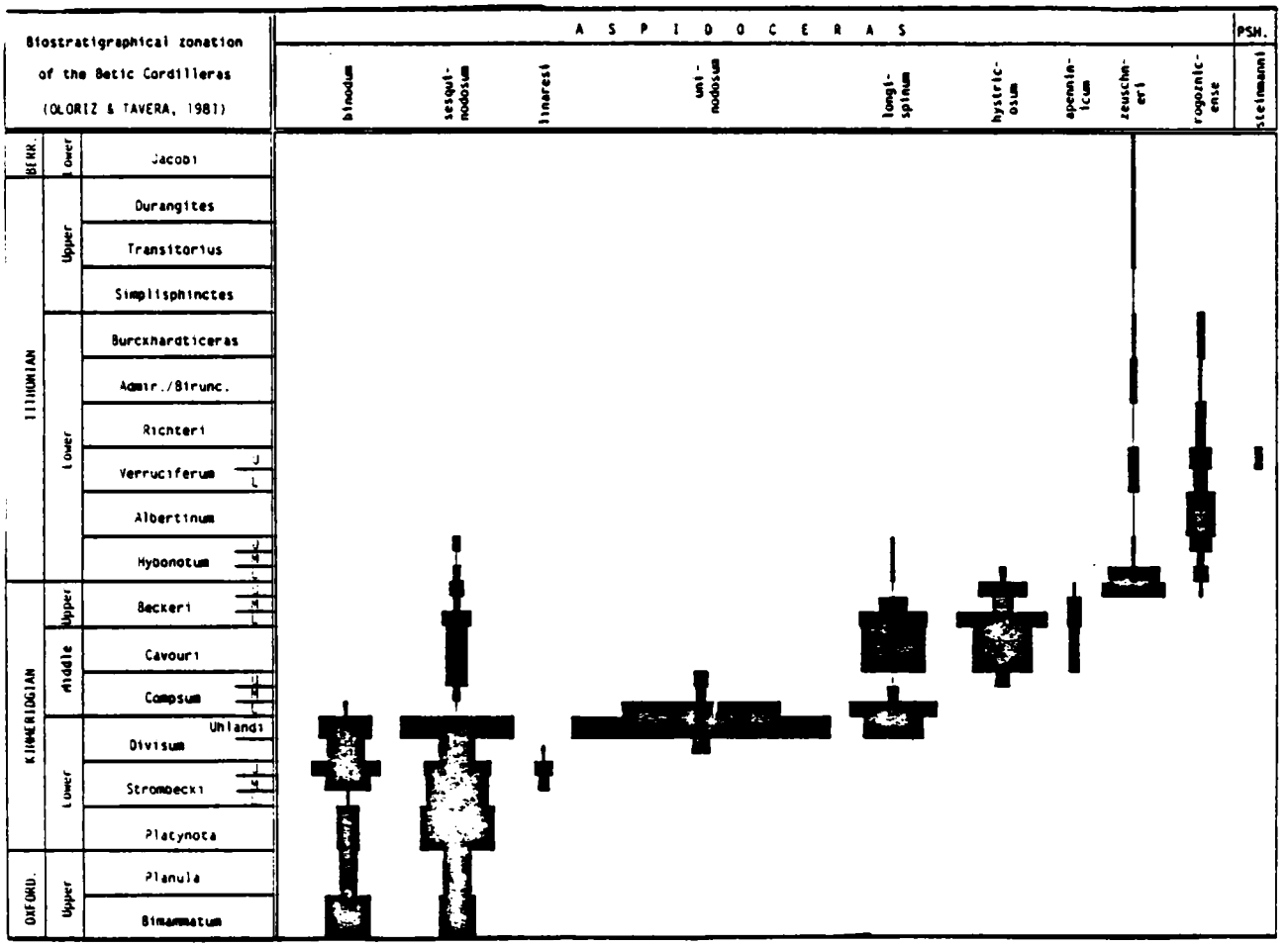

Figure 4: Quantitative record at species level in Aspidoceratinae.

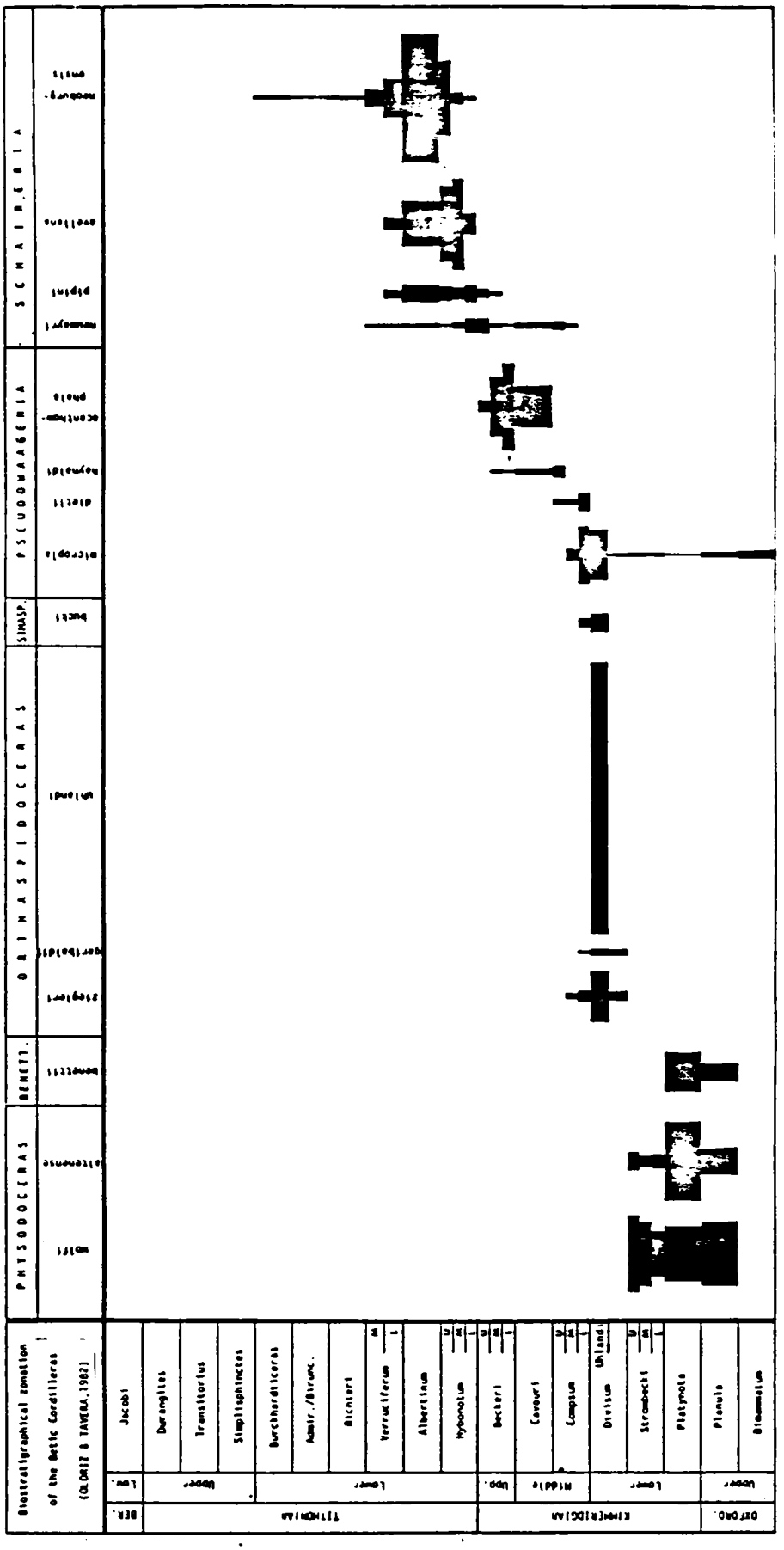

Figure 5: Quantitative record at species level in Physodoceratinae.

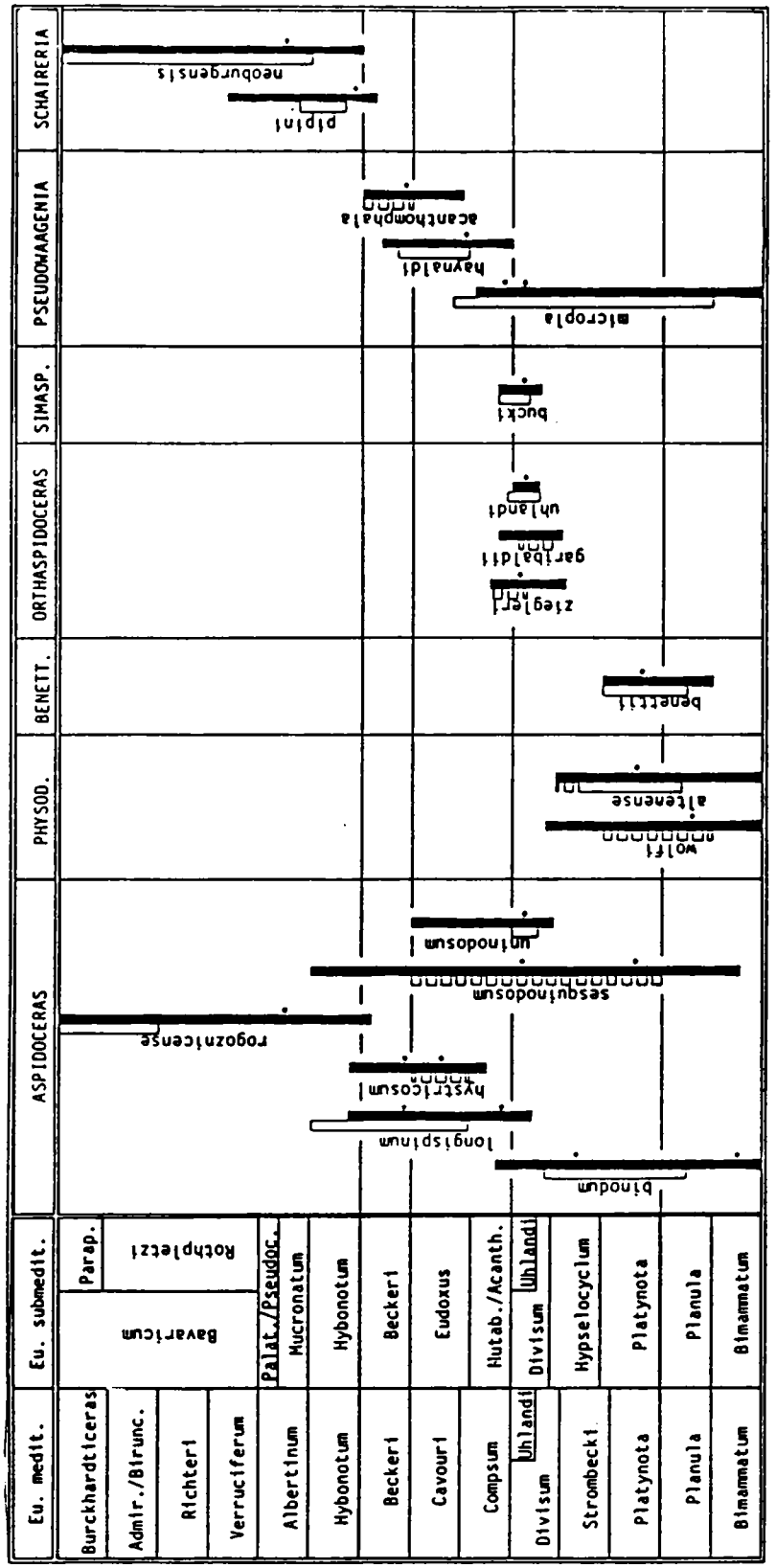

Figure 6: Biostratigraphical distribution of common mediterranean and Submediterranean species of "Aspidoceras".Black: mediterranean range. White: Submediterranean range. Points indicate the position of maximal frequency phase/s.

STRATIGRAPHIC VALUE PALEOBIOGEOGRAPHIC IMPLICATIONS OF OXFORDIAN AMMONITE FAUNA OF CHILE

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STRATIGRAPHIC VALUE PALEOBIOGEOGRAPHIC IMPLICATIONS OF OXFORDIAN AMMONITE FAUNA OF CHILE

G. Chong, W. Brochwicz-Lewinski, R. Myczynski, G. Melendez & L. Sequeiros.

In Chile, the lower Oxfordian is evidenced by the record of several peltoceratids and possible Prososphinctes. The former display well-developed Fe-Mn coatings and analyses of embedding rocks show some enrichment in cosmic dust and a geochemical anomaly, comparable and possibly correlable with those recently found in Europe. Middle Oxfordian assemblages comprise Gregoryceras, Ochetoceras canaliculatum-hyspidum group, Kranaosphinctes and Perisphinctes (Dichotomosphinctes) antecedens group, and P. (Dichotomoceras). The records of Euaspidoceras hypselum (Oppel) and its allies, Ochetoceras marantianum-semifalcatum group and Passendorferia (Enayites) birmensdorfensis, sensu Dorn make possible correlation with lower part of the Bimmamatum Zone in the submediterranean-Mediterranean zonal Schemes and Subnebrodites cf. proteron NITZ. and S. sp., with upper horizons of that Zone and/or lower ones of Planula Zone. The similarity to Submediterranean-Mediterranean assemblages appear striking throughout the Oxfordian, as noted by previous authors. Elements typical of the Indo-Ethiopian province seem to be missing in the studied fauna. Conexion with Cuba are indicated by some admixtures of Vinalesphinctes, ?Cubaspidoceras, and Cubaochetoceras. The use of thelatter for correlation will be possible after establishing their exact position in Chilean sections.

INTRODUCTION

This work summarizes the description of Oxfordian ammonites and its purpose is to study the bioestratigraphy, the reconstruction of their paleobiographic location and the connections with major world ammonites provinces in Jurassic times.

In the past ten years intensive field work has been carried out by one of us (G. CHONG) at the Cordillera de Domeyko of the preandean region of the southern Andes of Chile. Most of this programme was directed to

the study of Jurassic outcrops and large collections of fossils were gathered. It was found that the preandean region between 23º and 26º south latitude includes excellent sections of marine Jurassic rocks some of which have the most complete fossil record known in South America. Some localities can be described as "classic" in the Jurassic stratigraphy of the Andes, such as those of Caracoles (23º07'S/69º00N) and El Profeta (25º00'S/69º15'W). Most of the ammonites here described were collected in the localities mentioned above.

The collecting of fossils was done as part of a general mapping programme; therefore, further detailed work must be done to define the exact position of some ammonites in the stratigraphic column and to confirm some of the conclusions here discussed.

JURASSIC SETTING

In the Andes of Chile, Jurassic outcrops are distributed practically along two thirds of the length of the country. A volcanic belt is described along its western side meanwhile marine facies, almost free of volcanics, outcrop to the east, mainly in "horsts" at the preandean region.

These marine rocks can reach a thickness up to 3.000 m. Their ages range from Hettangian to possibly Tithonian and, with the exception of the highest part of the System, they are highly rich in fossils. The marine rocks are strongly folded and faulted and, in addition, intruded mainly by hypabisal and plutonic rocks of Cretaceous and Tertiary age. Its lower and upper limits are unconformities, with Triassic-Paleozoic basement rocks and with overlying mainly volcanic rocks of upper cretaceous age respectively. Other overlying units include Lower Cretaceous and Tertiary volcanic and continental sedimentary rocks.

In this sequence the Oxfordian is very well represented mainly by marls, shales minor limestones and sandstones and evaporites represented by gypsum and anhydrite. Its thicknes can reach up to 500 m. and the facies represent the first steps of the regression that will put an end to the marine regime of this region. An outstanding feature are the bituminous marls deposited in close basins with auxinic environments in their bottoms with plenty of nektonic, pseudonektonic or nekloplanctonic elements. The fossil fauna is mostly enclosed now in calcareous concretions in the marls.

From top to bottom an Oxfordian profile in the Cordillera de Domeyko (where fossils were collected) can be described as follows.

Capping beds: Sedimentary marine rocks (sandstones, shales, limestones, marls) with key-beds including bivalves,brachiopods crustaceans - and rare ammonites; kimmeridgian.

1. Mainly friable marls and shales interbedded with gypsum and anhydrite. An outstanding evaporite horizon (20-30 m) can be observed in the upper part of the sequence. Azoic. About 100 m. thickness.
2. Marls, sandstones, shales and limestones in centimetric to decimetric beds. Almost azoic but with very rare rests of fishes (Clupeids). - About 30 m. thickness.
3. Gypsiferous and bituminous black friable marls interbedded with shales Veins and dissemination of red-yellow hematite abundant concretions very rich in ammonites with predominance of Perisphinctes spp. Thickness about 50 m.
4. Azoic marls, shales and rare limestones. Thickness about 10 m.
5. Bituminous black, friable and gypsiferous marls with abundant concretions containing fishes (Leptolepids) and rare crustaceans and ammonites. Thickness about 20 m.
6. Azoic marls and shales. Thickness about 20 m.
7. Bituminous black friable marls with little (10-15 cm) ellipsoidal fetid concretions containing poorly preserved fishes (pholidosphorids). Gypsum interbedded. Thickness about 10 m.

The underlying rocks is a monotonous sequence with bituminous friable marls, shales, rare limestones with more than 400 m. thickness. At - least the upper two thirds of this section are azoic the first Callovian ammonites (Reineckeia)having been collected at the lower part of this sequence.

PREVIOUS REFERENCES

The Oxfordian in Southern Andes, especially the Caracoles Region, - has been studied by several researchers since the last decades of XIX century, (Steinmann 1881 and others). The studies have given numerous records of Ammonites usually placed in European taxa (including even boreal ones, as Cardioceras or Kosmoceras) and interpreted as indicative mainly of the Plicatilis and Canaliculatum Zones. The studies carried out in the last -

decades (Hillebrand 1970 and others) also favoured mainly European, west Tethyan, character of South Andine assemblages whereas in some analyses of Ammonite provinciality any direct connections between that region and western Tethys were questioned, casting therefore doubts on all the specific, or even generic identifications. In some analyses (e.g. in Stipanicic et al. 1975), connections with Indo-Ethiopian province were recognized as stronger than those with western Tethys.

When we began to analyse the newly gathered Ammonite fauna from the Oxfordian of Chile we found it strikingly similar to Mediterranean and Submediterranean assemblages from Europe. This is the case of the recorded representatives of the genera Gregoryceras and Ochetoceras whereas the similarity may actually be debatable in Perisphictids, which form the bulk (about 85%) of the studied fauna. In studying the fauna we were keeping in mind the possibility of endemism as well as homeomorphy. Much caution was also neccessary because of intense tectonic disturbance of the Ammonite-bearing Rocks and, thus, the hazard of mixing up fossils of different age.

BIOSTRATIGRAPHY

The analysis showed that the lower Oxfordian is undoubtedly present in the studied area (thus confirming some earlier statements-see Chong and Förster 1976). It is evidenced by several peltoceratids: Parawedekindia stephanovi SAPUNOV, P. cf. bodeni PRIESER sensu Matyja (1977, p. 5, figs. 6-7), Peltomorphites sp. and ? Rursiceras sp. First of these species is known from the Cordatum Zone (see Sapunov 1979; Matyja & Tarkowski 1981) whereas the remaining ones display some features suggesting somewhat earlier age (here we are indebted to I.G. Sapunov, D. Marchand and M. Gizejewska and other collegues for fruitful comments). Other lower Oxfordian forms may include two specimens very close to Prososphinctes SHIND. 1925, especially P. claromontanus (BUK.) group. This Ammonite assemblage appears, on general grounds similar, except for the lack of record of true representatives of Passendorferia (i.e.: P.(Enayites) czenstochowiensis (SIEM.) to the Bukowski's 1887 classical Cordatum-Zone Assemblage, and to that recently identified by Brochwicz-Lewinski (1976, 1981) for Czestochowa area (S. Poland, Polish Jura Chain), and by Meléndez et al. (1982) for the Iberian Chain (Spain), which would make the proposed S. Europe Perisphinctid zonation (Meléndez et al. 1984) also applyable for this S. American region.

The available speciments of Prososphinctes differ from typical representatives of that group in the lack, or underdevelopment of parabolic nodes and ventral furrow, but the underdevelopment of these features is also found in some extreme morphotypes of the group, especially in some representatives of P. matheyi DE LORIOL and mairei DE LORIOL. It should be added here that true Prososphinctes are unknown from strata younger than the Cordatum Zone in Europe, though forms close to that genus, and probably related with it have been reported from lower middle Oxfordian (Plicatillis Zone, Vertebrale Subzone) of SE. France (Beauvoisin), by Bourseau (1977, p. 37, Pl. 3, fig. 2-3), as Per. (Prososph. ?) sp. nov. A. and by one of the authors (Meléndez, 1984) from Iberian Chain, Spain (Antecedens Zone). It is therefore not excluded that the form reported (but unfortunately unfigured) by Stipanicic et al. (1975) from strata with Peltomorphites in Argentina may actually belong to that genus.

Attention should be also paid to well-developed Fe-Mn coating on all the above mentioned peltoceratids. Such coatings (mainly ferruginous) are common on coeval specimens in western Tethyam and adjoining areas so their presence may be an auxiliary, but nevertheless, useful feature in identifying the lowermost Oxfordian-uppermost Callovian strata in the studied region. This is further supported by preliminary results os studies on rocks accompanying these fossils (carried out together with M. Zbik and other collegues). The studies showed a geochemical anomaly (enrichment in several metals including Ni, Co, Cr, and REE) and increased frecuency of cosmic material (spherules from ablation of meteoroids, about 5 in number per 1 g. plus possibly increased amount of cosmic dust), i.e. phenomena possibly correlable with those recently found in Iberian Chain (Spain) and Czestochowa-Kracow area in Poland (Brochwicz-Lewinski et al. 1984).

The next assemblage comprises Ochetoceras hispidum (OPP), O. canaliculatum (v. BUCH), representatives of Gregoryceras, some of them close to G. transversarium, Kranaosphinctes sp., numerous speciments easily assignable to the P. (D.) antecedens group, p. (? Otosphinctes) sp. and firs specimens referable to the genus Subdiscosphintes MALINOWSKA, 1972. The assemblage may be easely correlated with those of the Antecedens Zone, and partly, Transversarium Zone, Wartae Subzone, in the same proposed subdivision and further studies should make possible more accurate correlations.

Subsequent Assemblage comprises two almost complete and some fragmentary large Ochetoceras cf. basseae FRADIN, numerous perisphinctids surprisingly close to submediterranean Perisphinctes (Dichotomoceras), especial

ly P.(D.) bifurcatoides-stenocycloides group and P.(D.) bifurcatus (QUENSTEDT), Mediterranean representatives referable to Passendorferia BR.-LEW. 1973 and Subdiscosphinctes cf. aeneas (GEMMELLARO). The assemblage also includes some forms with Dichotomoceras-like features (very fine and sharp-crestedt ribs, more densely spaced on inner whorls) and at the same time - similar to classic Chilean taxa, such as Per. roubyanus FONTANNES sensu - Steinmann (1881, Pl. 9, fig. 6); P. dorae STEINMANN, l.c., p. 275, Pl. 9, figs. 3-4) may also belong to the subgenus P. (Dichotomoceras). The whole assemblage appears well correlable with those of the Bifurcatus Zone (and possibly, lowermost part of the Bimammatum Zone) in the Submediterranean subdivision as characterised by Cariou et al. (1971, p. 20).

The assemblage described and figured from the Caracoles area by - Leanza (1947) appears correlable with the above discussed as his Ochetoceras cf. canaliculatum (v. BUCH), (l.c. p. 288, Pl. 1, fig. 1), well matches the diagnosis of O. raixense FRADIN, as given by Fradin (1947 p. 420) and subsequently by Hőroldt (1964, p. 59). Aspidoceras (Euaspidoceras) chilense n. sp. (l.c. p. 289, Pl. 1, figs. 2-3) appears actually close to early Euaspidoceras hypselum (OPPEL), Aspidoceras (Euaspidoceras) cf. perarmatum (SOW.) (l.c. p. 291, Pl. 1, fig. 4) to Euaspidoceras aff. costatum - (DORN) in Myczynski (1976, p. 272, Pl. 3, figs. 3-4, Pl. 4, figs, 1-4, Pl. 5, figs. 1-7). The above forms may be treated as indicative of upper horizons of the Bifurcatus Zone and lower ones of the Bimammatum Zone whereas the fourth species reported by A.F. Leanza (1947- Perisphinctes harringtoni LEANZA- appears characterised by inner whorls with very fine, sharp-crested and closely-spaces ribs of the Dichotomoceras type and it may represent P. (Perisphinctes) s. str., i.e, subgenus not known to pass the Bifurcatus-Bimammatum boundary.

The next assemblage is characterised by Ochetoceras cf. marantianum (D'ORB.) with characteristic crescent bifurcating intercalary outer ribs, - Euaspidoceras hypselum (OPPEL) and its allies, and Passendorferia (Enayites) birmensdorfensis (DORN, non MOESCH), i.e. taxa making possible its correlation with those of the Hypselum Subzone of the Bimammatum Zone in the Submediterranean subdivission.

The youngest assemblage comprises Subnebrodites cf. proteron (NITZOPOULOS) and S. sp., indicating that it corresponds to those of upper horizons of the Bimammatum Zone and/or lower part of the Planula Zone.

BIOGEOGRAPHIC COMMENTS

The studied Chilean material mainly comprises the above mentioned - and other forms referable to taxa known from Submediterranean and Mediterranean areas in Europe. Moreover, it comprises several other forms the - identifications of which appears troublesome. However, it should be stressed that up to the present we have not found any forms which would be Indo Ethiopian in character. In turn, the material comprises some admixture of elements which may be interpreted as reflecting influences of the Cuban - (or Caribbean) province (see Meléndez, 1983). This is the case of two representatives of Vinalesphinctes, several fragmentary ? Cubaochetoceras, ? Cubaspidoceras and Mirosphinctes pinarensis choffati MYCZYNSKI, as well as Subdiscosphinctes, which appear close to Cuban "Discosphintes". Nevertheless, the admixture of Cuban elements appears negligible in this overwhelmingly West-Tethyan-type fauna but they may appear highly important for - future correlations of the Oxfordian of the two regions, possible after - establishing exact position of these Cuban elements in Chilean sections.

The western Tethyan character of the recorded fauna gives further support for free migration of Ammonite fauna between South American basins and western Tethys through the Atlantic during the whole Oxfordian. Any - trends to endemism appear dificult to assume in the case of peltoceratids, though detected differences between European and S. American assemblages could be interpreted in that sense.

There remains to be solved the question of the repeated records of Boreal elements in S. America. According to Stipanicic et al. (1975, p.284) and some other authors, such records need reexamination because of geographic restriction of the taxa. Actually, some of these may be misidentifications. For example, classic Kosmoceras dunkeri n.f. figured by Steinmann - (1881, pl. 12, Fig. 9) may represent a Stephanoceras close to S. chilense HILLEBRANDT, in Hillebrandt (1977). However, records of undoubtful Boreal elements should not be surpraising as the elements are nowadays known also from NW.Africa (J. Thierry & N. Charpy, 1982), wherefrom migration further to the south should not be troublesome.

Warm thanks are due to M. Gizejewska, D. Marchand, L. Malinowska, I.G. Sapunov, R. Tarkowski, G. Westermann, M. Zbik, and other collegues - for valuable comments and advice.The Ammonite collection was partly gathered by A. Quinzo Sinn, and other collegues from Antofagasta University. Any errors in interpretation are entirely the authors'. The studies were gretly facilitated owing to generous financial support of the Rector of the Zarago

za University and The Instituto de Estudios Turolenses, Teruel, Spain.

This paper is a Contribution to IGCP project nº 171 - Circumpacific Jurassic.

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CAPTION TO FIGURE 1

1) Assemblage included by Wiedmann (1983) within Lamberti Zone, resituated by Hillebrandt (1984, Oran comm.) between Mariae and Cordatun Zone.
2) "Perisphinctes" dunkeri, also previously placed in Lamberti Zone, and - similarly resituated by Hillebrandt (Ibíd.) within Plicatilis Zone, Antecedens Subzone.
3) Antecedens Zone (cf. Brochwicz-Lewinski (1976), characterized by Per. - (D.) antecedens SALFELD, and some other Dichotomosphinctes in this re-- gion by the author.
4) Regarded as lower subzone of Transversarium Zone, equivalent to Per. (D.) wartae and Amoeb. alternans, Zone, (in Malinowska 1972).
5) Quenstedtoceras cf. mariae, referred by Klohn (1960), fide Stipanicic - (1966) determination rejected nowadays by (Hillebrandt (oral com.), and others.
6) The first faunistic record from Oxforfian of Cuba Would correspond, accor ding to various authors, to top Plicatilis-base of Transversarium Zone.
7) The first faunistic assemblage (Dichotomosphinctes spp.), presumably somewhat younger than, or slightly overlapping with cuban Plicatilis Zone -- assemblage, according to the author.

Editoral note: Nos, 6 and 7 are not indicated in fig, 1.

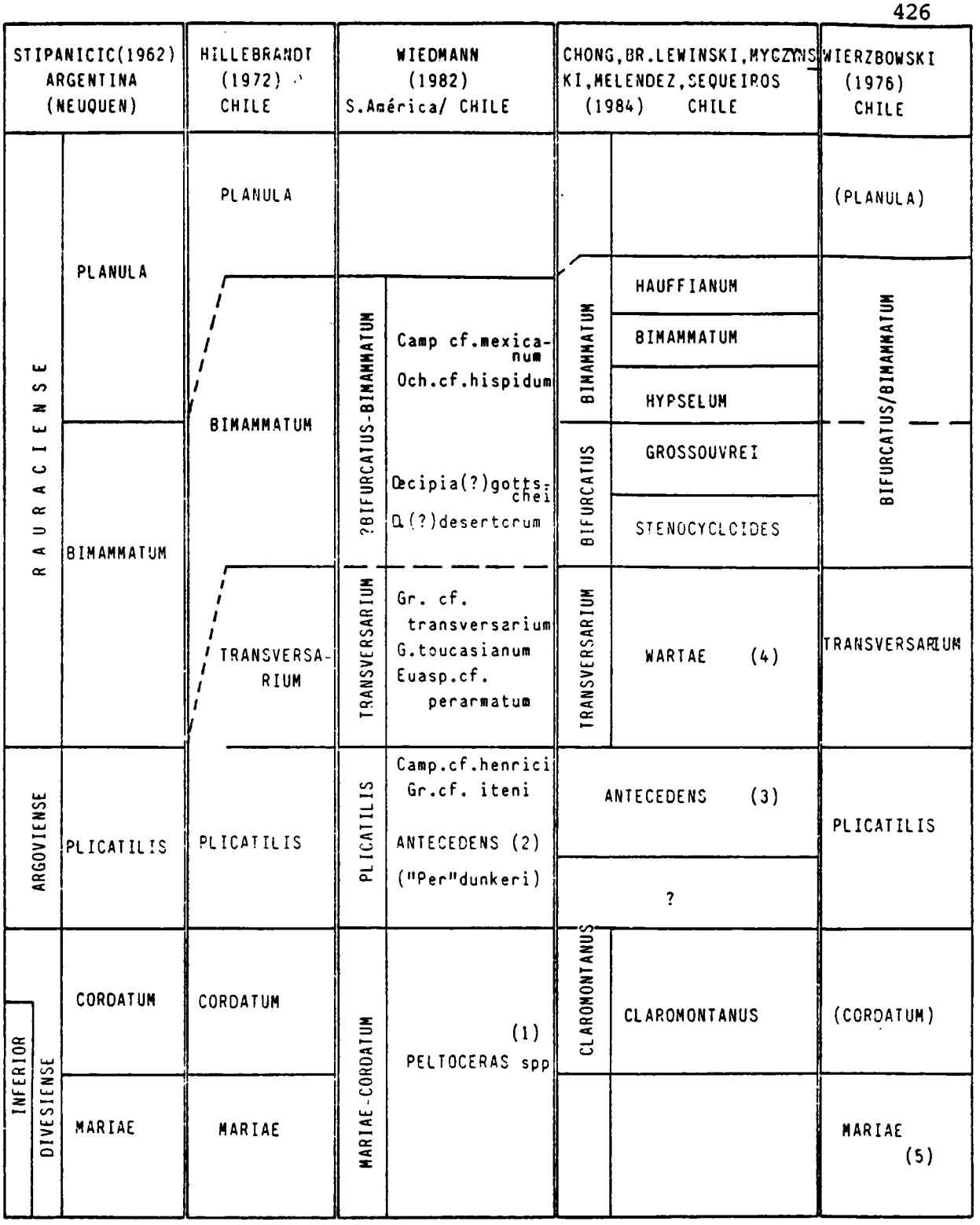

FIG.1.- Correlation of Oxfordian biostratigraphic scales by different authors for Andean Province, in comparison with the succession recognised here.

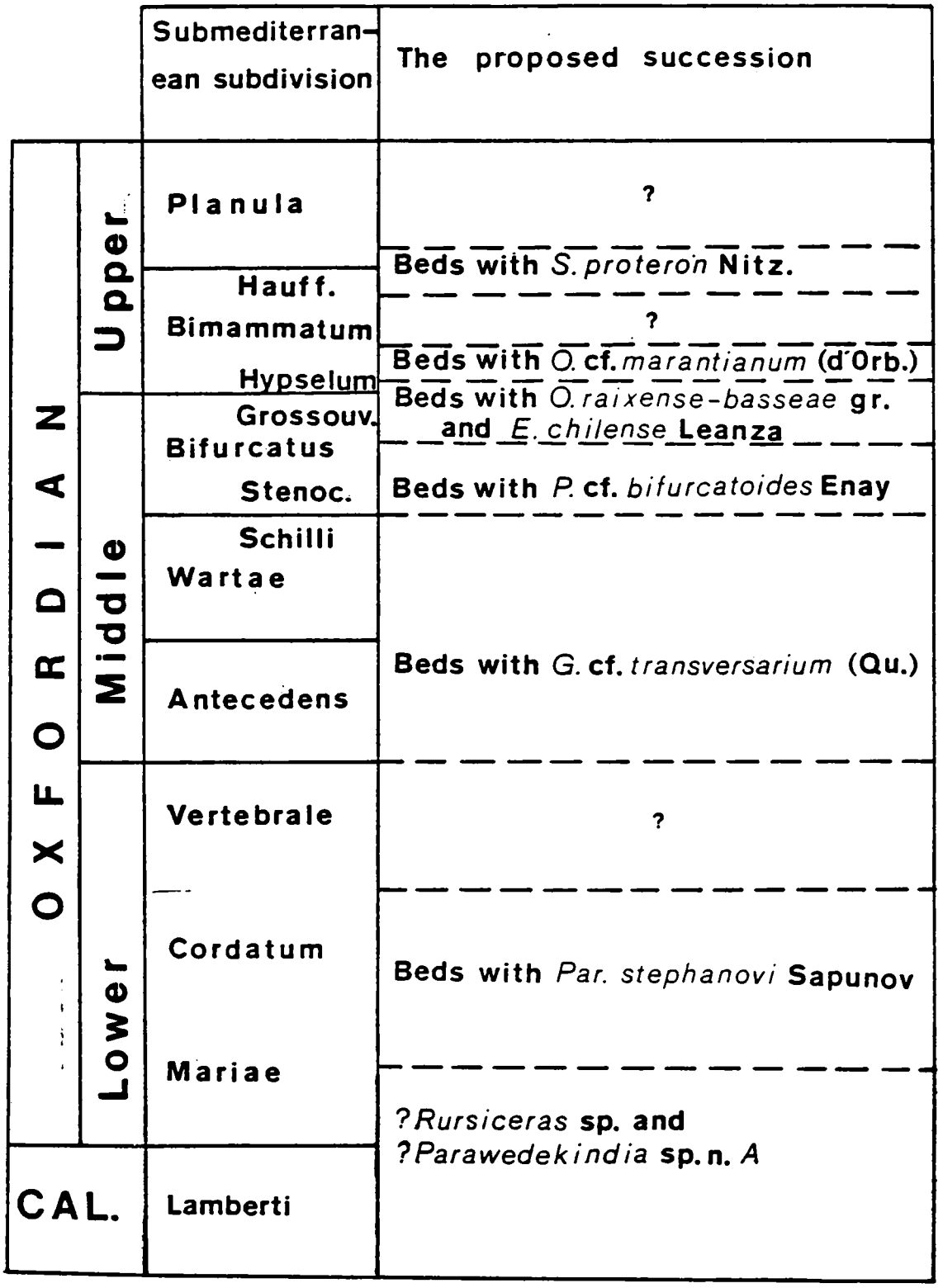

FIGURE 2: Succession of Ammonite Assemblages found in the studied fauna, and its correlation with the Submediterranean Biostratigraphic subdivision (after Cariou et al. 1971).

NANNOFOSSILS ACROSS THE JURASSIC/CRETACEOUS BOUNDARY IN THE TETHYAN REALM

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NANNOFOSSILS ACROSS THE JURASSIC/CRETACEOUS BOUNDARY IN THE TETHYAN REALM

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Abstract. The Jurassic/Cretaceous boundary is one of the most problematic biostratigraphical boundaries. There has been a number of previous nannofossil biostratigraphical schemes covering the boundary. Using conventional nannofossils biostratigraphical methods two problems are encountered.

1. Within the Tethyan Realm species have differing age ranges from locality to locality.
2. Nannofossil systematic need improving and there is plenty of evidence for individual species having been assigned two or more name.

Numbers localities in south east France were studied where there was good stratigraphical control. These studies resulted in the discovery of numerous events based on the accumulated percentages of the different nannofossil families of particular importance were the events seen close to the Jurassic Cretaceous boundary.

Fig. 1 Biostratigraphical Schemes for the Jurassic Cretaceous Boundary in the Tethyan Realm.

		THIERSTEIN 1974	ROTH et al 1984		THIS WORK	Ammonites * from LE HEGARAT 1971	Calpionellids from LE HEGARAT 1971
CRETACEOUS	VALANGINIAN	*Calcicalathina oblongata*	*Tubodiscus verenae*		*Calcicalathina oblongata*		
		Cretarhabdus crenulatus	*Retecapsa neocomiana*		*Cruciellipsis cuvillieri*	*Pertransiens*	*Calpionellopsis D*
	BERRIASIAN					*Boissieri*	
		Nannoconus colomi	*Nannoconus colomi*		*Parhabdolithus* Sp 1	*Occitanica*	*Tintinnopsella C*
						Grandis	*Calpionella B*
JURASSIC	TITHONIAN	*Conusphaera mexicana*	*Conusphaera mexicana*	*Polycostella beckmanni*	*N. steinmanni*	*Jacobi*	
					Conusphaera mexicana	?	
						Transitorius	*Crassicolaria A*
						Ciliata	*Chitinoidella*
						Contiguus	
	KIMMERIDGIAN			*H. cuvillieri*	*Vekshinella dibrachiate*		
			Vagelapilla stradneri				

* The ammonites correlation only applied to this work and not the works of Thierstein 1974 and Roth et al. 1984

INTRODUCTION

The Jurassic cretaceous boundary is one of the most problematical of all the Meazoic boundaries. A number of fossil groups have been used to provide a workable biostratigraphy, the most useful of which has been the ammonites and, in the Tethyan realm the calpionellids. These fossil groups also have problems such as provincialism, and they absence of a suitable evolutionary events as at the Triassic Jurassic or Cretaceous Tertiary boundary.

The Tethyan Realm has been chosen to demonstrate the application of nannofossils because of the difficulty of finding suitable sections for the study of nannofossils in the Boreal Realm.

Nannofossil Biostratigraphy

There has been a few biostratigraphical studies of calcareous nannofossils across the Jurassic Cretaceous boundary in the Tethyan Realm where the most commonly used is that of Thierstein (1974).

Thierstein's zone for the Tithonian is the *Conusphaera mexicana* Zone defined on the first occurrence of *C. mexicana* to the first occurrence of *Nannoconus colomi*.

The zone above starts at the base of the Cretaceous, and is the *N. colomi* Zone. Its definition is based on the first occurrence of *N. colomi* (at the base) to the first occurrence of *Cretarhabdus crenulatus* at the top. The *N. colomi* Zone is restricted to the Early Berriasian.

The next zone is the *C. crenulatus* Zone defined on the first occurrence of *C. crenulatus* to the first occurrence of *Calcicalthina oblongata*. This zone is of Late Berriasian to basal Valanginian age.

The most recent nannofossil zonation for the Jurassic Cretaceous boundary is that compile by Roth et al. (1984). Their zonation has been based on nannofossils from the Deep Sea Drilling Project Site 534A as well as from onshore localities from Britain and, north and south France.

The zone for the Late Oxfordian to Early Kimmeridgian period of time is the *Vagalapilla stradneri* Zone defined on the interval from the first occurrence of *V. stradneri* to the first occurrence of *Conusphaera mexicana*.

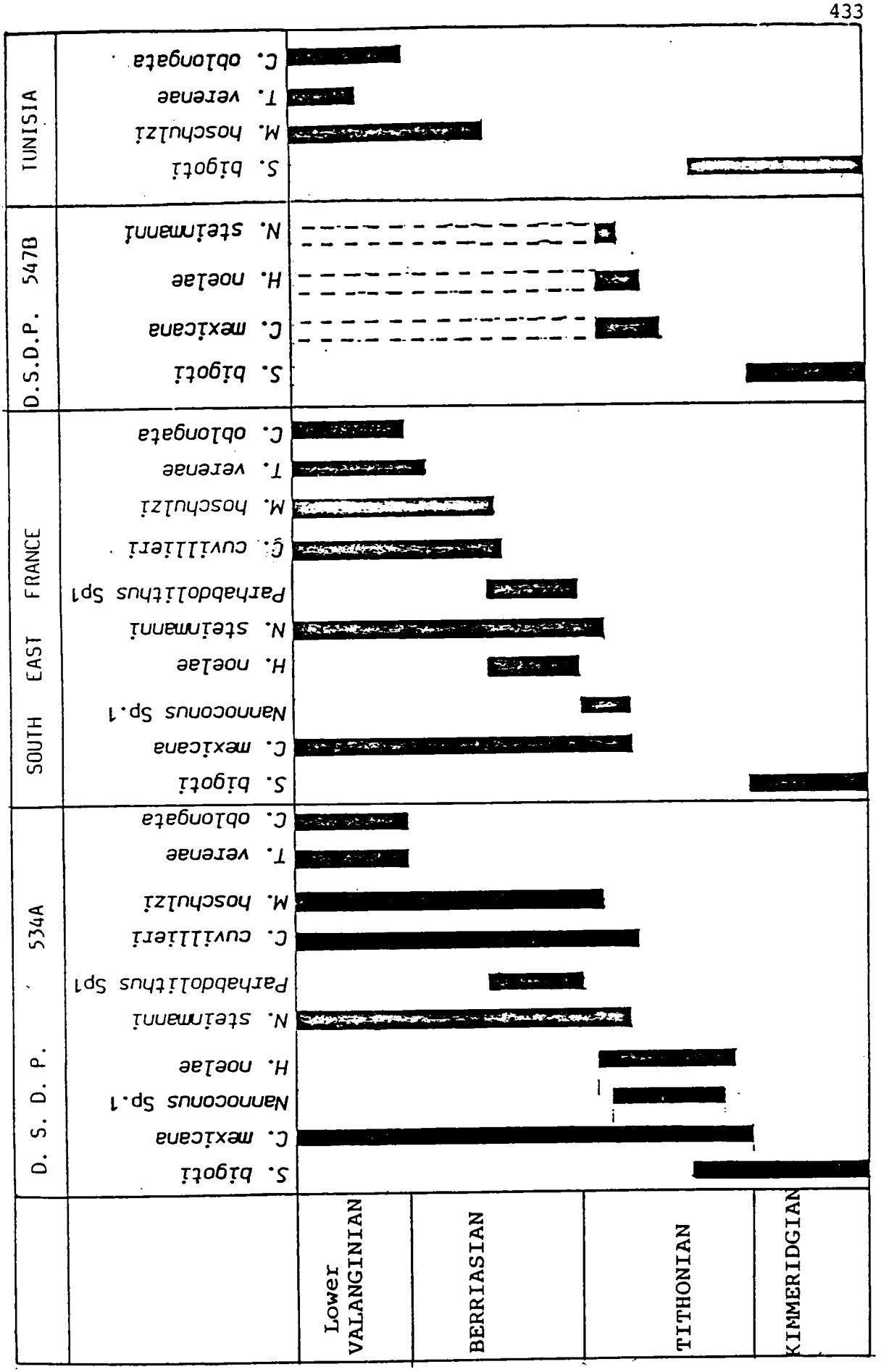


Fig. 2 Age Ranges of selected nannofossils species from various Tethyan localities

The next zone is the *C. mexicana* Zone the age range of which is from the Late Kimmeridgian to the top of the Tithonian. This zone is defined as being from the first occurrence of *C. mexicana* to the first occurrence of *Nannoconus colomi* and the last occurrence of *Polycostella beckmannii*. This nannofossil zone is further sub-divided into two subzones. The lower subzone is the *Hexapodorhabdus cuvillieri* Subzone defined on the first occurrenc of *C. mexicana* to the last occurrence of *Stephanolithion bigoti*. The range of this subzone is Late Kimmeridgian. The second subzone is the *Polycostella beckmannii* Subzone defined on the last occurrence of *S. bigoti* to the first occurrence of *Nannoconus colomi*, the age of this subzone is Tithonian.

The first nannofossil zone for the Cretaceous is the *N. colomi* Zone defined as being from the first occurrence of *N. colomi* to the first occurrence of *Retecapsa neocomiana*. The range of this zone is Early Berriasion.

The next zone is the *R. neocomiana* Zone of Late Berriasion to Early Valanginian age and is defined on the first appearance of *R. neocomiana* to the first occurrence of *Tubodiscus verenae, Diadorhombus rectus* and *Calcicalathna oblongata*.

These current biostratigraphic zonations have a number of problems. The first is that it soon becomes apparent in these Tethyen localities that there are discrepancies in the ranges of the selected nannofossils at each locality (see Fig. 2) At Deep Sea Drilling Project Site 534A *C. mexicana* is seen to first occur before the last occurrence of *S. bigoti*. This occurrence led Roth et al. (1984) to lower the existing range of *C. mexicana* into the Kimmeridgian. During my research on the nannofossils from the type Volgian I found that *S. bigoti* did not become extinct until the start of the Middle Volgian (*panderi* Zone) a line which is equivalent to the top of the Lower Tithonian. It was also found in rocks of Tithonian age in Tunisia. This could suggest that *C. mexicana* has its first occurrence at the base of the Tithonian and that it is *S. bigoti* which has an extinction later then recorded in the nannofossil literature.

C. mexicana also has a different first occurrence in these Tethyan localities. It was found in the Upper Tithonian at D.S.D.P. Site 547B and southeast France. *Nannoconus steinmanni* shows a similar east west pattern with its first occurrence. There are a number of other species which have an earlier first occurrence in D.S.D.P. Site 534A e.g. *Micrantolithus obtusus, Cruciellipsis cuvillieri* and *Hexalithus noelae*. This variation in species ranges during the Upper Jurassic and Lower Cretaceous suggests that the existir nannofossil biostratigraphy is not as accurate as first thought. Not all the species of nannofossil have this range variation between localities in the Tethyan realm e.g. *Parhabdolithus swinnertonii* and *Calcicalathina oblongata*.

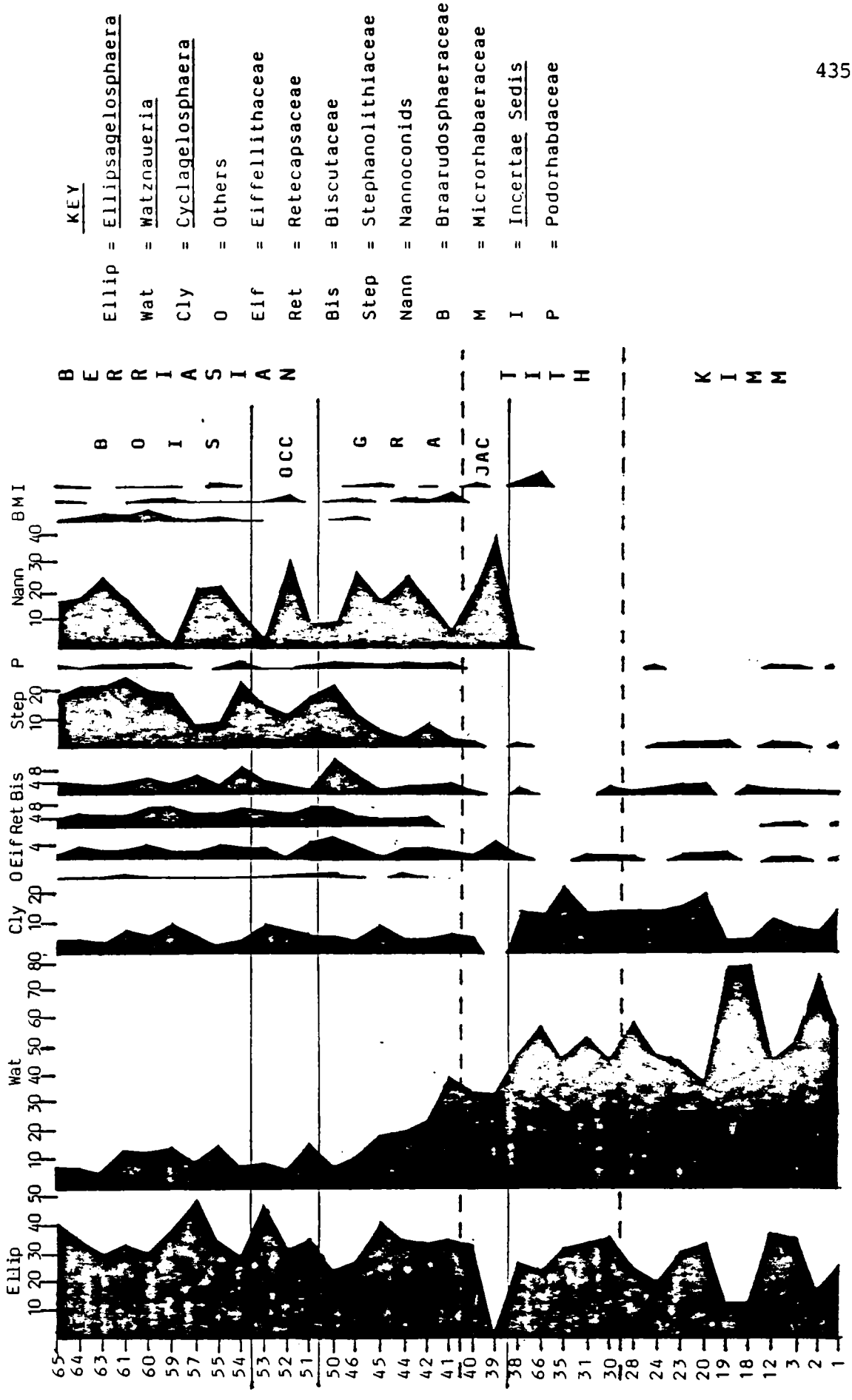


Fig. 3 Families percentage graph for the section at Saint-Nazaire-le-Desert (S.E. France)

The other major problem with nannofossil biostratigraphy rests with their systematics. The problem of *Nannoconus steinmanni* best typifies this. This species is considered by some workers to be a junior synomyn of *Nannoconus colomi*, while more recently Deres & Acheriteguy (1982) have shown it to be really two separate species. The problem is that from photographs and descriptions by some workers the specimens they refer to as *N. colomi* would be assigned to *N. steinmanni* on Deres & Acheriteguy's descriptions. This is not the only case of biostratigraphic marker species having systematic problems, other examples are *Retecapsa angustiforata/Cretarhabdus crenulata/ Retecapsa neocomiana* and *Vagelapilla stradneri/Vekshinella dibrachiate*.

A nannofossil biostratigraphy was attempted for the Jurassic/Cretaceous boundary (see Fig. 1) even though there is the problem of regional variation in species range and systematic problem.

The first zone is the *Vekshinella dibrachiata* Zone. It is difficult to define the base of this zone as there are no marker species appearing or becoming extinct during the Early Kimmeridgian; thus the base was defined from the nannofossil literature on the last occurrence of *Schizosphaerella punctulata*. The top of this zone is defined on the last occurrence of *Stephanolithian bigoti* and/or the first occurrence of *Conusphaera mexicana* (which ever of these events occurs first). The age of this zone is from Late Oxfordian to Early Tithonian.

The next nannofossil zone is the *Nannoconus steinmanni* Zone. It's top is defined by the first occurrence of *Parhabdolithus* Sp. 1. The age of the zone is Latest Tithonian.

The zone above this is the *Parhabdolithus* Sp. 1 Zone. Its top is defined by the last occurrence of *Parhabdolithus* Sp. 1 and/or *Polycostella senaria* and *Hexalithus noelae*. This nannofossil zone is of Early Berriasian age.

The nannofossil zone above the *Parhabdolithus* Sp. 1 Zone is the *Cruciellipsis cuvillieri* Zone. The top of the zone is defined by the first occurrence of *Calcicalathina oblongata*. The zone is of Late Berriasian age.

NANNOFOSSIL 'EVENTS' BIOSTRATIGRAPHY

As part of my research a statistical count was made of the nannofossil assemblage. The aim of this study is to see if there is any environmental or regional factors that could be distingushed in the different nannofossil families throughout time. The study is based on count of one hundred field of view in a single traves of a nannofossil slide. In each single field of view every specimen is recorded. (This count also allow logorimithic division to be used as a bases for a species range table). The total numbe of specimens is found and the percentage of each nannofossil family calculated.

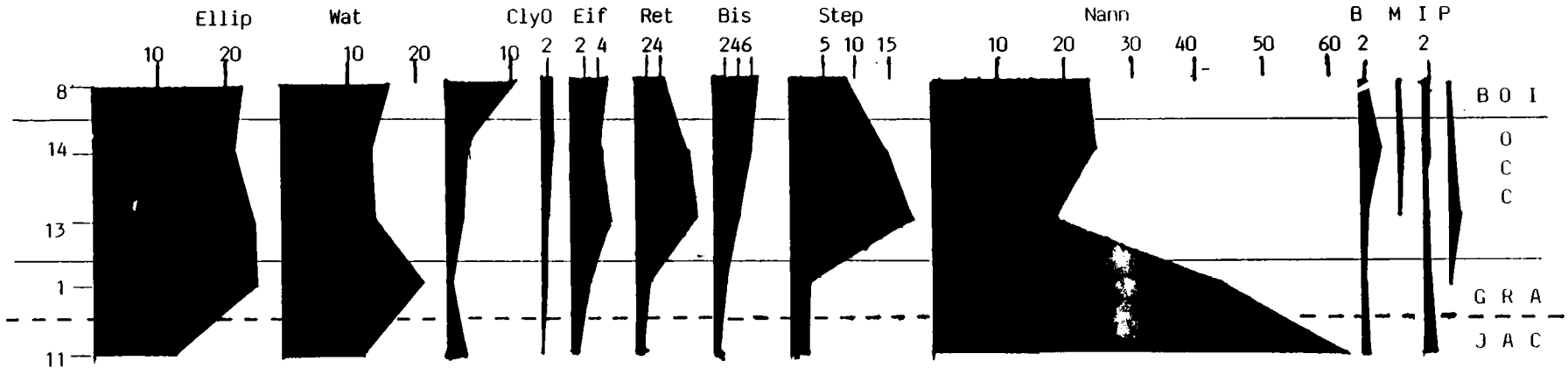


Fig. 4 Families percentage graph for the section at Luc-en-Diois (S.E. France).

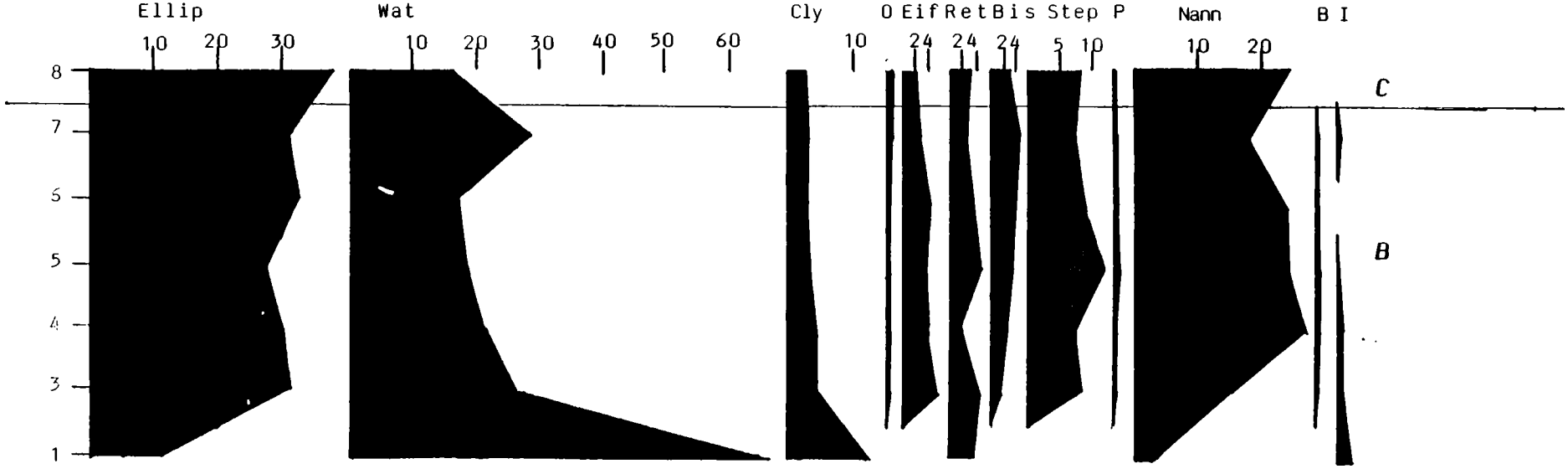


Fig. 5 Families percentage graph for the section at Gorge de la Meouge (S.E. France).

Fig. 6 Families percentage graph for D.S.D.P. Site 261 (Timor Sea)

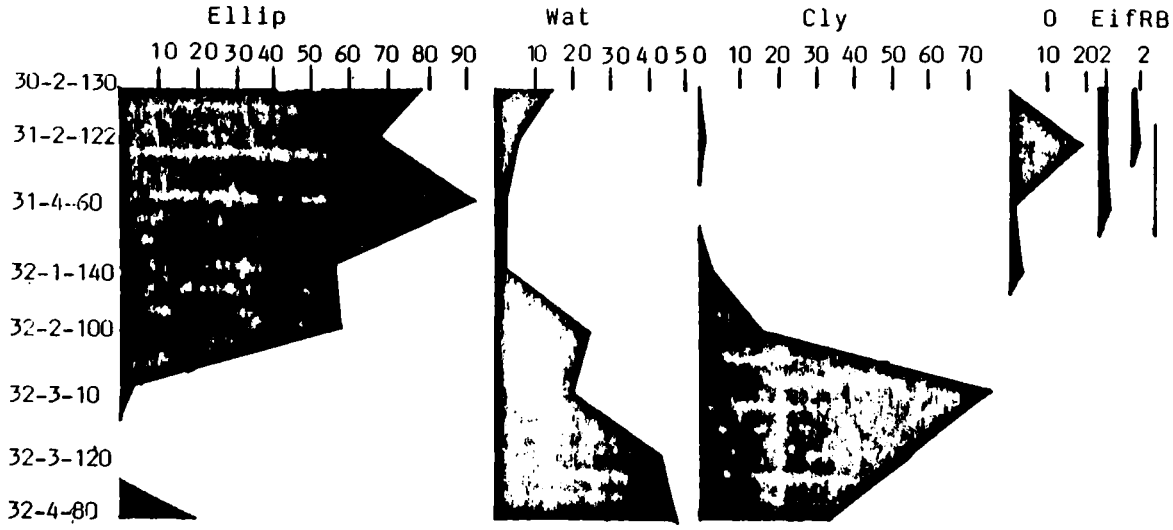
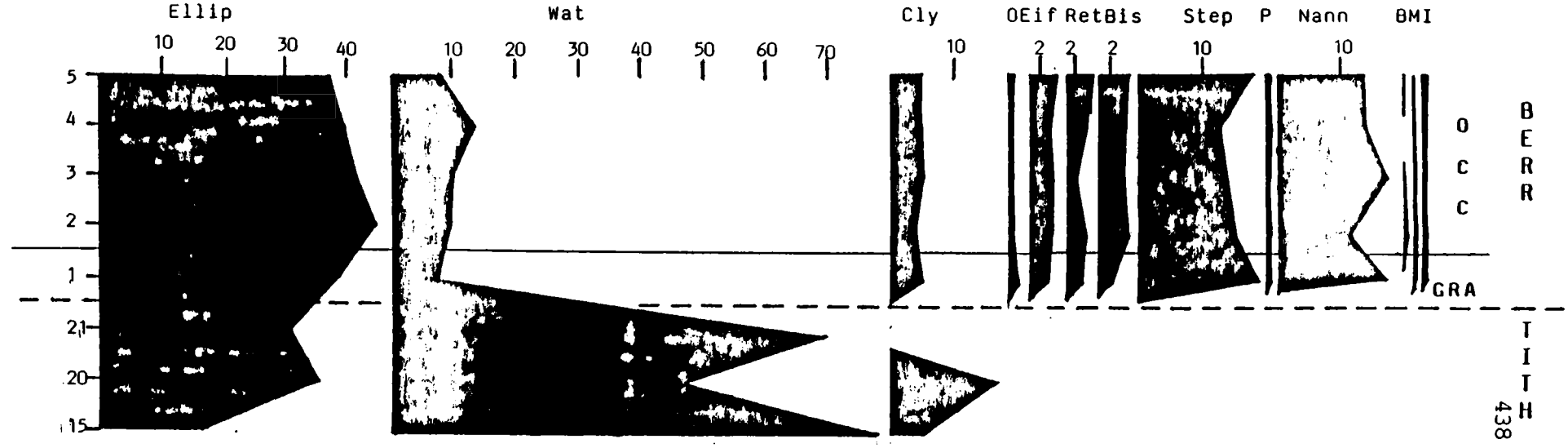


Fig. 7 Families percentage graph for the section at Tré Maroua (S.E.France).



It became apparent as more and more sections were studied that certain features or 'events were occurring within these family percentages in the some order at each section. When other fossil groups were used eg: ammonites and calpionellids in south east France, it was shown that these events occurred at the same stratigraphical level.

The nannofossil families can be divided into three group. The first is the Ellipsagelosphaeracea. As it is the most abundant family I divided it into generic groups. These groups are the *Ellipsagelosphaera,* the *Watznaueria,* the *Cyclagelosphaera* and a fourth group in which all the other genera belonging to the Ellipsagelosphaeracea are placed. The next group are all the other Coccolithophoids families. These families are the Eiffellithaceae, the Retecapsaceae, the Biscutaceae, the Stephanolithaceae and the Podorhabdaceae. The final grouping is the Coccolith related families and the *Incerdiae sedi* faimilies. This group includes the Nannoconaceae, the Braarudosphaerace, the Microrhabdaceae and the *Incerdiae sedis* which is represented by only one species *Conusphaera mexicana.*

In south east France there were a number of sections studied where there was good independant biostratigraphical control The resolution of sampling varied at each locality depending upon the lithology and the gase with which the ammonite zone could be seen at outcrop.

The first 'event' is that of a sharp increase in the nannoconids within the *Jacobi* ammonite zone. At Lac-en-Doise a higher proportion of nannoconids occur in the first sample which also comes from the the *jacobi* zone. A similar feature is seen in D.S.D.P. site 543A.

This event is followed by two other 'events'. The first is the *Watznaueria* which was the dominant genus in the Ellipsagelopshaeracea in the Upper Jurassic decreases and the Ellipsagelosphaera becomes dominant. The position of this event does vary in some south east France localities as it occurs at the top of the Tithonian in the *Jacobi* zone at Saint Nazaire-la-Desert whilst at Gorge de Merouge it occurres in the Early Berriasian.

The second event associated with the Jurassic Cretaceous boundary is a divergence in four Coccolith families, the Eiffellithaceae, the Retecapsaceae, the Biscutaceae and the Stephanolithaceae at Saint Nazaire-la-Desert these four start from less then 1% of the total nannofossil assemblage and steadily increase their accumulated percentages during the *Jacobi* and *Grandis* Zones. By the end of the *Grandis* Zone their accumulated percentages are about 40% of the total nannofossil assemblage. At a number of localities this gradual increase was not seen due to limited number of samples available.

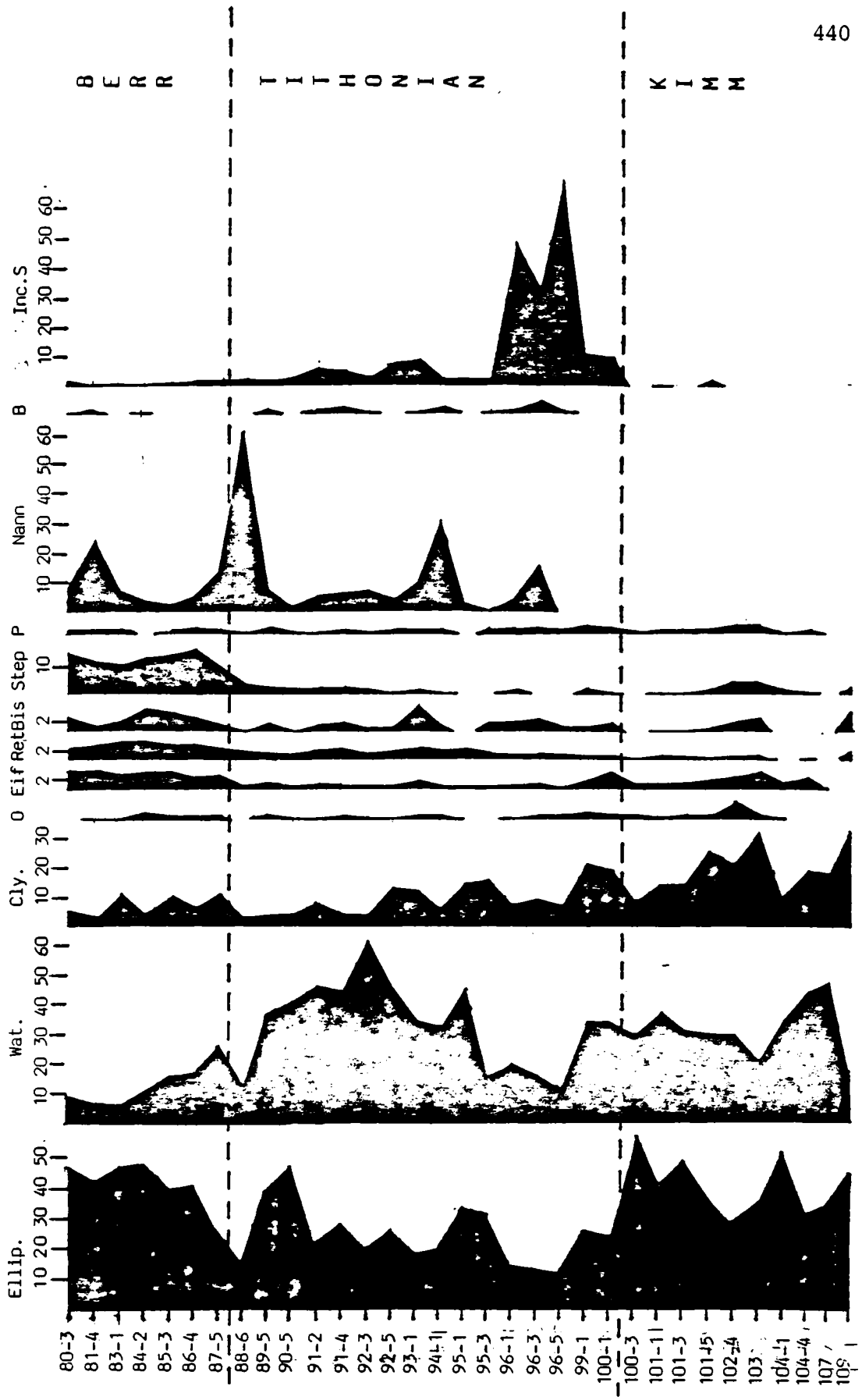


Fig. 8 Families percentage for D.S.D.P. Site 534A (off Florida)

sections where no samples were collected from the uppermost Tithonian *Jacobi* Zone e.g. e Maroura the nannoconid spike is not recorded, but both the decline in the *Watznaueria* d the increase in the four coccolith families is seen across the Jurassic/Cretaceous undary.

ere are a number of other 'events' which are recorded in sections from south east ance. In the *Boisseri* Zone at Tre Maroura a quite clear increase in nannoconid and ıe braarudospharaceae this was also seen in a section in Tunisia where calpionellids ıd given an Late Berriasian age to the rocks.

ıere are also three other 'events' where the biostratigraphic control is not as good at ıese 'events'. Across the Kimmeridgian-Tithonian boundary there is a decrease in most annofossil family groups and this is compatable to an increase in Ellipsagelosphaeracea. ı the Tithonian the *Incerdiae sedis* appear in nannofossil assemblage and increase apidly before declining with the first appearance of nannoconids. In the Valanginian here is a marked decrease in the nannoconids and the Braarudosphaeracea.

hese events are all clearly seen in the families percentage graphy for D.S.D.P. Site 534A see Fig. 8). This site section does not have such a detail independant biostratigraphical ontrol as the onshore localities. The position of the Jurassic/Cretaceous boundary was laced lower than the one envisaged from the nannofossil family percentages graph by he nannofossil worker on the Leg (Roth 1984). His position is also supported by ımmonites and aptychi worker on the Leg. The calpionellid and foraminifera are ınable to provide a detailed position for this boundary. The dinoflagellate ›rovide a similar position for the Jurassic Cretacepus boundary as this nannofossil study.

It is difficult to find a suitable explanation for the mechanism that cause these events. The nannoconid spike on the *Jacobi* Zone at the top of the Tithonian is probably a speciation event. Below the spike there are only three species of nannoconid recorded *N. steinmanni*, *N. dolomiticus* and a new species of nannoconid. At the level of the spike *N. globulus*, *N. quadratus* and *N. colomi* all have their first occurrence. The decrease in *Watznaueria* and the increase in all the four other families also seem to be linked.

CONCLUSIONS

A number of conclusions can be reached from this study.

1. That between the Tethyan localities examined there are discrepancies in the age ranges of certain nannofossils. Because of this the current biostratigraphic zonation schemes have a limited use to the region where they were constructed.

2. From a statistical count, family percentage diagrams were constructed. In these charts a number of biostratigraphically useful 'events' are recorded which, from independant biostratigraphical information occur at the same level at each locality. These events are:
   a. a sharp increase in the nannoconids in the *Jacobi* Zone at the top of the Tithonian
   b. a marked decline in the *Watznaueria* at the base of the Cretaceous
   c. a gradual increase in the Eiffellithaceae, the Retecapsaceae, the Biscutacea and Stephanolithaceae in the *Jacobi* and *Grandis* Zones before they become an important part of nannofossil assemblage in the *Occitanica* Zone of the Berriasian
   d. an increase in nannoconids and Braarudosphaeracea in the *Boisseri* Zone.

3. Other event were seen in the Upper Jurassic and Lower Cretaceous but these do not have such a good independant biostratigraphical control. These are:
   a. a decrease in most nannofossil families across the Kimmeridgian-Tithonian boundary with a compatable increase in the Ellipsagelopshaeracea
   b. in the Tithonian the *Incertiae sedis* appear in the nannofossil assemblage and increase rapidly before declining with the first appearance of nannoconids
   c. in the Valanginian there is a decrease in the nannoconids and the Braarudosphaeracea

4. Apart from the nannoconid spike at the top of Jurassic (a speciation event) the mechanism for these events is not known.

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ACKNOWLEDGMENT

I would like to thank the two supervisors of my research Prof. T. Barnard and Dr. A.R. Lord plus the staff and students of the Postgrad. Unit of Micropaleontology particularly Mr M Gay, Dr. A.J.J. Rees, Hilary Stowe, Christopher Mortimer and Barry Fitz-Gerald. I would also like to acknowledge the help from SSI (UK) Limited in particular Dr. R.H. Bate. A Natural Environment Research Council Research Studentship is gratefully acknowledged. The Deep Sea Drilling Project is acknowledged for providing some of the samples for this study.

THE TERMINAL JURASSIC STAGE

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THE TERMINAL JURASSIC STAGE

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ABSTRACT. A new proposal for international agreement on the terminal Jurassic stage involves: 1. Selection of the horizon at which the basal boundary is to be drawn; 2. Selection of a type section for this boundary; 3. The allocation of a name to the stage. Possible basal boundary horizons are discussed and the merits of the Dorset coast, as a possible area for a type section, put forward.

Many years of controversy have surrounded the problems of correlation between the three stage names in current use for the terminal stage of the Jurassic System. These are: Portlandian (d'Orbigny 1850) - used for the Anglo-Paris Basin, North Germany and applicable also to Greenland; Tithonian (Oppel 1865) - used for the Tethyan area; Volgian (Nikitin 1881) - originally introduced for Russia and used also in Poland; more recently it has attracted somewhat wider usage in the Boreal realm.

Up to now attempts to decide which of these names should be the internationally accepted terminal stage of the Jurassic have foundered on problems of the definition of each stage, on different interpretations of the definitions and, not least, on nationalistic prejudices.

Jurassic stratigraphers have long felt that they know more about stratigraphical principles than workers in any other Phanerozoic systems. It was after all for the Jurassic that Oppel introduced the zone and d'Orbigny's concept of a stage was also founded on the Jurassic. It is now over a century since three names have been in use for the terminal Jurassic stage. It may well be that each of these will continue to be of local use, but the time has surely come for a reappraisal of this problem and a fresh attempt made to resolve the difficulties.

A historical perspective was advocated by Arkell (1946) who suggested that since the stages were founded by d'Orbigny (1950) his stages should, where possible, be given priority. Thus, Arkell argued, the stage name which had priority for the terminal Jurassic stage was the Portlandian; it had priority over Tithonian (which under the criteria laid down by Arkell (1946 p.3) was inadmissible since it was not named after a place) and over

Volgian which it pre-dated by over 30 years. There remained one problem - the ambiguity over the meaning of the word "Portlandian" because d'Orbigny had originally cited species of ammonites, now included in the genus Gravesia, in his list of fossils characteristic of the Portlandian. Arkell pointed out, however, that d'Orbigny in naming the Kimmeridgian after Kimmeridge in Dorset had stated unequivocally that this was the Weymouth Beds and Kimmeridge Clay of Fitton (1836) and that the Portlandian, named after Portland in Dorset, was the Portland Sand and Portland Stone of Fitton. Thus, interpretation of the stages in either of these localities, in terms of lithostratigraphical units, is unambiguous.

The first to note that other interpretations were possible was Blake (1881) who noted that the upper beds of the Kimmeridge Clay were considered Portlandian in the French interpretation. To those who know the Boulonnais sections, the reason for drawing a Kimmeridgian/Portlandian boundary lower down seems obvious - the first major lithological change comes much lower in the succession than in Dorset. The Grès de la Crèche is a major sandy horizon yielding Gravesia. The Boulonnais was a swell area in the late Jurassic and received (like many other swell and platform areas) a thin and condensed succession replete with phosphatic nodule beds and concomitant non-sequences. Blake suggested the term "Bolonian" for the beds above the Lower Kimmeridge Clay (i.e. the Middle and Upper Kimmeridgian of Arkell 1947 a, b, 1956; the Upper Kimmeridgian of Cope 1967, 1978, 1980). The subsequent discovery of species of Gravesia in the middle of the Dorset Kimmeridge Clay by Salfeld (1914) confirmed Blake's views, though the term Bolonian has never been favoured (although it was used by Arkell, 1947a, p.67 as a substage name) and the term Portlandian has continued to be interpreted differently on either side of the English Channel.

Arkell reasoned that the citation of the species (now Gravesia) by d'Orbigny was in error; a confusion of Titanites pseudogigas (Blake) and related forms with Gravesia probably because of similar matrix (Arkell 1946 p.6). Arkell noted too that the German Portlandkalk (with Gravesia) was included by d'Orbigny in his Kimmeridgian stage, thus supporting the contention that d'Orbigny did intend the Portlandian to begin as now interpreted by all Jurassic stratigraphers in Britain.

Since the redefinition of the Volgian by Gerassimov & Mikhailov (1966) and their proposal that it should serve as the global standard, their correlations of the Volgian faunas with those of the British Kimmeridgian/Portlandian successions have been challenged by Casey (1967, 1973) and Cope (1978). Despite the fact that some ammonite evidence has been figured in

support of new correlations between the Volgian and the Kimmeridgian/ Portlandian (Casey 1973, Cope 1978) recent Russian views (Mesezhnikov 1982) have changed little from the correlations proposed by Gerassimov & Mikhailov (1966, tab. 1).

As shown elsewhere (Wimbledon, this volume) the proposed type area of the Volgian at Gorodishche is thin, has many phosphatic nodule beds, and is clearly condensed. As a candidate for an international stage is has major disadvantages. The thickness of the basal Klimovi Zone is very much thinner than its presumed equivalent in Britain, suggesting condensation at the base too.

Here, I propose a fresh approach to the problem of the terminal Jurassic stage. I do not claim this to be new, for what I am advocating is the approach taken by international cooperation in establishing the Silurian-Devonian boundary (McLaren 1977). In fixing the terminal Jurassic stage we have three problems; what I urge is that these three problems are considered in the order in which I list them, because I believe that only in this way is it likely that international agreement on the boundary is likely. The three problems are:

1. Selection of the horizon at which the boundary is to be drawn.
2. Selection of a type section for this boundary.
3. Selection of a name for the stage.

Let us consider each of these in turn.

1. SELECTION OF THE HORIZON

The base of the terminal Jurassic stage will ultimately be defined by the base of its basal zone in a named type section.

There are several possible horizons at which to draw the line, but in the case of an international Standard Stage one would urge the selection of a point from which ready correlation may be made over as wide an area as possible. Examples of horizons which could be taken are discussed below.

i. The base of the Elegans Zone

This horizon corresponds with the Lower/Upper Kimmeridgian boundary sensu anglico which is equivalent to the Kimmeridgian/Portlandian boundary sensu gallico. It corresponds approximately with the base of the Volgian (as redefined by Gerassimov & Mikhailov 1966) and also approximately with the base of the Tithonian. However, even at this level there are still major problems in correlation.

The chief ammonites in the Boreal regions belong to the Virgatosphinctinae. In Britain the principal genus is Pectinatites, and a succession of species of this genus provides the zonal and subzonal subdivision of the Upper Kimmeridgian (Cope 1967, 1974, 1978). In Russia Ilovaiskya provides the basis for three zones (Ilovaisky & Florensky 1941, Mesezhnikov 1982) or possibly four (see Callomon & Birkelund 1982 followed herein) whilst in southern Europe Franconites and its relatives overly beds with Subplanites and Lithacoceras (Zeiss 1968). The suggestion by Spath (1936) that the British Upper Kimmeridgian virgatosphinctids belonged to Lithacoceras and Subplanites was followed by Arkell (1947a, b, 1956). Arkell (1956) also followed Spath in identifying the Russian Ilovaiskya with Subplanites too. It was demonstrated by Cope & Zeiss (1964) that the British and Franconian forms were not congeneric and the presence of dimorphism in the two stocks has demonstrated clearly their differences. The Pectinatites characteristic of the British area occur also in Greenland (Spath 1936, Callomon & Birkelund 1982) and have a horned microconch (see Cope 1967, 1978). The Tithonian genera have microconchs with lappets (see Schneid 1914, Zeiss 1968). The position of Ilovaiskya is still not clear. Species such as I. klimovi (see Ilovaisky & Florensky 1941 pls. 21, 22) appear very close to Pectinatites (Virgatosphinctoides) elegans Cope, but no material of Ilovaiskya appears to have been figured with microconch peristomal processes. It may well ultimately be proven that the genus is distinct from both Subplanites and Pectinatites as suggested by Kutek & Zeiss (1974) and Callomon & Birkelund (1982).

Another genus occurring around this interval which could perhaps be useful is Gravesia. Species of this genus were formerly used as zonal indices in Britain after their introduction by Salfeld (1913). Salfeld proposed a zone of G. irius overlying a zone of G. gravesiana. I was able to establish by detailed collecting that Gravesia is exceptionally rare in Dorset and that G. gravesiana occurred above G. gigas - no G. irius appeared to exist in British collections; I thus abandoned the Gravesia zones when erecting a zonal scheme based on pectinatitids (Cope 1967 p.66-68). It is now known that Gravesia has a long range in Dorset and a detailed study of the Lower Kimmeridge Clay by Mr. C.P. Van der Vyver (Swansea) has revealed that Gravesia irius does occur in Dorset (but well below the level reported by Salfeld) its lowest level is some 2m below the Maple Ledge Stone Band (Arkell 1947a p.73) where it occurs together with Aulacostephanus autissiodorensis (C.P. Van der Vyver pers. comm. 1984). The highest record of Gravesia is from 1.8m above the base of the Scitulus Zone (Cope 1967 p.68).

It may be that internationally the correlations provided by Gravesia would prove useful; but before this can be done, much work is required on the ranges of species of the genus in each region.

It should be noted here that although it was reported as a resolution of the Luxembourg Colloquium of 1967 (Maubeuge 1970 p.38) that the summit of the Kimmeridgian was marked by the base of the Gravesia zone, my recollections, and those of several others present at that meeting, were that no such resolution was passed.

ii. The base of the Pallasioides Zone

A second horizon which could be selected was that advocated by Casey (1967 pp.132-3). That is, a boundary drawn at the base of the Pallasioides Zone in Dorset. Since Casey made this proposal, the fauna of the Pavlovia zones of Dorset has been monographed (Cope 1978). This boundary would correspond with the base of the Middle Volgian (as redefined by Gerassimov & Mikhailov 1966) and coincides with the base of the Volgian as understood until the revision of Gerassimov & Mikhailov. I have demonstrated the close similarities between the Volgian and British Pavlovia faunas - faunas which can be closely matched with Greenland (Callomon & Birkelund 1982). Kutek & Zeiss (1974) have shown that it is possible to correlate this level reasonably well with the Tithonian faunas and the horizon appears to correspond to the base of the Upper Tithonian (Zeiss 1983).

iii. The base of the Albani Zone

A third possible horizon at which the basal boundary of the terminal Jurassic stage could be drawn is at the base of the Albani Zone in Britain. This corresponds with the Kimmeridgian/Portlandian boundary (sensu anglico). Correlation at this level with the Tithonian seems at present tenuous but in the Volgian succession the boundary appears to correspond to a position near the base of the Nikitini Zone, since Epivirgatites seems to be confined in Britain to the Albani Zone. Casey (1967) quoted examples of British species which he assigned to Epivirgatites and I (Cope 1967 pl.55) figured specimens of Epivirgatites (including one I referred to E. nikitini from the Dorset Albani Zone. This evidence was, however, rejected by Mesezhnikov (1982). The rejection was based on two arguments:

(a) that the specimens I had figured (1978 pl.55 figs. 2, 3) were not Epivirgatites but were species of Lydistratites close to L. biformis Buckman (Mesezhnikov (1982 p.130). Interestingly, this latter species had earlier been identified as an Epivirgatites

(Casey 1967 p.132) though I had thought it to more closely resemble Progalbanites (Cope 1978 p.490). The specimens I figured as Epivirgatites still appear to me to be very close to the lectotype of E. nikitini figured by Michalski (1890). The apparently unique rib style of this genus, having constrictions preceded by a four-branched rib (Cope 1978 p.531) must surely reflect close relationship and I cannot accept that because one specimen I figured was a little more involute and slightly more coarsely ribbed than the lectotype, that it is unrelated to Epivirgatites. Regrettably our Russian colleagues continue to use the ill-founded genus Lydistratites (Buckman 1922) although I have discussed in detail all the specimens which Buckman figured under this name (Cope 1978 p.490) and suggested that the name is best treated as a junior synonym of Pavlovia.

(b) that although Casey had earlier correlated the Albani and Nikitini Zones (1967 pp.131-2) he had since "to all intents and purposes dissociated himself from this point of view" (Mesezhnikov 1982 p.128) by figuring a specimen he referred to Paracraspedites oppressus from the Volga at Gorodishche. Casey (1973 pl.1 fig. 4) recorded the specimen from the Blakei Zone and correlated the Blakei Zone with the Oppressus Zone; but Mesezhnikov (ibid. p.128, footnote 2) states that it was from a horizon yielding E. nikitini thus suggesting that the true correlative of the Nikitini Zone was the Oppressus Zone. This latter correlation was then incorporated into his Table 17 (Mesezhnikov 1982 pp.132-3). Unfortunately Paracraspedites was founded on rather unsatisfactory material and I cannot match in detail any character of the inner whorls shown by the Gorodishche specimen with the outer whorl of the holotype or British paratype (Casey 1973 pl.1). To base intercontinental correlations on such material seems to me to be inadvisable.

iv. The base of the Volgian Fulgens Zone

A further horizon at which to draw the boundary is at the base of the Upper Volgian as at present defined (i.e. at the base of the Fulgens Zone). This level can be traced from the Moscow area to Siberia and Spitzbergen and has possible correlatives in the British Primitivus Zone (Casey 1973). This horizon was proposed by Casey (1967 p.132) to form the base of a revised Volgian stage; he proposed that beneath this Volgian stage should be a revised Portlandian stage with the Pallasioides Zone at its base (ibid. pp.132-3).

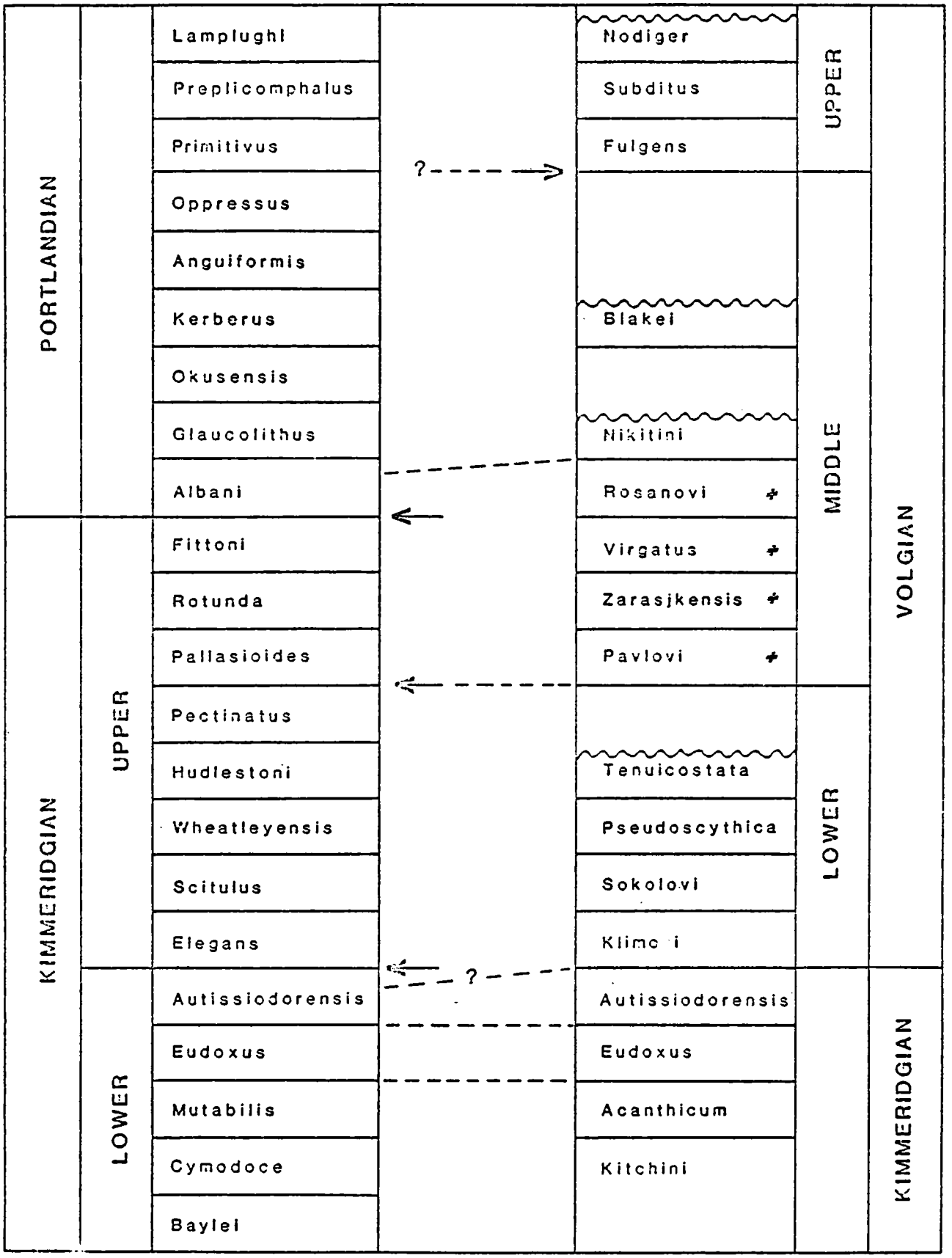

Figure 1.

The Kimmeridgian/Portlandian zones of Britain and the Kimmeridgian/Volgian zones of the Russian Platform. Possible basal marker points for the terminal Jurassic stage are indicated by arrows. Probable correlations are shown by broken lines. (* Indicates subzone).

Although there may be other horizons at which the base of the terminal Jurassic stage might be drawn, they merit, in my opinion, less serious consideration. It appears clear that because of the progressive provincialism of the faunas that it is easiest to correlate internationally at the lower stratigraphical levels. If such a lower boundary were ultimately to be chosen, then it might be considered that a further stage is required for the terminal Jurassic stage - and the problems of the terminal stage would thus begin again. It is worth noting that the Kimmeridgian (sensu anglico) has 13 zones and the Portlandian (sensu anglico) has 9. A boundary at the lowest level considered would give a revised Kimmeridgian with 5 zones and a terminal stage with 17 zones - a rather disparate division.

2. SELECTION OF A TYPE SECTION

In the early days of geology the drawing of geological boundaries was a simple process. The idea of "natural breaks" in the succession of events, of catastrophism, was pervasive and in creating stages d'Orbigny spoke of "les révolutions du globe" (see Rioult 1974). Nowadays, however, it is considered that the best place to draw a boundary is in a thick succession, devoid of major breaks and with fossils throughout.

One of the best places to draw a boundary must be within the magnificent sections along the Dorset coast, particularly in the Isle of Purbeck. Here, the sections display an unbroken marine succession from the Eudoxus Zone of the Kimmeridgian to the Oppressus Zone of the Portlandian. The section is virtually 400m thick and has been well described (e.g. Arkell 1933, 1947a, Ziegler 1961, Cope 1967, 1978, 1980, Wimbledon 1980). This thickness is in stark contrast to c.20m in the Gorodishche section of the Volga river (Mesezhnikov et al. 1977).

Whichever level is finally selected for the fixing of a type section of a basal zone used in the definition of the terminal Jurassic stage, the Isle of Purbeck successions have much to commend them. They are, as far as is known, devoid of any breaks; the succession is flat lying (average dips c.3°) and ammonites occur throughout. The sections are permanently accessible.

Other localities are, of course, available for such boundaries but I leave description of their merits to my colleagues in other countries.

3. SELECTION OF A NAME FOR THE STAGE

Until now the only candidates which have been considered as the terminal Jurassic stage (omitting the Purbeckian - now universally abandoned) are the Portlandian, the Volgian and the Tithonian. The proponents of these stages

have supported them, frequently, it may be suggested, in a nationalistic rather than a truly scientific spirit.

If the procedures which I have suggested above are followed - in other words before the name is selected, the level of the basal boundary and a type section for the basal zone will have already been decided - it may be that one of these names becomes the obvious candidate for selection. However, it seems possible that none of these three names will prove to be the obvious choice; all may be eliminated for one or more reasons. In that case a new stage name would be needed.

Ultimately we can hope for a single internationally accepted terminal Jurassic stage, but we can expect that the Portlandian, Volgian and Tithonian will continue to be used, on a local basis, for some years yet.

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PALYNOMORPH BIOSTRATIGRAPHY IN THE MARINE PORTLANDIAN ROCKS OF SOUTHERN BRITAIN: WITH COMMENTS ON THE BASE OF THE PORTLANDIAN STAGE

C. O. Hunt & W. A. Wimbledon

The British Portlandian is probably the most intensively studied of the currently available highest Jurassic marine sequences. One miospore and two dinoflagellate cyst biozones are currently recognised. A number of palynological events which may be used for refined biozonation in southern England are presented here. The results of biozonation using palynology are closely comparable with those from biozonation using ammonites. The definition of the base of the Portlandian Stage is discussed.

INTRODUCTION

In the type sections of the Portlandian Stage on the coast of Dorset, England, 80 m of marine Portlandian rocks conformably overlie the type Kimmeridgian. The Kimmeridge Clay Formation is followed by the Portland Sand Formation, up to 39 m of shales and dolomites (albani - okusensis ammonite biozones). This is followed by up to 39 m of shallow-marine limestones of the Portland Stone Formarion (okusensis - anguiformis ammonite biozones). The Portland Stone Formation is conformably overlaid by the lagoonal and sabkha evaporites, limestones and shales of the Purbeck Formation. The Portlandian-Berriasian boundary lies within the Purbeck formation, probably within the Soft Cockle Beds, but its position is yet to be accurately defined. Similar, but less complete sequences are known from the margins of the Wessex Basin at Wardour and Swindon in Wiltshire and in the area near Aylesbury in Berkshire. The Portland Sand Formation is also known from the Weald Basin in southern England but the Portland Stone Formation is missing and the basal Purbeck Formation is correlative with the middle part of the Purbeck Formation in Dorset (WIMBLEDON & HUNT, 1983). Correlation of the Portlandian rocks of eastern England with the type sequences in Dorset has yet to be definitively achieved, but marine deposition continued there after it had terminated in southern England.

Early accounts of the Portlandian rocks of the Wessex Basin include those of FITTON (1836), FORBES (1851), AUSTEN (1852), BLAKE (1880) and WOODWARD (1895). The sedimentology of the Dorset sections has recently been described by TOWNSON (1975). The ammonite biozonation has been redefined by WIMBLEDON (1976, 1980 and this volume) and WIMBLEDON & COPE (1978).

THE BASE OF THE PORTLANDIAN STAGE

Two points have been used to define the base of the Portlandian Stage in the Dorset type sections. These are the base of the elegans Zone (Portlandian sensu gallico) and the base of the albani Zone (Portlandian sensu stricto).

The former definition is based upon the use of Gravesia, on or about this level in the Kimmeridge section, as a correlative tool in comparing this interval with the basal Tithonian and basal Volgian. The genus in fact has a range from the autissiodorensis Zone, through the elegans Zone and into the scitulus Zone in Dorset and it is always infrequent (see GALLOIS & COX, 1981). The autissiodorensis-elegans zonal boundary was placed (COPE, 1967) at the point where Aulacostephanus disappeared rather than at the appearance of Pectinatus, for species of that genus (but not P. elegans itself) first appear well down in the autissiodorensis Zone. North of Dorset the elegans Zone saw the commencement of a major period of erosion and non-deposition. Palynologically, the elegans Zone is marked by the incoming of Egmontodinium polyplacophorum and Fromea spp., but the overlying scitulus zone is far more distinctive (SARJEANT, 1979).

Portlandian (sensu stricto) in the sense preferred here commences with the albani Zone, formally defined in the Hounstout cliff section in Dorset. The usage of the Stage name closely follows the intentions of D'ORBIGNY in including no part of the Kimmeridge Clay, following FITTON (1836).

The albani Zone marks an ammonite faunal turnover of some significance. Although Pavlovia persists from the Kimmeridge Clay below, new genera make their appearance in the basal beds of the Portland Sand Formation in Dorset. Some of these Dorset forms are of considerable importance for long-range correlation in the Boreal Realm, e.g. Progalbanites (N. France), Epipallasiceras (N. France, Greenland) and Epivirgatites (USSR).

The base of the Portlandian in Dorset is marked by the incoming of Parvisaccites radiatus. The widely-distributed Ctenidodinium culmulum comes in just above this level, and there is an evolutionary change from Gochteodinia mutabilis to a comparable, but semitabulate form.

One of the problems presently besetting the choice of a suitable boundary for the base of the terminal Jurassic stage has been the persistent use by some authors of limited faunas and often only a single genus, such as Gravesia, as infallible indicators for a preferred base. This approach can afford no more than an approximate correlation with any standard section. The problem is exacerbated by the lack of agreed reference sections for the terminal Jurassic in the Tethyan province. We prefer to follow the International Stratigraphic Guide (1976) in preferring to define a base in a complete marine sequence containing a wide range of fossil fauna and flora, and to recognise that base elsewhere and correlate with the stratotype using the presence of as many of these fossils as possible.

PALYNOLOGY OF THE TYPE PORTLANDIAN

Miospores were first described from the Upper Jurassic of southern England by COUPER (1958) and LANTZ (1958). More detailed studies were made by NORRIS (1963, 1969, 1970) and WIMBLEDON & HUNT (1983). NORRIS (1969) erected a broad miospore biozonation for the highest Jurassic/lowest Cretaceous rocks of southern England. His biozone ("Suite") A encompasses the highest parts of the type Kimmeridgian and all of the type Portlandian.

Dinoflagellate cysts were first described from the type Portlandian by LANTZ (1958) and NORRIS (1963, 1965). RAYNAUD (1978), DAVEY (1979), SARJEANT (1979), FISHER & RILEY (1980), DAVEY (1982), WOOLLAM & RIDING (1983) and RIDING SARJEANT (this volume) have given selected dinocyst ranges and have erected broad biozonations encompassing the Portlandian as part of wider biostratigraphic studies, mostly based on sequences in Eastern England and the North Sea. DAVEY (1979) divided the Portlandian into three dinoflagellate cyst biozones, however, later workers, such as WOOLLAM & RIDING (1983) divide it into two biozones. All of the marine Portlandian of Dorset falls into the Ctenidodinium culmulum biozone as defined by WOOLLAM & RIDING (1983).

DINOFLAGELLATE CYSTS AND ACRITARCHS

Dinoflagellate cysts and acritarchs are ubiquitous in the marine Upper Jurassic and Purbeck Formation in southern England. Deeper shelf assemblages from the Kimmeridge Clay Formation and Portland Sand Formation are very diverse, most samples containing over 50 species. Chorate cysts are common, especially the genera Hystrichosphaerina and Systematophora. The proximate genera Gonyaulacysta, Apteodinium and Millioudodinium are very common and the cavate genera Muderongia and Senonisphaera are also common. Acritarchs are not common, they are represented mostly by the acanthomorph genera Michrystridium and Solisphaeridium.

Shallow shelf assemblages can be divided into three broad facies-groups. Cross-bedded pyritic sands are often dominated by Senonisphaera and Muderongia species. Oolitic, bioclast and micritic limestones from Dorset and Wiltshire are dominated by the proximate genera Sentusidinium, Lanterna and Cyclonephelium and the proximochorate Ctenidodinium. Assemblages are often very diverse in these facies. Low-diversity assemblages dominated by the acritarch genera Pterospermella, Cymatiosphaera and Michrystridium and Tasmanites spp. are characteristic of spiculiferous limestones of the Cherty Beds of the Portland Stone Formation.

The lagoonal limestones and shales of the Purbeck Formation are characterised by low-diversity assemblages dominated by Mendicodinium, Lithodinia, Pareodinia, Apteodinium and Microdinium. Some assemblages, probably laid down in highly stressed, perhaps brackish, environments, are dominated by veryhachid and michrystrid acritarchs. The schizomorph acritarchs Schizophacus and Schizosporis are characteristic of rocks laid down under very low salinities.

MIOSPORES

Miospores are ubiquitous in the Upper Jurassic and Lower Cretaceous rocks of southern England and are especially useful in non-marine facies. Assemblages in marine rocks are generally of low diversity and dominated by gymnosperm pollen of the genera Classopollis, Spheripollenites, Inaperturopollenites, Araucariacites, Callialasporites, Abietineaepollenites and Alisporites.

Assemblages from non-marine rocks are generally moderately to very diverse (30-90 spp.). Most are dominated by gymnosperm pollen, but some are dominated by trilete spores, usually of the genera Densoisporites, Deltoidospora, Gleicheniidites, Trilobosporites and Cicatricosisporites.

MEGASPORES

Megaspores are present only in non-marine rocks. Assemblages rarely contain more than five taxa, but may be numerically abundant. Species of Trileites generally dominate the assemblages; other common taxa include species of Echitriletes, Verrutriletes, Ricinospora and Erlansonisporites.

STRATIGRAPHIC PALYNOLOGY

Most palynomorphs have ranges spanning several ammonite biozones, so palynological zonation is based on the incoming and outgoing of groups of taxa. Many stratigraphically useful palynomorphs are unpublished; these are excluded from consideration in this report. Biozonation using palynomorphs

is potentially as detailed as that using macrofossil groups such as the ammonites. Table 1 shows selected tops and bases in the type Portlandian, compared with the ammonite biozonation. These palynological events run

AMMONITE BIOZONE	BASES	TOPS
(Purbeck Fm.)	Gochteodinia villosa s. str. Pilosisporites trichopapillosus Cicatricosisporites purbeckensis Polysphaeridium warrenii Apiculatisporis verbitskayae	 Ctenidodinium panneum Ctenidodinium schizoblatum
anguiformis		Ctenidodinium culmulum Occisucysta balios Egmontodinium polyphlacophorum Tityrosphaeridium porosispinum
kerberus	Ctenidodinium schizoblatum Microreticulatisporites diatretus	Cannosphaeropsis thula Glossodinium dimorphum
okusensis		
glaucolithus	Egmontodinium expiriatum Cicatricosisporites crassistriatus	Perissiasphaeridium sp. (DAVEY '82)
albani	Ctenidodinium culmulum Parvisaccites radiatus	Gochteodinia mutabilis

TABLE 1. Palynomorph tops and bases in the Portlandian rocks of the Wessex Basin: comparison with ammonite biostratigraphy.

parallel to the ammonite biozonation across the Wessex and Weald Basins of southern England and can thus provide the basis for a refined biostratigraphy in this area. The ranges differ from the distributions that have been reported from the North Sea and Eastern England, areas which were probably isolated from the southern English basins by the glaucolithus zone, and where the rocks are zoned by an ammonite biostratigraphy in need of major revision (WIMBLEDON, this volume).

In the Portlandian type sections, the base of the Stage is marked by the incoming of Parvisaccites radiatus, soon followed by Ctenidodinium culmulum. The incoming of Egmontodinium expiriatum and Ctenidodinium schizoblatum and the exit of Glossodinium dimorphum and Gochteodinia mutabilis are important

datums in the Portland Group. In the Purbeck Formation the incoming of Polysphaeridium warrenii, Cicatricosisporites purbeckensis and Gochteodinia villosa and the outgoing of Ctenidodinium panneum and C. schizoblatum are palynological events which offer good possiblities for long-distance correlation.

CONCLUSION

The distribution of dinoflagellate cysts, acritarchs, and miospores in the type Portlandian of southern England shows potential for refined biostratigraphical subdivision. Palynological datums closely parallel the ammonite biostratigraphy. The Portland Sand, Portland Stone and Purbeck Formations of southern England provide a key reference section for the terminal Jurassic stage.

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BIOSTRATIGRAPHIE DE L'OXFORDIEN-KIMMERIDGIEN DE L'ALGARVE ORIENTALE

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BIOSTRATIGRAPHIE DE L'OXFORDIEN-KIMMERIDGIEN DE L'ALGARVE ORIENTALE

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La présence de sédiments jurassiques en l'Algarve orientale a été mise en évidence par plusieurs auteurs, parmi lesquels on peut citer P. CHOFFAT (1887), J. PRATSCH (1958), B. ZIEGLER (1971) et R. ROCHA & B. MARQUES (1979). Ces auteurs ont fait connaître les grands ensembles lithologiques et leur contenu faunistique; la stratigraphie presentée est sommaire pour la plupart des cas, ce qui n'a pas empêché des considérations paléogéographiques détaillées et importantes.

Récemment B. MARQUES (1983) a entrepris des recherches plus détaillées de ces formations qui ont abbuties à une connaissance plus rigoureuse des unités lithostratigraphiques et à l'établissement de la biostratigraphie de l'Oxfordien-Kimméridgien.

*

La biozonation proposée a été établie essentiellement à partir de l'étude des faunes de l'Oxfordien moyen-Kimméridgien inférieur, en comparaison avec d'autres régions de caractéristiques semblables (province subméditerranéenne).

Ainsi, les éléments récueillis sur la succession des faunes permettent de caractériser les ensembles faunistiques suivants:

- Ensemble marquée par un net enrichissement des Perisphinctidae, associés à une faune abondante et variée (surtout d'Oppeliidae et de Phylloceratidae);

- Ensemble où les Ataxioceratinae dominent et les Aspidoceratidae sont communs;

- Ensemble réduit, avec de rares Idoceras, mais de grande importance stratigraphique;

- Ensemble où les Ataxioceratinae dominent avec quelques représentants d'autres groupes.

La biozonation locale, établie à partir de ces associations faunistiques, est identique à d'autres déjà admises jusqu'ici (CARIOU & al, 1971, ATROPS, 1982) pour des formations de même âge et de la même province paleobiogéographique. Cependant, il existe un hiatus correspondant à l'ensemble de l'Oxfordien inférieur, à peine connu en Algarve occidentale, dans un niveau de condensation avec d'autres fossiles de l'Oxfordien moyen et même du Callovien supérieur (ROCHA, 1976, p. 74).

Les discontinuités faunistiques semblent être généralement liées à des problèmes sédimentologiques et non évolutifs.

1 - OXFORDIEN MOYEN

L'Oxfordien moyen est caractérisé par l'abondance et variété de différents taxons et correspond à l'extension géographique maximale du fácies marno-calcaire.

Phylloceratidae, Holcophylloceratidae (surtout le genre Sowerbyceras) et Perisphinctinae sont abondants. D'autres familles (Oppeliidae) ont été reconnues, mais sont peu abondantes ou mêmes rares.

1.1 - Zone à Plicatilis

Cette zone, utilisée dans le sens de R. ENAY (1966, pp. 267--277), est divisée en deux sous-zones caractérisées par des associations faunistiques légèrement différentes.

1.1.1 - Sous-zone à Tenuicostatum ou Vertebrale

Cette zone, caractérisée par la présence de Cardioceras très abondants en France et rares au Portugal, n'a pas été mise en évidence.

Les représentants de la famille Cardioceratidae d'affinités boréales, arrivent à la province subméditerranéenne à partir du début de l'Oxfordien; ils y restent pendant l'Oxfordien moyen et

ont une nouvelle incursion au Kimméridgien inférieur (base de la zone à Platynota).

En Algarve, et malgré les affinités subméditerranéennes, la présence de Cardioceras est très rare; au contraire, d'autres groupes (Oppeliidae et Phylloceratidae) sont abondants.

1.1.2 - Sous-zone à Antecedens

L'espèce indice est commun en Algarve et elle se trouve dans presques tous les affleurements.

Cette sous-zone est caractérisée par l'abondance de Dichotomosphinctes gr. P. (D.) antecedens (SALF.), P. (D.) buckmani (ARK.), P. (D.) dobrogensis (SIM.), P. (D.) elisabethae De RIAZ, P. (D.) rotoides (RONCH.), P. (D.) wartae (BUK.) associés à P. (Otosphinctes), [P. (O.) pulvinus ENAY, P. (O.) siemiradzkii ENAY] et P. (Arisphinctes) plicatilis (SOW.).

Les Oppeliidae sont fréquents, particulièrement Glochiceras [G. subclasum (OP.)], Ochectoceras, Campylites [C. (N.) henrici henrici (d'ORB.)], Trimarginites et Taramelliceras [T. (T.) argoviense (JEAN.), T. (T.) calicerum (OP.)]. On peut signaler la présence d'un seul exemplaire de Cardioceras et de rares Gregoryceras. Les Pachyceratidae, abondants dans la zone sous-bétique (SEQUEIROS & OLORIZ 1979, p. 467) sont très rares en Algarve (ROCHA, 1976, pp. 124-126).

1.2 - Zone à Transversarium

Cette zone, liée à un important changement faunistique, est divisée en deux sous-zones.

1.2.1 - Sous-zone à Parandieri

Malgré l'absence de l'espèce indice, l'association faunistique est semblable à celle proposée dans la litérature pour la province subméditerranéenne. Ainsi cette unité est caracterisée par l'association de Ochetoceras [O. Canaliculatum (BUCH) et O. hispidum (OP.)], Campylites [C. Neoprionoceras) lautlingensis (ROL.)], Perisphinctes [P. (Dictomosphinctes) elisabethae De RIAZ, P. (D.) luciaeformis ENAY, P. (D.) wartae (BUK.), P. (Otosphinctes) birmensdorfensis (MOESCH)], Subdiscosphinctes [S.

(Subdiscosphinctes) aeneas (GEMM.), S. (S.) aeniformis (DACQUÉ), S. (S.) lucingae (FAVRE), S. (S.) mindowe (SIEM.)] , Gregoryceras [G. (Gregoryceras) fouquei (KIL.)] et Euaspidoceras [E. (Euaspidoceras) oegir (OP.), E. (E.) perarmatum (SOW.)].

Il faut signaler l'absence de Larcheria, abondante en France à la partie supérieure de cette unité.

1.2.2 - Sous-zone à Schilli

En Algarve n'a pas été possible l'individualisation de cette sous-zone due la rareté des Larcheria. En effet on connaît un seul exemplaire de Larcheria sp. gr. L. (L.) subschilli-latumbilicata.

2 - OXFORDIEN SUPÉRIEUR

L'Oxfordien supérieur est marqué par l'apparition de nouveaux taxons: Microbiplices (rare), Orthosphinctes s.l. (sous-genres Ardescia et Lithacosphinctes), Idoceras, Decipia et Epipeltoceras.

2.1 - Zone à Bifurcatus

La faune caractéristique de la zone à Bifurcatus en Algarve est la suivante: de rares Glochiceras [G. (Coryceras) crenatum (OP.), G. (C.) microdomum (OP.)] , Ochetoceras [O. hispidiforme (FONT.), O. Canaliculatum (BUCH)] , Trimarginites stenorhynchus (OP.), Microsphinctes gr. bukowskii (CHOF.) et Perisphinctes (Dichotomoceras) sp.

La comparaison de cette zone avec les zones équivalentes des Chaînes Bétiques (Biozones à Riazi et à Bifurcatus) est très significative. En Algarve les Phylloceratáceae, les Haploceratáceae et les Perisphinctidae sont abondants, les Peltoceratinae sont rares et les Aspidoceratinae sont communs; au contraire dans les Chaînes Bétiques ce sont les Phylloceratidae, les Perisphinctidae et les Peltoceratidae qui sont abondants et les Haploceratáceae rares.

2.2 - Zone à Bimammatum

La plupart de l'association faunique de la zone à Bimammatum se trouve dans les niveaux de resédimentation et de condensation, ce qui n'empêche pas que cette faune soit la plus riche en variété et quantité des formes.

Les sous-zones de la zone à Bimammatum n'ont pas été individualisées et delimitées à cause du caractère condensé de la faune.

2.2.1 - Sous-zone à Hypselum

L'unité est caracterisée par une association faunique qui comprend: Glochiceras [G. (G.) tectum ZIEGL., G. (Coryceras) canale (QUENST.), G. (C.) microdomum (OP.)], Ochetoceras hispidiforme (FONT.), Taramelliceras [T. (Strebliticeras) externodosum (DORN.), T. (T.) pichleri (OP.)], Orthosphinctes [O. (O.) delgadoi (CHOF.), O. (O.) fontannesi (CHOF.), O. (O.) rogosensis (CHOF.), O. (O.) torresencis (CHOF.)], Epipeltoceras berrense (FAVRE) et Euaspidoceras [E. (E.) costatum (DORN), E. (Clambites) clambus (OP.)].

2.2.2 - Sous-zone à Bimammatum

Association caractéristique: Ochetoceras [O. marantianum (d'ORB.), O. semifalcatum (OP.)], Taramelliceras [T. (T.) costatum (QUENST.), T. (Metahaploceras) pseudowenzeli (WEG.)], Decipia [D. decipiens (SOW.), D. latecosta (DOHM)], Epipeltoceras bimammatum (QUENST.), Orthosphinctes [O. (Praeataxioceras) laufenensis (SIEM.), O. (P.) virgulatus (QUENST.), O. (Pseudorthosphinctes) alternans ENAY], Subdiscosphinctes (Aureimontanites) castroi (CHOF.), O. (Ardescia) gr. enayi ATROPS.

2.2.3 - Sous-zone à Hauffianum

Association caractéristique: Glochiceras (Coryceras) modestiforme (OP.), Taramelliceras [T. (Taramelliceras) hauffianum (OP.), T. (Metahaploceras) kobyi (CHOF.)] et Orthosphinctes [O. (Praeataxioceras) laufenensis (SIEM.), O. (P.) virgulatus (QUENST.), O. (Pseudorthosphinctes) alternans ENAY].

La comparaison, pour la zone à Bimammatum, entre l'Algarve

et les Chaînes Bétiques est aussi significative. Ainsi dans les Chaînes Bétiques on constate que les Phylloceratacеae et les Peltoceratidae sont caractéristiques, les Perisphinctidae communs et les Lytoceratacеae et les Haploceratacеae rares; par contre, en Algarve, ce sont les Perisphinctidae qui dominent, les Haploceratacеae (Haploceratidae et Oppeliidae) sont caractéristiques et les Phylloceratacеae (surtout Sowerbyceras tortisulcatum (d'ORB.) et les Aspidoceratidae (surtout Epipeltoceras) sont communs.

2.3 - Zone à Planula

La faune de cette zone est très réduite en nombre et variété d'individus, ce qui a empêché une bonne définition de l'unité.

L'association faunique de cette zone, très identique à celle de la zone à Bimammatum, avec le changement des Epipeltoceras par les Idoceras, est la suivante: Idoceras [I. planula (HEHL), I. minutum DIET., Idoceras sp. (cf. NITZOPOULUS, 1974, taf. 10, fig. 2-4] et Aspidoceras (Physodoceras) gr. circunspinosum/altenense avec quelques Oppeliidae et Orthosphinctes [O. (O.) freybergi (GEYER), O. (O.) polygyratus (REIN.), O. (Lithacosphinctes) gr. evolutus (QUENST.)] .

3 - KIMMÉRIDGIEN INFÉRIEUR

En Algarve, comme partout dans la province subméditerranéenne, la limite entre l'Oxfordien supérieur et le Kimméridgien inférieur est difficile à établir. En effet, le changement de l'ensemble faunique n'est pas significatif et on n'a pas une apparition de nouveaux stades ornamentaux.

Dans la province subméditerranéenne, la limite est placée entre la dernière apparition de Sutneria galar (OP.) et la première apparition de S. platynota (REIN.) (ATROPS, 1982, p. 323); en Algarve ces individus sont très rares ce qui a empêché l'utilisation de ce critère.

Les modifications imposées par l'absence ou la rareté de certaines formes (Aulacostephanus, Sutneria) ont conditionné le schéma zonale presenté pour le Kimméridgien inférieur qui s'est basé sur la biozonation de F. ATROPS (1982, pp. 321-331).

3.1 - Zone à Platynota

Dans la zone à Platynota les espèces les plus fréquentes sont: Taramelliceras [T. (T.) rigidum (WEG.), T. (M.) subnereus (WEG.)], Orthosphinctes [O. (O.) polygyratus (REIN.), O. (L.) pseudoachilles (WEG.), O. (Ardescia) desmoides desmoides (WEG.), O. (A.) proinconditus (WEG.)], Ataxioceras [A. (Schneidia) guilherandense ATROPS, A. (Parataxioceras) homalinum (SCHNEID)], Nebrodites [N. (Mesosimoceras) herbichi (HAUER), N. (Nebrodites) hospes (NEUM.)] et Aspidoceras (Physodoceras) altenense (d'ORB.).

3.1.1 - Sous-zone à "Orthosphinctes"

Elle est caractérisée par l'association faunique suivante: Taramelliceras [T. (T.) rigidum (WEG.), T. (Metahaploceras), subnereus (WEG.)], Orthosphinctes [O. (Orthosphinctes) gr. polygyratus (REIN.), O. (Lithacosphinctes) gr. evolutus (QUENST.)] et Sutneria gr. platynota (REIN.). A l'extrême base de la sous-zone à "Orthosphinctes" s'individualise un horizon riche en Amoeboceras, temoin d'une brève incursion de la faune boréale ou subboréale dans la province subméditerranéenne.

3.1.2 - Sous-zone à Desmoides

Faune caractéristique: Orthosphinctes (Ardescia) desmoides desmoides (WEG.), O. (A.) proinconditus (WEG.), O. (Lithacosphinctes) pseudoachilles (WEG.) et Sutneria sp. A ces formes sont associés quelques Taramelliceras (Metahaploceras) subnereus (WEG.), T. (M.) rigidum (WEG.) et Aspidoceras (Physodoceras) altenense (d'ORB.).

3.1.3 - Sous-zone à Guilherandense

Définie par la présence d'Ataxioceras (Schneidia) guilherandense ATROPS associés à des espèces déjà présentes dans les sous-zones antérieures: T. (M.) subnereus (WEG.), T. (M.) rigidum (WEG.), T. (M.) wegelei SCHAIRER, A. (Physodoceras) altenense (d'ORB.) .

3.2 - Zone à Hypselocyclum

Selon F. ATROPS (1982, p. 327) la limite inférieure de cette zone se place au-dessus des dernières S. platynota et la limite supérieure est tracée à la disparition des Ataxioceras (Parataxioceras) gr. lothari et A. (P.) gr. oppeli, des A. (A.) gr. hypselocyclum et des Orthosphinctes (Ardescia) gr. perayensis.

Cette zone correspond au développement maximum des Ataxioceratinae (surtout Ataxioceras s.str. et Parataxioceras) et coincide avec la zone de distribution verticale composée d'Ataxioceras (A.) hypselocyclum (FONT.), d'A. (Parataxioceras) lothari (OP.), d'A. (P.) oppeli GEYER et de Taramelliceras strombecki (OP.).

L'importance relative de A. (Ataxioceras) et de A. (Parataxioceras) peut changer régionallement, peut-être dû à différences écologiques (ENAY & al in MOUTERDE & al., 1971, p. 97).

L'association caractéristique de cette zone est la suivante: Taramelliceras [T. (T.) hauffianum (OP.), T. (Metahaploceras) nodosiusculum (FONT.), T. (M.) strombecki (OP.)], Progeronia sp., Ataxioceras [A. (Parataxioceras) oppeli (GEYER), A. (P.) homalinum (SCHNEID), A. (P.) wemodingense (WEG.)], Nebrodites (N.) peltoideus (GEMM.) et Crussoliceras sp.

La sous-zone à Lothari peut être individualisée.

Elle correspond à la présence de l'association de: Ataxioceras (Parataxioceras) oppeli oppeli (GEYER), A. (A.) hypselocyclum hypselocyclum FONT., Progeronia (Hugueninsphinctes) breviceps (QUENST.), T. (Taramelliceras) trachinotum (OP.), Nebrodites gr. herbichi HAUER, Garnierisphinctes sp. et Crussoliceras sp.

3.3 - Zone à Divisum

La zone à Divisum, qui correspond à l'acmé des genres Crussoliceras et Garnierisphinctes associés à des T. (Taramelliceras) trachinotum (OP.) et à la disparition d'Orthosphinctes et d'Ataxioceras s. str., n'est pas bien individualisée en Algarve. En effet les affleurements sont rares et les formes citées dans la bibliographie sont très rares ou ne sont pas présentes.

Ainsi l'association qui caractérise cette zone en Algarve est la suivante: Taramelliceras trachinotum (OP.), Idoceras baldeum (OP.), Aspidoceras (Pseudowaagenia) microplus (OP.), A. (Aspi

doceras) uhlandi (OP.), Crussoliceras sp. et Garnierisphinctes sp.

*

La faune recoltée en Algarve orientale dans l'Oxfordien-Kimmé ridgien est dominée par l'abondance de Perisphinctidae (Dichotomosphinctes, Perisphinctes, Otosphinctes, Arisphinctes, Microsphinctes), Phylloceratidae (Sowerbyceras, Holcophylloceras et Callyphylloceras) associés à de fréquents Oppeliidae (Campylites, Taramelliceras, Glochiceras, Ochetoceras et Trimarginites) et Aspidoceratidae (Euaspidoceras et Gregoryceras). On y ajoute la faible représentation des Idoceras et Nebrodites qui ont été remplacés par des Orthosphinctes et des Ataxioceras.

Dans l'ensemble cette association est caractéristique de la province submeditérranéenne. Les incursions de faunes boréales pendant l'Oxfordien-Kimméridgien (Cardioceras, Microbiplices, Decipia, Larcheria, Amoeboceras) suggèrent d'une part l'existence de voies de migration "océanique" et d'autre part le caractère ouvert et profond de la Mésogée. Des variations importantes de la temperature des eaux ont peut-être du facilité ces migrations des faunes boréales et mésogèennes.

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THE AMMONITE DISTRIBUTION WITHIN THE SPONGE MEGAFACIES, OXFORDIAN STAGE

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THE AMMONITE DISTRIBUTION WITHIN THE SPONGE MEGAFACIES, OXFORDIAN STAGE

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The sponge megafacies is herein understood as an assemblage of limestones and/or marls featured by the usually common occurrence of siliceous sponges. This megafacies was distributed at Late Jurassic time upon the northern Tethyan shelf, and it ranged from Spain, through France, Switzerland, Germany, Poland, the Ukraine, as far as Dobruja in Rumania. In Poland, this megafacies had developed the most extensively in Early and early Middle Oxfordian (see Fig.1 in Kutek, Matyja and Wierzbowski; this volume). A diversity in ammonite distribution within the sponge megafacies of that time is exemplified herein by the events recognizable in the Polish Jura, Central Polish Uplands.

Within the sponge megafacies distinguishable are the following main subdivisions: (i) algal-sponge-bioherm facies, (ii) sponge-bioherm facies, (iii) sponge-bank facies, (iv) layered-limestone facies. The first three facies yield ammonites of dimensions reaching 3-5 cm, and occurring rarely in the algal-sponge-bioherm facies, and quite frequently in the sponge-bioherm and sponge-bank facies. In the layered-limestone facies, in which the sponges are much dispersed, dominate the ammonites of dimensions ranging from over a dozen centimetres to about half a metre.

A lateral transition between these facies is often displayed even by small exposures scattered throughout the whole Polish Jura. The same scale is therefore needed to demonstrate the diversity in ammonite distribution!

The assemblage of small-sized ammonites are characterized by the presence not only of the adult microconchs, belonging to the most common genera, but also of the adult miniaturized macroconchs of the genera Taramelliceras, Neocampylites, and Cardioceras, associated with the juveniles of the species attaining reasonable dimensions at the adult stage e.g. those of Perisphinctes.

A distance less than one metre, at which the changes in distribution of ammonites varying in size are displayed, as well as a dependence of these changes on the sponge density, are thought to have resulted from the sheltering of only small-sized ammonites by the sponge mazes.

TENTATIVE BIOSTRATIGRAPHIC SUBDIVISION FOR THE OXFORDIAN OF THE SUB-MEDITERRANEAN PROVINCE ON THE BASE OF PERISPHINCTIDS

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TENTATIVE BIOSTRATIGRAPHIC SUBDIVISION FOR THE OXFORDIAN OF THE SUBMEDITERRANEAN PROVINCE ON THE BASE OF PERISPHINCTIDS

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The development of the genus Prososphinctes makes it possible to define a Claromontanus Zone for the lower Oxfordian, comprising two subzones, Claromontanus (lower) and Mazuricus (upper). The expansion of representatives of P. (Otosphinctes) allows the recognision of a Paturattensis Zone, in which a lower assemblage (= Paturattensis and related forms), and an upper one (characterized by elements close to P. (O.) magnouatius ARKELL), can be distinguished. The Lower-Middle Oxfordian boundary is placed at the base of Antecedens Zone, comprising two subzones: Rotoides and Buckmani, corresponding to successive evolutive stages of representatives of Dichotomosphinctes. The classical Transversarium Zone is subdivided in two subzones: Wartae (= last stages of Dichotomosphinctes) and Schilli (= sudden expansion of the genus Larcheria). - The Bifurcatus Zone, characterised by the mass occurrence of Dichotomoceras comprises the two classical subzones: Stenocycloides and Grossouvrei.

The base of Upper Oxfordian is here placed at the base of Bimammatum Zone (= base of Hypselum Subzone). Attempts are made to precise the value of mediterranean Perisphinctids for Biostratigraphy, as differences are already clear, specially in relation to the fauna from underlying strata.

Some remarks on biostratigraphic correlation with proposed Ammonite zonations for other European regions are also briefly outlined.

INTRODUCTION

Recent studies on Oxfordian Ammonites carried out by several authors (Enay 1966; Cariou et al. 1971; Marchand & Brochwicz-Levinski 1980; Malinowska 1980) have led to the definition of different standard biostratigraphic schemes for the Oxfordian of the Submediterranean Province, based both on Perisphintics and Cardioceratids fauna. Several attempts to establish an Am

monite zonal Scheme for the Submediterranean Oxfordian, mainly on the base of Perisphinctids were made by one of the present authors (W. Brochwicz-Lewinski 1976, 1978, 1980) and by I. G. Sapunov (1976). A proposal is here made of a detailed zonal scheme for the Oxfordian of Submediterranean -- Province on the base of Perisphinctids.

Such a Biostratigraphic subdivision appears most convenient in that Mediterranean areas, where Boreal groups are markedly scarce or even still absent, which is, for example, the case of Iberian and Betic chains. The Ammonite Successions, in different parts of mediterranean realm, show a marked similarity on what concerns the distribution of groups and the species of Perisphinctids recorded during Lower and MIddle Oxfordian, as shown by different authors in recent years. In that sense some tentative zonal scales proposed (e.g. Brochwicz-Lewinski 1976) appear valuable as an intent to correlate Cardioceratids and Perisphinctids biostratigraphic ranges.

The similarity of Oxfordian Perisphinctids succesions in different parts of submediterranean Europe has become evident after the works of numerous authors, subsequently to that classical of Enay (1966). These are, -- mainly, Enay et al. (1967); Cariou et al. (1971); Malinowska (1972, 1972a), for middle and upper middle Oxfordian, Sequeiros (1974) and Sequeiros and Oloriz (1979) for the middle and upper Oxfordian of Betic Range, Spain, where the markedly "true-mediterranean" character of Ammonite fauna is evidenced on the base of the high share of the genus Passendorferia among the studied population; Brochwicz-Lewinski & Rozak (1974, 1976) and Brochwicz-Lewinski (1976, 1978, 1981), for the Oxfordian of Czestochowa area; Barbulescu (1974), for middle-upper Oxfordian of Dobrogea, Rumania, Sapunov, (1976), for the Oxfordian of Balkans (Bulgaria), Bourseau (1977) for the lower middle Oxfordian of S.E. France, (Beauvoisin) where a good correlation between Cardioceratids and Perisphinctids species distributions is exposed; Meléndez (1978), Fernández-López et al. (1978), Sequeiros & Meléndez (1979), for Middle and upper Oxfordian of Iberian Chain, Spain; Meléndez et al. (1982), for Lower Oxfordian of the same area, and Meléndez (1984), where a general view of Oxfordian Perisphinctids succession for the Iberian Chain, Spain, is exposed. As far as Oxfordian of South America (Andean province) is concerned, subsequently to the data provided by Stipanicic (1966) and Hillebrandt (1970), it is worth to note the faunistic succession, exposed by -- Wiedmann (1982) (in Zakharov et al.; Upper Jurassic), and more recently, by Chong et al. (1984).

In all the commented references, the homogeneity of Oxfordian Perisphinctids faunas appear remarkable throughout the whole Oxfordian, with some particularities, depending on the different areas, such as the high share of true mediterranean taxa in Betic Chain, Spain (Sequeiros, 1974, 1977). The common taxa, allowing correlation between different European areas are usually found in almost all zones and Subzones.

The here proposed Perisphinctid Zonal Scheme has been greatly facilitated as long as new findings of representatives of the family Perisphinctidae in Southern Europe have led to know accurately, their precise stratigra

phic range, as well as their exact correspondence with well known representatives of boreal groups (i.e. Cardioceratidae). Discussions are still widely open as far as lowermost Oxfordian (i.e. Mariae-Zone) is concerned, the Perisphinctids of this stratigraphic interval being still poorly known and gaps being commonly detected in South European carbonate series. In turn, during lower upper Oxfordian (Bimmamatum Zone), representatives of mediterranean Perisphinctids (= Passendorferiinae) appear highly useful both for biostratigraphy and for correlations, in a similar way than representatives of Epipeltoceratinae. Ataxioceratinae appear as a highly diversified group at uppermost Oxfordian-lowermost Kimmeridgian (Planula-Platynota Zones), with the exception of typically mediterranean areas, and of major importance for biostratigraphic correlations in submediterranean areas. Finally, components of the subfamilly Perisphinctinae (= genus Perisphinctes and its allies) are traditionally regarded as a first importance group for biostratigraphic subdivissions during Middle Oxfordian.

II.- THE PROPOSED PERISPHINCTID BIOZONATION

In establishing the here proposed zonal scheme we have kept in mind the general principle, as exposed by Sykes and Callomon (1979) of "no gaps, no overlaps". Similarly, every unit is defined by its lower boundary. Finally, the assignment of a unit to a certain rank being, surely, arbitrary, the "rule of a thumb" followed by the same authors (p.843) is also here assumed. Therefore, the main names of zones have been here conserved as far as possible, in terms of stability. Subzones have been proposed, or else, accepted when they can be recognized through wide areas in Southern Europe. Horizons should be regarded as pure local units, being not excluded that their characteristic faunistic association may be recognized elsewhere.

The proposed zonal scheme and its correlation with other standard biozonations for different european areas is exposed in fig.1.

LOWER OXFORDIAN:

Subdivisions of lower Oxfordian by means of Cardioceratids have been numerous, the more classical and widely used being that summarized by Cariou et al. (1971). Sapunov (1976) defines for the Bulgarian Jurassic a lower, Peltomorphites athletoides zone, and upper, Creniceras renggeri zone, roughly equivalent to the classical Mariae and Cordatum zones. A recent attempt to subdivide the lower Oxfordian in base of the high diversity of representatives of the Genus Prososphinctes has been made by Brochwicz-Lewinski (1976, 1981).

1) ? Mariae Zone:

Beds with characteristic faunistic association of this stratigraphic interval seem to be largely absent in southern Europe, in carbonate series. The zone appears much better represented in areas of central and western Europe, preferently in clay-detritic facies, being characterized by a rich

fauna of Cardioceratids. The recent figuration, by Lebert & Marchand (1983) of Perisphinctes bernensis DE LORIOL, from well dated beds of Praecordatum Subzone age of l'Orne et la Sarthe, France, Leaves an open Possibility that some Perisphinctids close to Loriol's original (i.e. Properisphinctes SPATH) may characterize that stratigraphic interval.

2) Claromontanus Zone BROCHWICZ-LEWINSKI 1981

Index: Prososphinctes claromontanus (BUKOWSKI)
Remarks: The Claromontanus Zone, as defined by Brochwicz-Lewinski, would be roughly equivalent to the Bukowskii Subzone of the Cordatum Zone. It corresponds to the moment of maximum development of the genus Prososphinctes, together with representatives of Mirosphinctes: M. mirus (BUKOWSKI) and M. frickensis (MOESCH) and early representatives of P. (Otosphinctes) i.e. P. (O.) moeschi DE LORIOL, P. (O.) picteti DE LORIOL, P. (O.) spathi (= Per. bernensis, ARKELL, non LORIOL). Representatives of Passendorferia are also common, i.e. Pass. (Enayites) czenstochowiensis (SIEMIRADZKI), and its presumable - macroconch (forms close to P. (Kranaosphinctes) promiscuus BUKOWSKI, in Malinowska, 1963, Pl. XXXVII, fig.175). The observed succession of species of Prososphinctes allows the author (Brochwicz-Lewinski)to distinguish two successive associations, regarded here as full subzones, on account of the separate stratigraphic range of both index species, as remarked by the author in the type region (Czestochwa area).

2.1. Claromontanus Subzone BROCHWICZ-LEWINSKI 1981

Index: As for the zone.
Remarks: The index species appears the common, characteristic form of many areas of Southern Europe and as far as South America, and the andean province (Chong et al. 1984). In the Iberian Chain, where it occurs normally associated to Prososphinctes of the mairei-matheyi group, the species has also been found in many localities (Meléndez et al. 1982). It is also worth to - note the repeated occurrence in this subzone of primitive Otosphinctes and first representatives of Passendorferia (see above).

2.2. Mazuricus Subzone BROCHWICZ-LEWINSKI 1981

Index: Prososphinctes mazuricus (BUKOWSKI).
Remarks: The upper horizon of the author (loc. cit.) is characterized by a generaly similar Perisphinctid fauna, being specially typical the presence of Pr. mazuricus (BUKOWSKI), normally associated to Pr. consociatus (BU- - KOWSKI), which may appear as well in the lower subzone, as well as the lack of Pr.claromontanus(BUKOWSKI).References to the index especies are due to Malinowska(1963) in the Polish Jura Chain, and Bourseau (1977) in Beauvoisin (SE.France), right below levels with P.(O.)paturattensis DE LORIOL.The subzone has been characterized by Brochwicz-Lewinski(1981) in the Czestochowa area.

3) Paturattensis Zone BROCHWICZ-LEWINSKI 1981

Index: Perisphinctes(Otosphinctes)paturattensis DE LORIOL

Synonime: Episcopalis Subzone SAPUNOV 1976.
Characteristic taxa: Perisphinctes (Otosphinctes) of the paturattensis-montfalconensis (groups) DE LORIOI and some forms more coarsely ribbed, belonging to P. (O.) ouatius (BUCKMAN)-magnouatius ARKELL group: (?) "Perisphinctes" of the episcopalis-laisinensis group: primitive representatives of -- kranaosphinctes, close to Kr. promiscuus (BUKOWSKI), most probably forerunners of this forms, as remarked by Brochwicz-Lewinski. Euaspidoceras of the catena-ovale groups, and related forms. Large size Microsphinctes are referred from Czestochowa by Brochwicz-Lewinski (loc. cit.) M. frickensis -- (MOESCH) is reported by Bourseau (1977). Numerous representatives of Cardioceratidae, characteristic of the Vertebrale Subzone, as defined by Cariou et al. (1971)

Remarks: The zone is well characterized by the faunistic assemblage described by Brochwicz-Lewinski (1981) in the Czestochwa area. Its characteristic taxa well match the Perisphinctid faunistic association exposed by Bourseau (1977). It should be noted, however, that Bourseau's assemblage shows distinct aspect, comprising larger size, more coarsely ribbed forms than that typical of true paturattensis assemblage. Moreover some of the forms figured by this author could be regarded as primitive Dichotomosphinctes, and some presumable macroconchs could be considered as small sized representatives of Kranaosphinctes and Arisphinctes. True representatives of Arisphinctes and Dichotomosphinctes are known to occur rather from Antecedens Zone onwards. Therefore, it could be tentatively assumed that Bourseau's assemblage represents a somewhat younger population than true paturattensis one.

Subzones: This leaves an open possibility to distinguish two subzones within Paturattensis Zone: A lower one (Paturattensis Subzone s. str.) with typical representatives of this group and related forms (Small-sized, finely ribbed), and an upper one, which would correspond partly to Bourseau's assemblage, and for which the name; Magnouatius Subzone, index: P. (O.) magnouatius ARKELL could be safely proposed, as this species has been normally regarded as a direct forerunner of the subgenus Dichotomosphinctes.

The Paturattensis Subzone has been largely identified besides the cited and known areas (French Jura, SE. France, Polish Jura Chain, Bulgaria), in the Iberian Chain, Spain, within the Ferruginous-oolithic level, or in the first spongy limestone levels (Meléndez et al. 1982).

Equivalence: The Episcopalis Zone of the Middle Oxfordian.
Index: Per. episcopalis DE LORIOL, was proposed by Sapunov (1976) for this same stratigraphic interval in his Oxfordian zonation of Bulgaria. Objections to that election were first cast by Brochwicz-Lewinski (1976, 1981), who proposed P. (O.) paturattensis as an alternative index for that zone, on account of its wider expansion and abundance throughout Southern Europe. Besides these remarks, Per. episcopalis DE LORIOL is still a poorly known species, and its systematic location within the subgenus Dichotomosphinctes would appear, at least, debatable. It seems, therefore, that P. (O.) paturattensis DE LORIOL may be regarded as a better index species.

4) Antecedens Zone ARKELL 1947

Index: Perisphinctes (Dichotomosphinctes) antecedens SALFELD.
Remarks: This unit, traditionally considered as the upper Subzone of Plicatilis Zone (Arkell 1947, Cariou et al. 1971) was raised to a full Zone rank by Brochwicz-Lewinski (1976), on account of the major faunistic change detected at its lower part, the Lower-Middle Oxfordian boundary being delineated at its base. Evidence coming from different South European Areas, including Iberian Chain (Meléndez 1984), Betics (Sequeiros 1974), and even from South America (Chong et al. 1984), give further support to that criteria.

4.1 Rotoides Subzone BROCHWICZ-LEWINSKI 1976

Index: Perisphinctes (Dichotomosphinctes) rotoides RONCHADZE.
Remarks: The faunistic change detected at the Paturattensis-Antecedens boundary comprises, according to Brochwicz-Lewinski, the dissappearance of primitive taxa Prososphinctes, Otosphinctes (of the above cited groups), and the development of Dichotomosphinctes of the Rotoides group, and related forms, and presumable macroconchs: Kranaosphinctes, and many Arisphinctes. Kranaosphinctes promiscuus is found to be present from the base of this subzone (Brochwicz-Lewinski 1979). Besides the Perisphinctids, Neocampylites (of the lautlingense group), and Proscaphites anar (OPPEL), are also reported from this subzone.

The Rotoides Subzone is well characterized at Czestochowa. Similar faunistic associations are reported from several parts of France (Cariou et al. 1971).

4.2) Buckmani Subzone BROCHWICZ-LEWINSKI 1976[1]

Index: Perisphinctes (Dichotomosphinctes) buckmani ARKELL.

Remarks: As defined by Brochwicz-Lewinski (1976) the subzone would be characterized by the presence of large Dichotomosphinctes of the antecedens-buckmani groups; and of giant macroconch: Arisphinctes, and first Perisphinctes s. str. (= Martelliceras) as well as by the dissappearance of Kranaosphinctes, and the appearance of some other taxa, such as Ochetoceras, Glochiceras gr. subclausum (OPPEL). This association coincides remarkably with the assemblages studied by Arkell (1934-48, Corallian Beds), and Enay (1966).

Correlations: In the Iberian Chain, elements of Antecedens Zone are commonly found within the basal ferrouginous oolithic level, the distinction of both subzones not being generally possible. Attention should be paid to repeated occurrence of Kranaosphinctes referable both to kranaus group and to mediterranean ones (cyrillii-methodii groups), which could come from Buckmani Subzone. A similar case is that of some representatives of large size Dichotomosphinctes displaying intermediate features between typical buckmani and wartae groups. An Antecedens Zone, indiferenciated fauna, has been also identified from S. America, Chile (Andean province), in Chong et al. (1984).

Finally, large size Otosphinctes, of the crotalinus-siemiradzkii groups would be also typical of this stratigraphic interval.

5) Transversarium Zone OPPEL 1863.

Index: Gregoryceras transversarium QUENSTEDT

Remarks:

a) Correlation between Plicatilis and Transversarium, as discussed by Enay (1966, pp. 263-269).

b) Per. wartae and Amoeb. alternans Zone of Malinowska 1972, would be more or less equivalent to Transversarium Zone, sensu Cariou et al. (1971).

c) Riazi Biozone of Sequeiros (1974), would be roughly equivalent to Parandieri Subzone of Transversarium Zone, whereas the Riazi Zone of Sapunov (1976) would rather correspond to the whole Transversarium Zone of French authors.

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(1) An alternative index species for this subzone, Antecedens Subzone, could be elected, in order to avoid confusion with Pleidellia buckmani Subzone of upper Toarcian.

Subzones: In describing the Transversarium Zone, Brochwicz-Lewinski (1976) has distinguished two successive faunistic associations for the Czestochova area, without formal character of Subzones: A lower one, dominated by Dichotomosphinctes of the wartae group, and an upper one, by the representatives of Larcheria, "confined to the upper parts of this Zone".

The remarkable similarity of Ammonite successions found in the Iberian Chain, in relations both to Czestochowa and to Southern Europe, sensu Cariou et al., makes it possible to propose a similar Subzonal subdivission of Transversarium Zone for this area.

5.1) Wartae Subzone MALINOWSKA 1972

Index: Perisphinctes (Dichotomosphinctes) wartae BUKOWSKI.
Remarks: The acception of a Wartae Subzone as lower subzone of Transversarium Zone appears specially valuable in South European regions such as Iberian Chain, where Perisphinctes parandieri seems not to be a common form, - the scarce possible representatives of the species being restricted to Antecedens Zone, Buckmani Subzone.

P. (D.) wartae BUKOWSKI appears well represented in Transversarium - Zone throughout Southern Europe. In the Iberian Chain, where it is a fairly common species, typical representatives of this form are found in the lower part of this subzone, in what may be well regarded as a Wartae Horizon; (Index species as, for the Subzone). In the upper part it is observed the sudden replacement of larger size P. wartae by smaller sized representatives - of Dichotomosphinctes of the luciaeformis-luciae groups, making it sometimes possible to identify an upper, Luciaeformis Horizon.

A similar reduction in size is observed in their presumable macroconchs from large size Perisphinctes (= Martelliceras), of the parandieri-cuneicostatus group, to smaller size Per. aguilonensis MELENDEZ-martelli — (OPPEL). As far as Perisphinctes cautisnigrae ARKELL is concerned, the species appears much more as a typical Transversarium Zone taxa than a true representative of Bifurcatus Zone Perisphinctes. (Brochwicz-Lewinski & Rozak 1974; Brocwicz-Lewinski 1976,1980). So, the Cautisnigrae Subzone as exposed in Sykes & Callomon (1979) is here partly incorporated to Transversarium Zone, in probable correspondance with Schilli Subzone. (See Test-Fig.1).

Representatives of Otosphinctes show a similar decrease in size -- through Wartae Subzone, from large P. (O.) nectobrigensis MELENDEZ (lower horizon) to smaller P. (O.) vermicularis LEE (upper Horizon). Besides these taxa it is also worth to note the progressive importance of Oppelids during this subzone: Ochetoceras, of the canaliculatum-hispidum groups, Glochiceras gr. subclausum (OPPEL), and first Trimarginites of groups aroli-- cus-stenorhynchus (OPPEL).

5.2) Schilli Subzone BOONE 1922; CARIOU 1966.

Index: Larcheria schilli (OPPEL).

Remarks: The Subzone has been widely recognised throughout Submediterra- - nean Province, and accurately characterized by Cariou et al. (1971). In -- the Iberian Chain the sudden abundance of Larcheria makes the subzone easy to identify at the top of Transversarium Zone, being typical its associa-- tion with smaller sized Otosphinctes of the sorlinensis group LORIOL (with involute coiling and depressed whorl section), being characteristic at the top of the subzone the giant Per. (Dichotomosphinctes) ultimus ENAY. It is also worth to note the mass occurrence at the turn of Wartae/Schilli levels of representatives of Passendorfiinae, i.e. Pass. (Enayites) birmensdorfen- sis (MOESCH), and their presumable macroconchs, which should be looked -- for among representatives of Passendorferia (Pass.) tenuis (ENAY)-ziegleri (BROCHWICZ-LEWINSKI). Representatives of Mediterranean "Arisphinctes" and Dichotomosphinctes" are also common in this Subzone. Among Oppelids: Glo-- chiceras subclausum (OPPEL), Trimarginites gr. stenorhynchus (OPPEL), and the last Ochetoceras of the canaliculatum-hispidum group.

Horizons: The species succession of Larcheria within the Schilli Subzone - makes it possible sometimes to distinguish two horizons, a lower one (Schi lli Horizon), with typical representatives of L. schilli (OPPEL), (index, as for the Subzone), and an upper one, Subschilli, index species: Larche-- ria subschilli (LEE), with forms characterized by larger size, evolute coi ling, and compressed whorl section, whose comparison with representatives assigned to this species by Enay (1966) appears questionable. The presence of true representatives of Larcheria schilli (OPPEL) within Bifurcatus Zone, as reported by Marchand (1982) has not been undoubtedly proved in the Iberian Chain.

6) Bifurcatus Zone BOONE 1922, ENAY 1964.

Index: Perisfinctes (Dichotomoceras) bifurcatus (QUENSTEDT).
Definition: As characterized by Cariou et al. (1971), and by Brochwicz-Lewinski (1976, 1980).
Remarks: The zone is typically characterized by the mass occurrence of representatives of genus Dichotomoceras and their presumable macroconchs, i. e. Perisphinctes s. str., of the variocostatus group, with U. shaped initial part of rib curve.

6.1) Stenocycloides Subzone CARIOU 1967, BROCHWICZ-LEWINSKI 1976.

Index: Perisphinctes (Dichotomoceras) stenocycloides SIEMIRADZKI.(1967). - Faunal associations, characteristic of this subzone have been subsequently recognised as far as Chabrières, Basses Alpes (Duong 1974), and Chełochowa area (Brochwick-Lewinski 1976). In the Iberian Chain it is well represented by the mass ocurrence of large size Dichotomoceras, of the bifurcatoides-stenocycloides groups. In the upper part new, smaller sized elements replace the large ones of the base, some forms, such as P. (D.) duongi MELENDEZ becoming very typical. This makes it possible to distinguish two clear horizons:

a) Bifurcatoides Horizon MELENDEZ 1984.

Index: Perisphinctes (Dichotomoceras) bifurcatoides ENAY.
Characterized by large Dichotomoceras (see above) and Perisphinctes (Perisphinctes) panthieri ENAY and related forms.

b) Duongi Horizon MELENDEZ 1984.

Index: Perisphinctes (Dichotomoceras) duongi MELENDEZ.
Characterized by Dichotomoceras of the duongi group, comprising middle size Dichotomoceras, still finely ribbed, close to P. (D.) bifurcatoides ENAY but of smaller size, and including P. (D.) stenocycloides, RONCHADZE (non SIEMIRADZKI). They are accompannied by common representatives of small-sized Perisphinctes (s. str.), close to Ampthillia ARKELL (sensu Enay 1966).

6.2) Grossouvrei Subzone FRADIN 1947, emmend. CARIOU 1967.

Index: Perisphinctes (Dichotomoceras) groussouvrei SIEMIRADZKI.
Definition: First defined for Poitou area, it was similarly extended for - the Polish Jura Chain and other european areas by Brochwicz-Lewinski (1976), and Duong (1974), (see above). It is well represented and readily identi-- fiable throughtout the Iberian Chain, and has been evidenced as well in - Betics (S. Spain), by Sequeiros (1974).

Characterization: Small-sized, coarsely ribbed Dichotomoceras, of the grossouvrei-bifurcatus-crassus groups, P. (D.) falculae RONCHADZÉ being also localized at its lower part. Perisphinctes s. str. of the variocostatus - group (now found to be present in most of South European areas including - Iberian Chain. Extremely reduced in size representatives of Perisphinctes (Per.), of the malinowskae group, localized at the top part of the subzone, with late representatives of Dichotomoceras of the bifurcatus-crassus -- groups of very small size (see Duong, 1974).

7) Bimammatum Zone (OPPEL 1963).

Index: Epipeltoceras bimammatum (QUENSTEDT).
Remarks: The base of the zone is delineated at the base of lower subzone - (= Hypselum Subzone), coinciding with the first record of Euaspidoceras -- hypselum (OPPEL), which sometimes may cooccur with last representatives - of Dichotomoceras (see Duong 1974).

7.1) Hypselum Subzone DORN 1930.

Index: Euaspidoceras hypselum (OPPEL).
Definition and characteristic taxa: as exposed by Cariou et al.(1971) and by Brochwicz-Lewinski (1976).
Remarks: First representatives of Epipeltoceras appear at the lower part - of this subzone, the successive species of this genus, allowing to distinguish two horizons, i. e. Semimammatum Horizon (lower) and Berrense Horizon (upper). These are clearly recognisable in the Iberian Chain on what - concerns the general faunistic succession given by Cariou et al. (loc. cit.). A exception is made in this area for the accompanying Amoeboceras fauna, - the genus not having still been found in the Iberics. Inturn, mediterranean Perisphinctids (= Passendorferia and related forms appear highly diversified and abundant at the turn of Grossouvrei/Hypselum Subzones (see -

also Brochwicz-Lewinski, 1978). Such forms as "Perisphinctes" birmendorfensis, DORN (non MOESCH), and Passendorferia (Enayites) gygii BROCHWICZ-LEWINSKI & ROZAK (= Per. birmensdorfensis, OPPEN HEIMER, non MOESCH) are found well localised along Hypselum Subzone, appearing as good, complementary tools for Biostratigraphy and correlation purposes.

7.2) Bimammatum Subzone OPPEL 1863.

Index: As for the zone.
Characteristic taxa: as described by Cariou et al. (1971). The Lackof representatives of Ringsteadia in the Iberian Chain is noticeable.
Remarks: Together with the index species, and Epipeltoceras treptense, it is worth to note the presence of giant representatives of "Decipia" (sensu ENAY 1966) its presence having being recorded as far as Portugal at these same levels (MOUTERDE et al. 1973). Numerous large size Orthosphinctes (= gr. tiziani OPPEL) and O. (Pseudorthosphinctes) are also typical of this interval. Passendorferia (Enayites) sampedroi MELENDEZ, and representatives of its presumable macroconch are typically found in levels with Epipeltoceras bimammatum (QUENSTEDT).

7.3) Hauffianum Subzone OPPEL 1863.

Index: Taramelliceras (Taramelliceras) hauffianum (OPPEL).
Characterization: After Cariou et al. (1971).
Remarks: The identification of this subzone appears problematic for the most of South European regions, the index species having been reported from Swabian-Francanian Alb (Fide: Enay, in Cariou et al. 1971) and in Portugal (Mouterde et al. 1973). In the Iberian Chain (and in the other areas such as Poitou; see Enay et al. 1967), some levels appearing above Bimammatum beds, displaying a high share of Oppelids (Taramelliceratinae/Glochiceratinae) could belong to this subzone, or, perhaps, already to lower Planula zone. The finding of forms close to Subnebrodites proteron (NITZOPUOLOS) in some sections in the Iberian Chain (Meléndez, 1984) could be an argument supporting the setting of these "pre-Planula" levels in that subzone.

8) Planula zone WEGELE 1929.

Index: Subnebrodites planula (HEHL, in ZIETEN).
Characteristic taxa: As described by Cariou et al. (1971).

Remarks: Since its description by the french authors the zone has been recognised in wide areas throughtout Southern Europe, Bulgaria (Sapunov -- 1976). Extra Carpathian Poland (Malinowska 1980) SE. France (Atrops 1982), Iberian Chain (Fernández-López et al. 1978); Meléndez et al. 1983; Meléndez 1984), and Betics (Sequeiros 1974, Sequeiros & Olóriz 1979; Olóriz -- 1978). The two typical subzones are normally identified.

8.1) Planula Subzone ZEISS 1965.

Index: As for the zone.
Characteristic Fauna: Subnebrodites of the planula group dominates, minutum appearing localized in the Iberian Chain in some defined levels in its Middle-upper part. Two horizons, i.e. Tonnerense (Index: Subnebrodites tonnerense (LOREAU & TINTANT), and Praecursor (Index:Sutneria praecursor DIETERICH) have recently been defined by Atrops (1982) for SE. France.

8.2) Galar Subzone ZEISS 1965.

Index: Sutneria galar (OPPEL).
Characteristic taxa: The index species, S. galar, typically present above levels with Subnebrodites. Orthosphinctes gr. polygyratus (REINECKE) and related forms.
Remarks: Schairer (1974) in Franconian Alb and Atrops (1982) for SE. France have well characterized the typical taxa of uppermost Oxfordian. According to the last author the Perisphinctid assemblage of Galar Subzone and lowermost Platynote Zone (Orthosphinctes subzone) are not distinguishable in case of absence of representatives of the genus Sutneria.

In the Betic Range the species S. galar (OPPEL) in reported by Olóriz (1978). In the Iberian Chain the Galar Subzone has been identified in many localities (Meléndez 1984) with a similar assemblage of Orthosphinctes. In the Calanda-Bergé area (NE. Iberian Chain) a succession remarkably similar to that defined by Atrops (Loc. cit.) has been identified -- (Atrops & Meléndez 1984).

A special attention should be paid to some representatives of the genus Passendorferia recently identified in the Iberian Chain, coming -- from uppermost Oxfordian levels, together with Sutneria galar (OPPEL) and Orthosphinctes polygyratus (REINECKE), which would appear characteristic

of the subzone (see Meléndez 1984).

CONCLUSIONS

The described Ammonite succession appears similar on general grounds to that exposed by the French authors for Southern Europe. The biostratigraphic subdivission here proposed is complementary to that classical one and appears most idoneous for that South-European areas, where boreal groups -- are underdevelopped or even still not recorded, such as Iberian or Betic -- Ranges. The Perisphinctids zonation appears applicable for many Submedite-- rranean and, partly, for Mediterranean areas within Europe, and as far as - South America (Andean Province).

The modifications made by Brochwicz-Lewinski (1976) to the classical zonation of Franch authors, such as the position of the lower-Middle, and - Middle-upper Oxfordian boundaries, are here assumed, as new evidence coming from studied South European areas in these recent years support that views, on account of evolutionary proccesses undergone by Perisphinctids during the Oxfordian.

Mediterranean Perisphinctids (Passendorferia and its allies) appear widely spread throughout Southern Europe and their repeated occurrence in - Submediterranean areas should be of major importance as far as biostratigraphic correlation is concerned.

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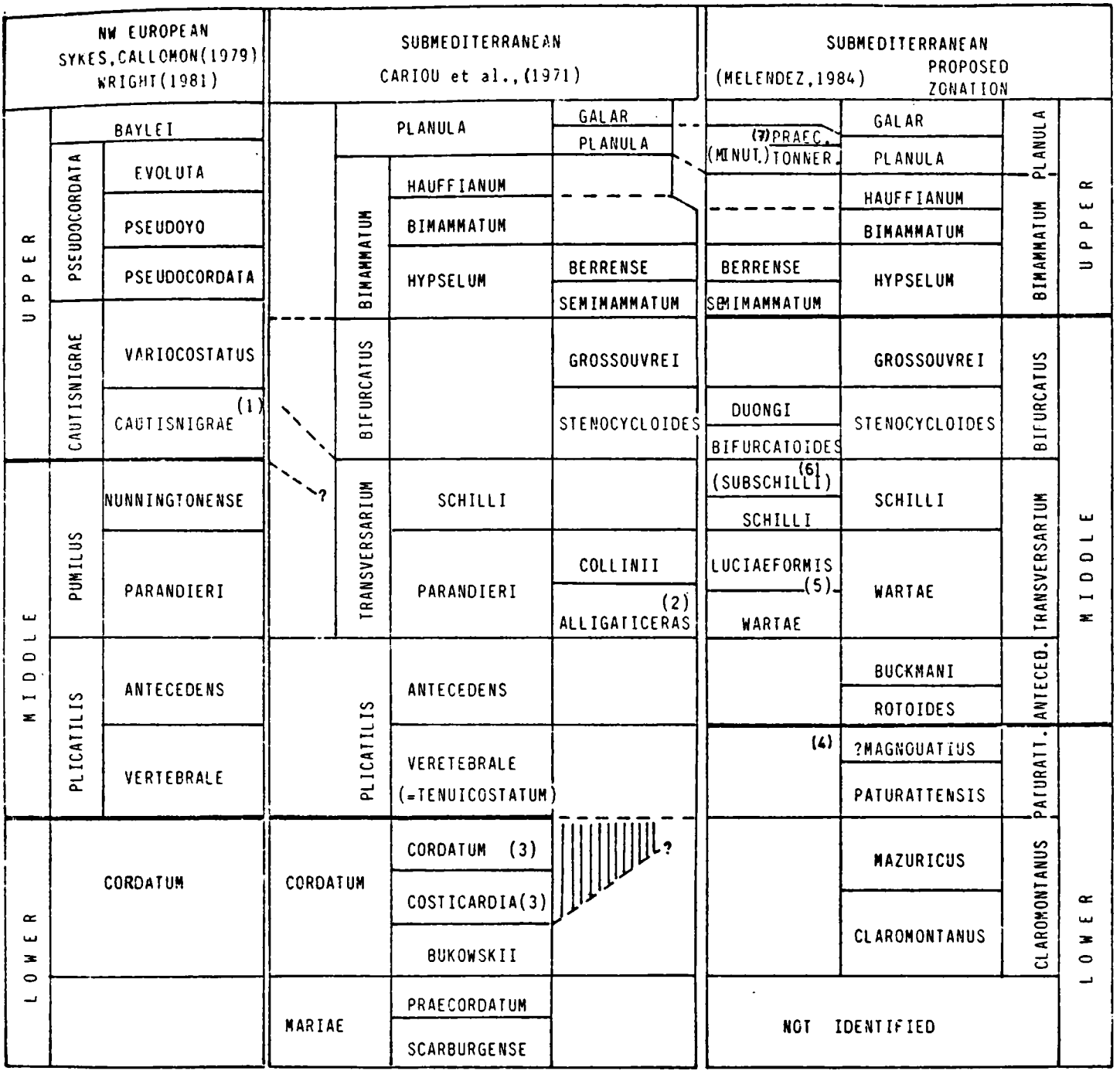
This paper was greatly facilitated owing to a generous financial support from the Instituto de Estudios Turolenses, Teruel, Spain.

CAPTION TO FIGURE 1

1) Cautisnigrae Subzone, most probably correlable with upper part of Transversarium Zone, in Submediterranean Zonatio, according to Brochwicz-Lewinski (1976).
2) Alligaticeras Horizon, equivalent to Birmensdorfensis levels in Iberian Chain, localized rather at the top Wartae-lower Schilli Subzone.
3) Costicardia and Cordatum Subzones, not identifies in major part of studied successions in Southhern Europe.
4) Magnouatius Subzone, proposed as hypothetically, not formally defined.
5) Luciaeformis Horizon, locally identified in Iberian Chain.
6) Subschilli Horizon, similarly as 5.



(MELENDEZ, SEQUEIROS, BROCHWICZ-LEWINSKI (1984))

FIG.1 .- Proposed zonal scheme for submediterranean Province, and presumable correlations with standard submediterranean and NW European correlations.

FINE BIOSTRATIGRAPHY IN THE LOWERMOST PART OF THE LOWER KIMMERIDGIAN PLATYNOTA ZONE OF THE CELTIBERIC CHAIN (SPAIN)

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FINE BIOSTRATIGRAPHY IN THE LOWERMOST PART OF THE LOWER KIMMERIDGIAN PLATYNOTA ZONE OF THE CELTIBERIC CHAIN (SPAIN)

L. Moliner & F. Oloriz

Abstract: From sampling on several profiles on the upper Jurassic of the eastern celtiberic chain (Alcorisa-Berge sector) a profuse ammonite fauna, Ataxioceratinae, has been obtained. This is especially abundant in the Platynota zone where the exhaustive control of the record makes possible the cognition of the bioestratigraphical framework. The following bioestratigraphical schema is the first detailed approximation to the fine bioestratigraphy in the celtiberic Kimmeridgian. Some advantages of this accurate fossil record are commented.

INTRODUCTION: In the last twenty years the eastern celtiberic upper Jurassic has been frequently studied. Among regional papers those of BULARD et al. (1971), FELGUEROSO COPPEL & RAMIREZ DEL POZO (1971), DEFAUT (1971), CANEROT (1974) and GOMEZ (1979) are significant. Focused on middle and/or upper jurassic, and about the Dogger-Malm discontinuity, those of BULARD (1966, 1968, 1971), MARIN et TOULOUSE (1972), BULARD et CANEROT (1972) and BULARD et al. (1974). In GEYER et al. (1974) and GOMEZ (1979) remarkable sedimentological considerations are included. GEYER & PELLEDHUN (1979) offer the most accurate Kimmeridgian biostratigraphy at present. Recently MELENDEZ (Univ. Zaragoza, Spain) and others are working on the celtiberic Oxfordian.

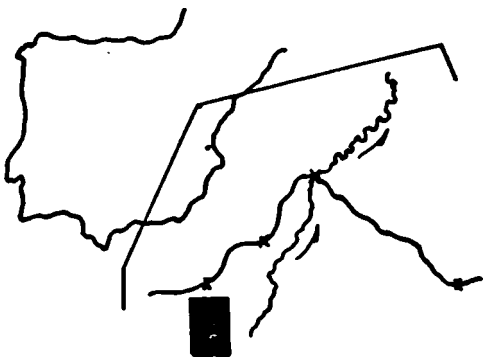

Fig. 1: Location of the studied area.

Az- Alcañiz
C - Calanda
Al- Alcorisa
V - Valencia
- Guadalope river

In the Alcorisa-Berge sector (prov. of Teruel) outcrops of upper jurassic materials of the celtiberic range can be observed. Among the different outcrops analyzed a detailed paleontological sampling of the lowermost Kimmeridgian has been possible in three of them -MTG_0, MTG_1 (Alcorisa sector), MSC (Berge sector). In these a well stratified sequence of grey limestones 40 m. thick has been studied.

LITOLOGY: The strata with **Sutneria platynota** (REIN.) are found in a sequence of grey limestones and marls 9 to 12 m. thick. Marly levels are scarce and no thicker than 15 cm. The strata of limestones are 20-80 cm thick, but the most frequent are 40-60 cm. thick. They are mudstones with scarce but variable amount of peloids and echinoderms bioclasts -ossicles, plates and spines- and poor ostracodes and foraminifera. At the base, the boundary contact with the grey marls of Margas de Sot de Chera Formation is clearly established. At the top dolomitic insets may be developed and after, without litological variation, the A. hypselocyclum levels are found.

AMMONITE DISTRIBUTION: In the outcrops MTG_0, MTG_1, and MSC, 5, 22 and 29 strata have been sampled. Significative species are the following:

$\underline{MTG_0}$

level 1 - O. (orthosphinctes) polygyratus (REIN.), O.sp., Metahaploceras litocerum (OPP.).

levels 2,3 - O. (Orthosphinctes) polygyratus (REIN.), O. sp.

level 4 - O. (Orthosphinctes) polygyratus (REIN.), O. (Ardescia) sp., O. sp. O. (Lithacosphinctes) sp., Sutneria platynota (REIN.), Pseudowaagenia micropla (OPP.).

level 5 - O. (Lithacosphinctes) sp. gr. O. (L.) evolutus (QUENST.).

$\underline{MTG_1}$

level 0 - **Orthosphinctes sp., O. (Ardescia) sp., Sutneria platynota** (REIN.).

level 1 - **O. (Lithacosphinctes) sp., O. (Ardescia) sp.**

level 2 - **O. (Lithacosphinctes) sp.,** Ataxioceratinae (celtiberic form A).

level 3 - **O. (Ardescia) enayi** ATROPS, **O. (Ardescia) sp., O. (Lithacosphinctes) sp.**

level 4 - **Orthosphinctes sp., O. (Ardescia) enayi** ATROPS, **O. (A.) desmoides desmoides** (WEG.), **O. (A.) sp., O. (Lithacosphinctes) sp.,** Ataxioceratinae (celtiberic form A), **Sutneria platynota** (REIN.).

level 5 - O. (Ardescia) desmoides quenstedti ATROPS, O. (A.) desmoides desmoides (WEG.), O. (A.) sp., O. (Lithacosphinctes) sp., Ataxioceratinae (celtiberic form A).

level 6 - O. (Ardescia) sp. gr. O. (A.) desmoides (WEG.), O. (A.) sp.

level 7 - O. (Ardescia) desmoides desmoides (WEG.), Sutneria platynota (REIN.) Pseudowaagenia sp., Physodoceras sp.

level 8 - O. (Ardescia) sp. gr. O. (A.) desmoides (WEG.), O. (A.) sp., O. (Lithacosphinctes) sp., A. (Parataxioceras) prehomalinum ATROPS.

level 9 - O. (Ardescia) sp. gr. O. (A.) desmoides (WEG.), O. (A.) sp. gr. O. (A.) thieuloyi ATROPS, A. (Schneidia) guilherandense ATROPS.

level 10 - O. (Ardescia) desmoides desmoides (WEG.), O. (A.) schaireri ATROPS, O. (Lithacosphinctes) sp. cf. O. (L.) blondeti ATROPS, A. (Schneidia) guilherandense ATROPS, Ataxioceratinae (celtiberic form B), Sutneria platynota (REIN.).

level 11 - O. (Lithacosphinctes) sp. gr. O. (L.) pseudoachilles (WEG.), O. (L.) sp., A. (Schneidia) guilherandense ATROPS, A. (Schn.) sp., Ataxioceratinae (celtiberic form B), Sutneria platynota (REIN.).

level 12 - O. (Ardescia) schaireri ATROPS, O. (Lithacosphinctes) sp. gr. O. (L.) pseudoachilles (WEG.), O. (L.). sp., A. (Schneidia) guilherandense ATROPS, Ataxioceratinae (celtiberic forms A and B).

level 13 - O. (Ardescia) Schaireri ATROPS, O. (A.) sp., O. (Lithacosphinctes) sp. gr. O. (L.) subachilles (WEG.), A. (Schneidia) sp. aff. A. (Schn.) guilherandense ATROPS, A. (Schn.) sp., Ataxioceratinae (celtiberic forms A and B).

level 14 - O. (Ardescia) schaireri ATROPS, O. (Lithacosphinctes) sp. gr. O. (L.) pseudoachilles (WEG.), O. (L.) sp., Ataxioceratinae (celtiberic forms A, B and C).

level 15 - O. (Ardescia) schaireri ATROPS, O. (Lithacosphinctes) sp. gr. O. (L.) pseudoachilles (WEG.), Ataxioceratinae (celtiberic form C), Sutneria platynota (REIN).

level 16 - A. (Schneidia) sp.

level 17 - O. (Ardescia) sp., A. (Schneidia) guilherandense ATROPS, A. (Schn.) sp.

levels 18,19 - Indeterminable Ataxioceratinae -fragments and nuclei.

level 20 - A. (Schneidia) guilherandense ATROPS.

level 21 - Sutneria platynota (REIN.).

MSC

level 2 - O. (Ardescia) sp. gr. O. (A.) enayi ATROPS, O. (A.) sp.

level 3 - O. (Ardescia) sp.

level 4 - O. (Ardescia) sp. gr. O. (A.) proinconditus (WEG.), O. (A.) sp., Pseudowaagenia micropla (OPP.).

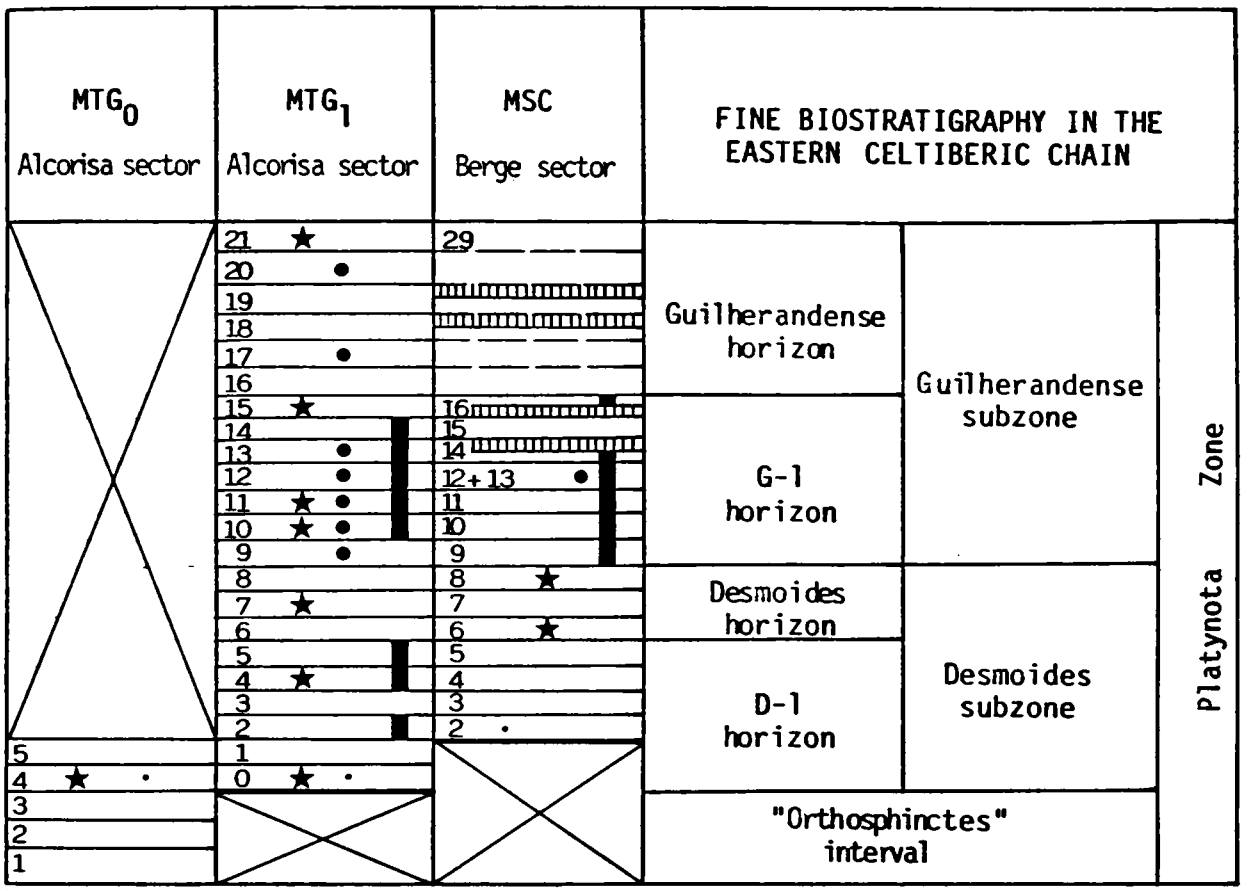

Fig. 2: Correlation among the studied outcrops and fine biostratigraphical framework in the Celtiberic Chain (Alcorisa-Berge Sector). ★ Sutneria platynota ; · first record of Orthosphinctes (Ardescia) ; ● A.(Schneidia) guilherardense; ▮ Ataxioceratinae (celtiberic forms); ▥ Dolomitic levels with impoverished fauna

level 5 - **O. (Lithacosphinctes) sp., O. (Ardescia) sp.**

level 6 - **Sutneria platynota** (REIN.).

level 7 - Indeterminable Ataxioceratinae -fragments.

level 8 - **O. (Ardescia) desmoides desmoides** (WEG.), **O.** (A.) **sp. gr. O. (A.) desmoides** (WEG.), **O. (A.) sp., O. (Lithacosphinctes) sp.,** Ataxioceratinae (celtiberic form C), **Sutneria platynota** (REIN.).

level 9 - **O. (Ardescia) desmoides desmoides** (WEG.), **O. (A.) sp. gr. O. (A.) thieuloyi** ATROPS, Ataxioceratinae (celtiberic form C).

level 10 - **O. (Ardescia) sp. gr. O. (A.) desmoides** (WEG.), Ataxioceratinae (celtiberic form B).

level 11 - **O. (Ardescia) desmoides desmoides** (WEG.), **O. (A.) sp., O. (Lithacosphinctes) sp.,** Ataxioceratinae (celtiberic form B).

level 12 - **O.** (Ardescia) sp. gr. O. (A.) thieuloyi ATROPS, **O. (A.) sp., O. (Lithacosphinctes) sp.,** Ataxioceratinae (celtiberic form B).

level 13 - **O. (Ardescia) sp. gr. O. (A.) thieuloyi** ATROPS, **O. (Ardescia) sp., A. (Schneidia) guilherandense** ATROPS, **A. (Schn.) sp.,** Ataxioceratinae (celtiberic forms A and B).

level 14 - **Ataxioceras sp., A. (Schneidia) sp.,** Ataxioceratinae (celtiberic forms B and C).

level 15 - Ataxioceratinae (celtiberic form C).

level 16 - **O. (Ardescia) sp., O. (Lithacosphinctes) sp.,** Ataxioceratinae (celtiberic form C).

level 17 - Indeterminable remains

level 18 - **O. (Ardescia) sp.,** indeterminable Ataxioceratinae.

level 19 - Indeterminable remains

level 20 - **O. (Ardescia) sp.**

levels 21,22 - Indeterminable remains

level 23 - **Ataxioceras sp.**

levels 24-29 - Indeterminable Ataxioceratinae -fragments, nuclei.

BIOSTRATIGRAPHY AND CORRELATIONS: From the formerly quoted data about the stratigraphical distribution of significative species it is possible to propose the bioestratigraphical framework as follows (Fig. 2).

Platynota zone: Based on the distribution of the index. Moreover, at the base, some strata without oxfordian markers are added.

"Orthosphinctes" interval: It includes levels without any typical oxfordian index. The Ataxioceratinae are not specialized. This interval is litologically undistinguisable from the materials of the rest of Platynota zone. It is here

proposed as "interval" because of the field difficulties for a complete identification. Presumably incomplete, it shall be neccesary to analyze a greater number of outcrops to precise it.

Desmoides subzone: Interval between the first record of O. (Ardescia) and the appearance of A.(Schneidia). In the studied area the first species of A. (Schneidia) is A. (Schneidia) guilherandense ATROPS. This subzone is equivalent to the same one denominated, proposed by ATROPS (1982).

Intra-Subzone interval, D-1 horizon: The lower boundary is that one of the subzone. The upper limit corresponds to the dissapearance of the largest and primitive O. (Ardescia). Presumably this interval will be precised by celtiberic forms. D-1 interval is equivalent to the Enayi horizon from ATROPS (1982).

Desmoides horizon: As defined by ATROPS (1982). Here, this is the interval from the upper boundary of the D-1 to the upper limit of the subzone -just under the appearance of A. (Schneidia) guilherandense ATROPS.

Guilherandense subzone: From the first record of A. (Schneidia) guilherandense ATROPS to the last strata with Sutneria platynota (REIN.). It is subdivided in two intervals: the lowest, G-1, and the upper guilherandense horizon. The subzone is completely equivalent to the same denominated and proposed by ATROPS (1982).

Intra-subzone interval, G-1 horizon: From the base of the subzone to the dissapearance of O. (Ardescia) schaireri ATROPS, at least presently. Also the upper limit is fixed by the last record of the endemic celtiberic fauna of guilherandense subzone. At present it is not possible to precise the correlation with the Thieuloyi horizon of ATROPS (1982). This G-1 interval will be accurately subdivided by celtiberic fauna.

Guilherandense horizon: From the top of G-1 interval to the last record of Sutneria platynota (REIN.). The upper limit is the same of the Platynota zone. The difficulties for a precise correlation with the same denominated and proposed by ATROPS (1982) may be deduced from the previous definition of G-1 interval.

The correlations of this schema are shown in the fig. 3. Failure of minute biostratigraphical subdivisions, inconsonances and/or uncertainty in the correlations of the mediterranean sstr. ammonite associations, are induced by the scarce record of Sutneria platynota (REIN.), along with the lower

specialization of the Ataxioceratinae and the sampling difficulties related to the facies, in the studied sectors of those areas.

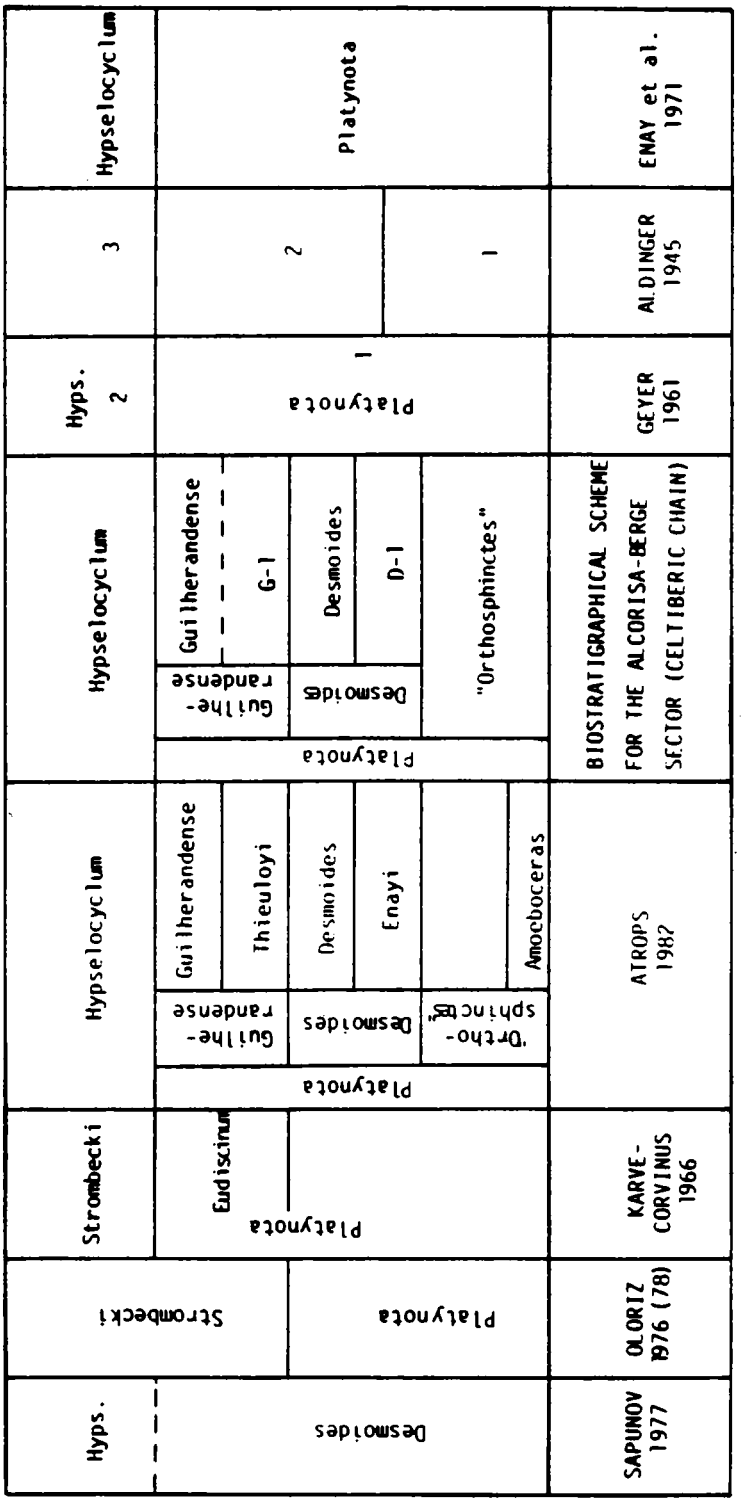

Fig. 3: Correlations with Submediterranean and Mediterranean areas.

SOME CONSIDERATIONS ON FINE AMMONITE BIOSTRATIGRAPHY: As may be inferrible from this paper, the possibility to carry out a detailed sampling in ammonite successions give us a handle for a profitable practice. In this way stimulative perspectives in evolutionary paleontology as well as in sedimentology are open to us.

According to deliberate limitations by authors, in the present paper only a short commentary about the fluctuations in the environment will be exposed. Other precisions about patterns and process of evolution of the implicated faunas will be the aim of a next paper. As an example we can see data about thickness in the SE France (ATROPS, 1982) and in the Alcorisa-Berge sector in the eastern celtiberic chain (MOLINER, 1983). In the french area the localities are Crûssol and Lourye (Ardèche), Massif du Bois-Noir (Gard), Châteauneuf d'Oze, Côte mare and Vaynes, Champerus (Hautes Alpes), Sêderon and La Roche sur le Buis (Drôme). The differences may be interpreted as induced by local paleogeographical peculiarities: First of all the externe -proximal- paleogeographical character of the studied region. GOMEZ (1979) and ANADON et al. (1982) provide insight on the paleogeography in related areas. In the eastern celtiberic chain jurassic activity in the Ejulve and similars uplifted areas has been quoted. SALAS ROIG (1983) proposes a model for the depositional sequences in the eastern celtiberic -southern catalinids controled by listric faults. In this context the authors have detected biostratigraphical inconsonances in the studied sector

In the comparison between the french and the celtiberic areas, for an equivalent mean thickness in the Platynota zone, the following is manifested:

- The Orthosphinctes subzone in the SE France acquires a thickness more than four times the celtiberic sector does nevertheless, incomplete erosion or no deposition in the iberian area could be envisaged; In this last hypothesis the Platynota zone in the studied region could develop higher thickness than in the french area if a similar thickness for the Orthosphinctes subzone should be considered.

- During the time interval conformable to the Desmoides horizon, thickness in the Alcorisa-Berge sector is equivalent or 25-30 % smaller. It is proper to precise the existence of fluctuations in the sedimentation rate -french sectors formerly with a twofold rate fall to about 25%.

- The significant differences for comparative thickness in the Guilherandense subzone. In the celtiberic sector thickness is twofold or triple than that

developed in SE France.

- Seemingly, a reversal in the formerly increasing sedimentation rate is manifested or, at least, in the volume of preserved materials. In the lower Kimmeridgian, Platynota zone, up to Desmoides subzone thickness may be thus far higher in the SE France. Into Desmoides subzone localities where differences are diminished can be found. During Guilherandense subzone the pattern is reversed and higher thickness are developed in the eastern celtiberic chain -Alcorisa-Berge sector.

From the above commented it is clear the productiveness of fine biostratigraphy to bring out fluctuations in the environmental parameters, as sedimentation rate, or hypothetical elusive events, erosion or no deposition, actives in sedimentary basins with similar faunistic associations.

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ANALYSIS OF STRATIGRAPHICAL VALUE OF CARDIOCERAS ELIZABETHAE TARK. AND C. ZALASIENSIS TARK. FROM THE OXFORDIAN OF SOUTHERN POLAND

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ANALYSIS OF STRATIGRAPHICAL VALUE OF CARDIOCERAS ELIZABETHAE TARK. AND C. ZALASIENSIS TARK. FROM THE OXFORDIAN OF SOUTHERN POLAND

Radosław Tarkowski

Stratigraphical reaches of Cardioceras elizabethae Tark. and C. zalasiensis Tark. have been discused in this study. They are numerous in profiles of southern Poland, in the Lower - Middle Oxfordian passage beds. These two taxons can be utilized for biostratigraphy, locally there where they occur. It was suggested by the author, that these two species can be utilized as species, as suplementary biostratigraphical classifications of Oxfordian. They can also be utilized to define the horizons: Cardioceras elizabethae and Cardioceras zalasiensis, as infra-subzonal unit having no formal status.

Stratigraphic studies on the Oxfordian from the vicinities of Cracow /Tarkowski, 1983/ made it possible to gather some new data on occurence and stratigraphic ranges of ammonites. Two of the recorded species were found to be highly interesting from the point of view of biostratigraphy: Cardioceras elizabethae Tark. and C. zalasiensis Tark. /Tarkowski, 1983/.
First representatives of these taxa have been found in the Zalas section /vicinites of Cracow/ in the 1980's /Matyja and Tarkowski, 1981/ and subsequent detailed biostratigraphic studies on that and other sections in the Cracow area showed that they are fairly common. In all the studied sections their occurence appears limited to the Lower - Middle Oxfordian passage beds which suggests high potential biostratigraphic value of the two taxa.

The studies on Lower and Middle Oxfordian strata exposed in numerous quarries and trenches in the vicinities of Cracow made it possible to gather rich collection of cardioceratids. The gathered material, mainly comprising young forms but also numerous fully grown, appeared sufficient for identification several species, including two new: Cardioceras elizabethae Tark. and C. zalasiensis Tark. /Tarkowski, 1981/. In the Cracow area, stratigraphic range of the two latter species appears limited to the Lower - Middle Oxfordian passage beds. It should be also noted that specimens referable to these species were mostly small, young forms which may explain why the species were not described in the past.

As it was noted above, C. elizabethae Tark. and C. zalasiensis Tark. appear of high potential value for biostratigraphy. The available data on distribution of these species are still insufficient to propose a new zone or subzone to the biostratigraphic subdivisions of the Oxfordian such as those proposed by Cariou et al. /1971/, Callomon /1964/. However, it seems desirable and justified to use the species to define some informal infra-subzonal units which would supplement the subdivisions.

In Oxfordian sections in the vicinities of Cracow, C. elizabethae Tark. and C. zalasiensis Tark. have been faund in greyish marls and calcareous marls, sometimes with green or pink shade. In comparison with underlaying pink, yellow and green marls and calcareous marls, the strata indicate uniform sedimentation, with less advanced condensation and without structures of the hardground type /see Tarkowski, 1984/. Small thickness of strata bearing these fossils may be explained in terms of a very low rate of carbonate sedimentation, a phenomenon typical of the Upper Callovian and Lower Oxfordian in Europe and other parts of the world /see Melandez et al., 1982/.

The strata with C. elizabethae Tark. and C. zalasiensis Tark. are directly overlain by grey marly limestones and limestones with ammonites of the Middle Oxfordian age and indicative of more uniform sedimentary conditions.

Stratigraphical position of the species

Stratigraphic distribution of the species C. elizabethae Tark., and C. zalasiensis Tark. in Oxfordian section in the vicinites of Cracow has been discussed in detail elsewhere /Tarkowski, 1983/ so here are anly made references to the sections described in the above mentioned paper: Zalas locality - sections W, L and U, Nowa Krystana - section O, Radwanowice - section T, Szklary - section Y and Paczółtowice - section R.

Cardioceras zalasiensis Tark. has been found in the following layers /section/number of layer/: W/16-23, L/7-13, O/9-10, T/4-6 and Y/9-10. The cooccurring taxa include: Cardioceras cordatum /Sow./, C. persecans /Buck./, C. elizabethae Tark., C. excavatum /Sow./, C. tenuicostatum /Nik./, C. tenuistriatum Bor., C. vertebrale /Sow./, Perisphinctes plicatilis /Sow./, Glochiceras distortum /Buk./, Glochiceras sp. A Tark., Lissoceratoides erato /d'Orb./, Neocampylites delmontanus delmontanus /Oppel/, N. delmontanus helveticus /Jeannet/, N. thirriai /Petitclerc and Maire/, N. inermis /Jeannet/, Popanites paturattensis /Greppin/, Scaphitoides paucirugatus /Buk./ and others.

Cardioceras elizabethae Tark. has been found in the layers: W/15-19, L/7-12, O/9, R/2-3, along with: Cardioceras persecans, /Buck./, C. zalasiensis Tark., C. excavatum /Sow./, C. aff. tenuicostatum /Nik./, Glochiceras distortum /Buk./, Neocampylites delmontanus delmontanus /Oppel/, N. thirriai /Petitclerc and Maire/, Scaphitoides paucirugatus /Buk./ and others.

First representatives of C. elizabethae Tark. and C. zalasiensis Tark. appear in the same level in the studied sections. Strata bearing these fossils are directly underlain by either those of the C. bukowskii and C. costicardia subzones /W/7-13, L/4-5, U/7, O/5-6, T/2-3 and Y/5-6/or strongly condensed strata representing time interval Quenstedtoceras mariae zone - Cardioceras cordatum subzone /R/2/. The species have been found to be missing in a condensed layer C/3 /Zalas/ with ammonites of the C. costicardia and C. cordatum subzones and interpreted as representing upper part of the C. costicardia subzone and lower part of C. cordatum subzone. It should be noted that top parts of strata underlaying those with C. elizabethae Tark. and C. zalasiensis Tark. display some features indicative of breaks in sedimentation structures of the hardground type /Tarkowski, 1984/. The beds with these fossils - grey marls and calcareous marls - and directly overlain by those dated at lower part of the C. tenuicostatum subzone, Plicatilis zone /Middle Oxfordian/. Taking into account the above data, especially the composition of ammonite faun accompanying the two species, it may be stated that the oldest layers with C. elizabethae Tark. and C. zalasiensis Tark. represent the uppermost part of the C. cordatum subzone /C. cordatum zone, Lower Oxfordian/.
Cardioceras elizabethae Tark. does not pass upper bundary of that subzone as the accompanying fauna does not comprise any taxon which would be indicative of the Middle Oxfordian /C. tenuicostatum subzone/. In turn, C. zalasiensis Tark. has been found in levels dated at the uppermost part of the C. cordatum subzone as well as in those of the C. tenuicostatum subzone /Middle Oxfordian/ In the latter, it has been found along with C. tenuicostatum /Nik./ C. tenuistraitum Bor. and C. vertebrale /Sow./. Up to the present, there is no record of the latter in layers of upper part of the C. tenuicostatum subzone, i.e. those with C. densiplicatum Bod., C. zenaidae Ilov., C. sowerbyi Arkell. This indicates that its upper range comprises lower part of the C. tenuicostatum subzone /Plicatilis zone, Middle Oxfordian/ only.

Cardioceras elizabethae Tark. and C. zalasiensis Tar. belong to the familly Cardioceratidae, the representatives of which give

the basis for biostratigraphic subdivision for the Lower and Middle Oxfordian in both Subboreal /Arkell, 1941, Callomon, 1964/ and Submedirerranean /Cariou et al., 1971; and others/ provinces. It should be noted here that C. elizabethae Tark. presumably represents a transitional form between C. plastum Buck. and C. tenuicostatum /Nik./ and C. tenuistraitum Bor. /see Matyja and Tarkowski, 1981, Tarkowski, 1981/ whereas C. zalasiensis Tark. may be best treated as an evolutionary offshoot of C. excavatum /Sow./, the eventual derivatives of which still remain to be identified.

Geographic distribution of C. elizabethae Tark. and C. zalasiensis Tark. may be fairly wide. I have found representatives of the former species in the material from Kłobuck and Częstochowa, described by L. Malinowska /1965/, and of the latter - in collections of the material of the C. cordatum and C. tenuicostatum subzones from Neuvizy /France/, and Herznach and Herszumenschichten /FRG/, made available through the courtesy of D. Marchand /Dijon University/.

Biostratigraphic interpretation

The above data suggest high potential biostratigraphic value of C. elizabethae Tark. and C. zalasiensis Tark. as the taxa match requirements of index ones. Taking into account their narrow stratigraphic ranges I propose differentiation of two new horizons in the Lower + Middle passage beds. The horizons may be differentiated in both the Submediterranean /Cariou et al., 1971/ and Subboreal /Arkell, 1941, Callomon, 1964/ subdivisions. The usability of these horizons has been shown in the sections from the vicinities of Cracow /see Fig. 1/.

Cardioceras elizabethae horizon

Index: Cardioceras /Plasmatoceras/ elizabethae Tarkowski.

1981 C. /Plasm./ elizabethae n. sp.; R. Tarkowski, Plate I Fig. 10, 11, 13, 14, 15, 18 /cum syn./.

Definition: Horizon characterized by presence of Cardioceras /Plasmatoceras/ elizabethae Tark.

Remarks. The species Cardioceras elizabethae Tark. is usually accompanied by C. persecans /Buck./, Glochiceras sp. A, Scaphitoides paucirugatus /Buk./, C. zalasiensis Tark., C. excavatum /Sow./, Popanites paturattensis /Greppin/ and other taxa. C. persecans /Buck./ is also known from older strata, in which the index taxon is missing. C. zalasiensis Tark., C. excavatum /Sow./

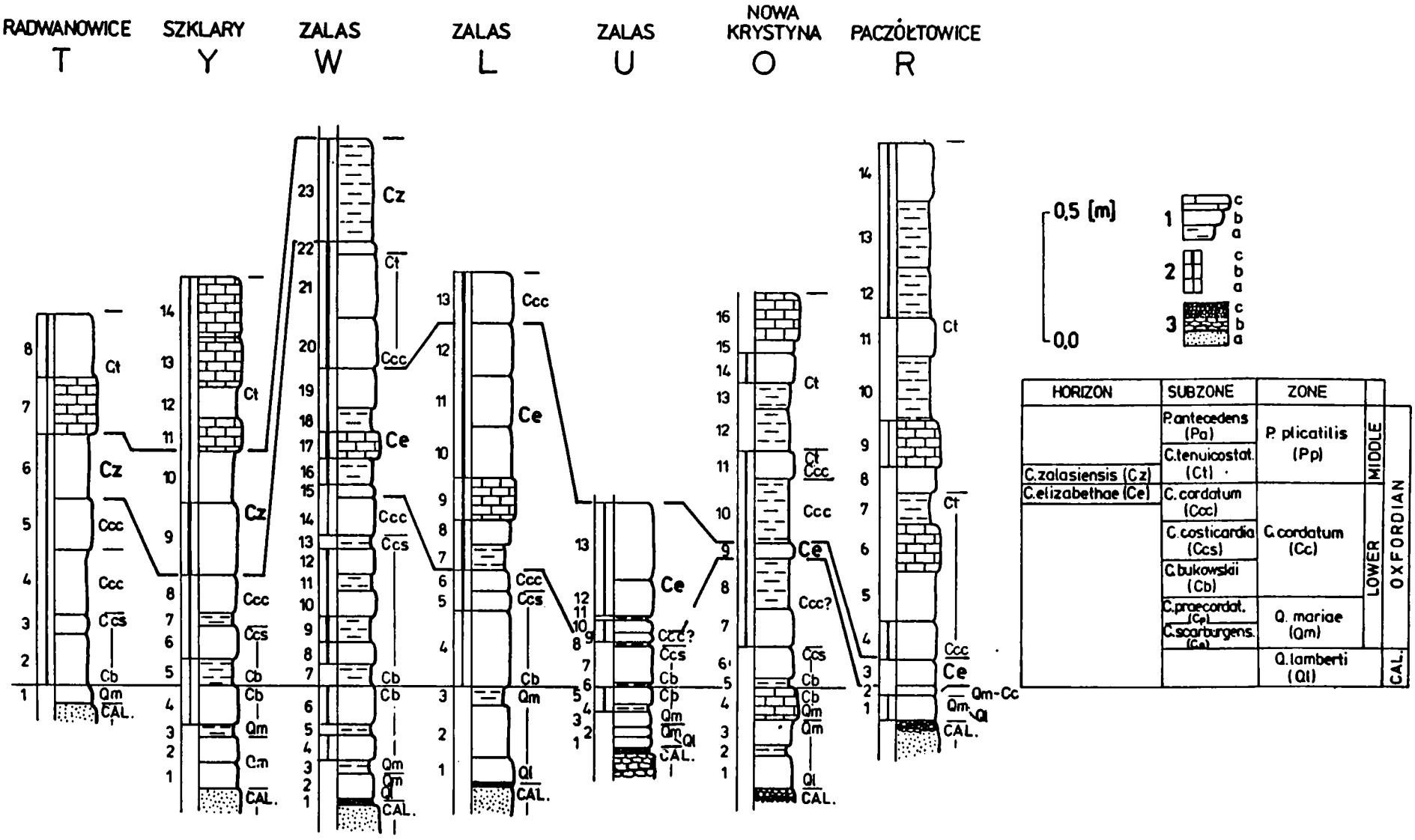

Fig. 1. Biostratigraphical correlation of the Oxfordian section: 1 - lithology: 1a - marls, 1b - marly limestones, 1c - limestones, 2 - sponges: 2a - not numerous, 2b - numerous, 2c - aboundant, 3 - Callovian deposits: 3a - sands and sandstones, 3b - nodular crinoid limestones, 3c - stromatolite.

and Popanites paturattensis /Greppin/ here appear for the first time, being also known from the next, C. zalasiensis horizon. The available data suggest that Glochiceras sp. A in Tarkowski /1963/ and Scaphitoides paucirugatus /Buk./ are limited to this horizon in the section from the vicinities of Cracow.

Age: Lower Oxfordian, Cardioceras cordatum zone, upper part of C. cordatum subzone.

Lithology: Marls and calcareous marls of grey colour, sometimes green or pinky, thickness 1 m.

Occurrence: Zalas /profiles W/15-19, L/7-12, U/10-13/, Nowa Krystyna /profile O/9/, Paczółtowice /profile R partly layers 2 and 3/.

Cardioceras zalasiensis horizon

Index: Cardioceras /Scoticardioceras/ zalasiensis Tarkowski.

1981 C. /Scot./ zalasiensis n. sp.; R. Tarkowski, Plate I Fig. 1-9, 12, 16 /cum syn./.

Definition: Horizon characterized by presence of Cardioceras /Scot./ zalasiensis Tark. along with C. /Plasmatoceras/ tenuicostatum /Nik./, C. /Plasm./ tenuistriatum Bor. or C. /Vertebriceras/ vertebrale /Sow./.

Remarks. Cardioceras elizabethae Tark. is missing here. The horizon is characterized by presence the index taxon, C. excavatum /Sow./, Popanites paturattensis /Greppin/, and other taxa also known from the underlaying strata. In turn, C. zalasiensis Tark. was nowhere found together with C. densiplicatum Bod., C. zenaidae Liov., C. sowerbyi Arkell, i.e. species indicative of upper levels of the C. tenuicostatum subzone, also in the Cracow area.

Age: Middle Oxfordian, Perisphinctes plicatilis zone, lower part of C. tenuicostatum subzone.

Lithology: Marls and calcareous marls of grey colour, thickness several tens of centimeters.

Occurrence: Zalas /profile W/23/, Radwanowice /profile T/6/, Szklary /profile Y/9-10/.

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CHANGES IN AMMONITE FAUNA AT THE BOUNDARY OF THE CARDIOCERAS CORDATUM AND PERISPHINCTES PLICATILIS ZONES/OXFORDIAN/IN SOUTHERN POLAND

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The analysis shows that qualitative and quantitative changes in ammonites as well as other macrofossils groups are much greater at the C. tenuicostatum - P. antecedens boundary than at the C. cordatum - C. tenuicostatum boundary. This conclusion is supported by results of analyses of faunal spectra and their similarities and data published by other authors. It is suggested that the Lower - Middle Oxfordian boundary drawn at the base of the C. tenuicostatum - P. antecedens boundary may appear easier to trace and correlate than that hitherto accepted /C. cordatum - C. tenuicostatum/.

In the course of studies on the Oxfordian in Cracow area /southern Poland/, a large collection of ammonites and other macrofossils has been gathered / Tarkowski, 1983a/. The recorded ammonites, among which Submediterranean ones clearly predominate, made possible accurate biostratigraphic subdivision of the strata with the use of the Submediterranean zonal scheme of Cariou et al. /1971/. This, is turn, made possible analysis of qualitative and quantitative changes in composition of the fauna at boundaries of individual zones and subzones /Tarkowski, 1981, 1983a, b/. Of the recorded changes, the most interesting are those in composition of ammonite, belemnite, brachiopod, bivalve, gastropod and echinoid assemblages in strata dated at the Cardioceras cordatum and Perisphinctes plicatilis zones. In the Cracow area, strata of that age appear fairly uniform in development /marly-limestone, usually grey-coloured rocks/. It should be noted here that the boundary between the two zones is widely treated as the Lower-Middle Oxfordian boundary /Arkell, 1956, Callomon, 1964, Cariou et al., 1971, Sykes and Callomon, 1979/.

Oxfordian sections in the Cracow area may be recognized as classic for Europe on account of the wealth of fossils, large

number of natural and artificial exposures and possibilites to study by the bed-by-bed method. Moreover, a large number of type specimens of taxa currently used in characterizing and identifying zones and subzones of the Quenstedtoceras mariae - Perisphinctes plicatilis interval in the Submediterranean zonal scheme have been found in this region.

In the Cracow area, strata of the Cardioceras cordatum subzone, upper subzone of the Cardioceras cordatum zone, are characterized by the presence of numerous representatives of Cardioceratinae, mainly of the subgenera Cardioceras and Plasmatoceras as well as first Scoticardioceras: Cardioceras cordatum /Sow./, C. persecans /Buck./, C. excavatum /Sow./, C. zalasiensis Tark., C. elizabethae Tark.. These forms are accompanied by numerous Oppeliidae /Neocampylites delmontanus delmontanus /Oppel/, N. delmontanus helveticus /Jeannet/, N. thirriai /Petitclerc et Maire/, Popanites paturattensis /Greppin//, small, unidentifiable perisphinctids, several Lissoceratidae /Lissoceratoides erato /d'Orb.// and innumerous Phylloceratina and Aspidoceratinae.

Ammonite fauna of lower part of the Perisphinctes plicatilis zone /Cardioceras tenuicostatum subzone = C. vertebrale subzone/ does not differ much from the above one. The differences are the greatest in Cardioceratinae as cardioceratid species typical of the latter are replaced by new ones, mainly of the subgenera Plasmatoceras, Scoticardioceras and Subvertebriceras: C. tenuicostatum /Nik./, C. tenuistriatum Bor., C. rachis Buck., C. vertebrale /Sow./, C. quadratum /Sow./, C. densiplicatum Boden, C. zenaidae Ilov. and C. sowerbyi /Arkell/ whereas C. excavatum /Sow./ and C. zalasiensis Tark. passes the boundary. Oppeliids are still numerous and represented by all the species known from upper parts of the Cardioceras cordatum zone, similarly as the representatives of Lissoceratidae. Perisphinctids are here represented by small, specifically unidentifiable forms of the subgenera Otosphinctes and Arisphinctes, and Phylloceratina - by scarce Sowerbyceras tortisulcatum /d'Orb./ and Holcophylloceras zignodianum /d'Orb./. Aspidoceratinae appears also poorly represented in this assemblage.

The changes recorded at the lower and upper /Perisphinctes antecedens/ subzone of the Perisphinctes plicatilis zone are found to be much larger than the above outlined. In upper part of this zone, the subfamily Cardioceratinae is represented by

innumerous forms of the subgenera Maltoniceras and Cawtoniceras, Oppeliidae - by several new species such as Taramelliceras calicerum /Oppel/, Trimarginites arolicus /Oppel/ and Neocampylites henrici henrici /d'Orb.//it should be noted that some of these species appear in top part of the C. tenuicostatum subzone in southern Poland/, and Perisphinctinae /predominating quantitatively in that assemblage/ - by several new species, especially of the subgenera Dichotomosphinctes and Arisphinctes: Perisphinctes rotoides Ronchm. P. antecedens Salf., P. dobrogensis Simion., P. helenae Riaz, P. pickeringius /Young and Bird/. Phylloceratids are here represented by innumerous forms of the same taxa as in the underlaying strata.

Analyse of ammonite spectra in the Oxfordian in the Polish Jura Chain /Tarkowski, 1983b/ gave some additional data for characterizing quantitative changes in ammonite fauna /Fig. 1/. The changes found in strata of the Cardioceras cordatum subzone of the C. cordatum zone and Perisphinctes plicatilis zone /levels IV-VI in Fig. 1/ are as follows /for discussion of those found in lower parts of the section - levels I-III in Fig. 1 - see Tarkowski, 1983b/:

The share of cardioceratids in ammonite spectra is the greatest in the Cardioceras cordatum subzone /up to 27%/, decreasing in overlaying strata: to about a dozen per cent in lower parts of the C. tenuicostatum subzone, a few per cent in upper part of that subzone, and close to zero in the Perisphinctes antecedens subzone. A similar trend is displayed by oppeliids: their share is the highest /about a dozen per cent/ in the Cardioceras cordatum subzone and lower parts of the C. tenuicostatum subzone to drop to a few percents in upper parts of the Perisphinctes plicatilis zone.

The share of representatives of Perisphinctinae, equal about 20% in the C. cordatum subzone and lower parts of the C. tenuicostatum subzone, markedly increases in younger strata at the expense of the above mentioned. In upper parts of the C. tenuicostatum and Perisphinctes antecedens subzones perisphinctids quantitatively predominate in ammonite assemblages /their share in ammonite spectra is always over 60%, and sometimes even over 90%/.

The share of representatives of the family Lissoceratidae appears highly varying in the section, whereas those of the

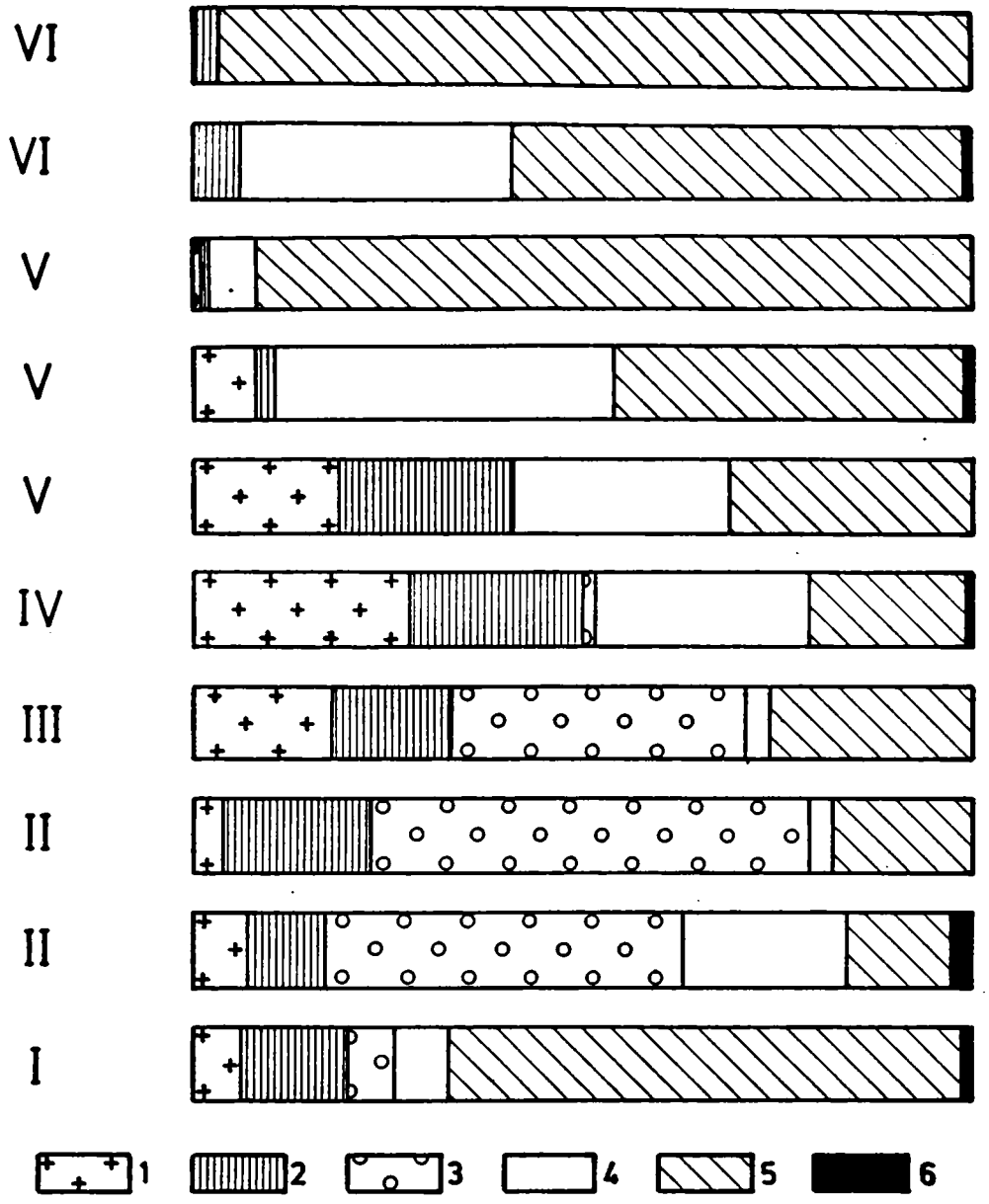

Fig. 1. Ammonite spectra in the Oxfordian of the Cracow area: 1 - Cardioceratinae, 2 - Oppeliidae, 3 - Aspidoceratidae /Aspidoceratinae and Peltoceratinae/, 4 - Lissoceratidae, 5 - Perisphinctinae, 6 - Phylloceratina; I-VI zones and subzones: I - Quenstedtoceras mariae zone, II - interval comprising Cardioceras bukowskii and C. costicardia subzones, III - interval comprising C. costicardia and C. cordatum subzones, IV - C. cordatum subzone, V - C. tenuicostatum subzone, VI - P. antecedens subzone.

subfamily Aspidoceratinae and suborder Phylloceratina remain negligible.

Attention should be also paid to estimations of similarities of the analysed ammonite assemblages, made on the basis of results of taxonomic analyses of the spectra /Tarkowski, 1983b/. Spectra of the C. cordatum subzone were found to be markedly similar to those of lower part of the C. tenuicostatum subzone, and those of upper part of the latter - to spectra of the Perisphinctes antecedens subzone. In comparaison with spectra of the P. antecedens subzone, those of the C. cordatum and C. tenuicostatum subzones are characterized by marked homogeneity within a given unit /Tarkowski, 1983b/.

The results of comparative analyses of a number of species in common in assemblages of belemnites, brachiopods, bivalves and echinoids from the C. cordatum - P. plicatilis junction beds appeared coherent with the above outline image of changes in quantitative and qualitative composition of ammonites. Fauna of the C. tenuicostatum subzone /Ct/ comprises more elements in common with that of the C. cordatum subzone /Ccc/ than with that of the P. antecedens subzone /Pa/. The obtained data are as follows: belemnites Ccc-Ct = 4 species, Ct-Pa = 1 species, brachiopods Ccc-Ct = 6 species, Ct-Pa = 3 species, bivalves Ccc-Ct = 3 species, Ct-Pa = 1 species, echinoids Ccc-Ct = 1 species, Ct-Pa = 1 species.

The above data unequivocally show that the greatest changes in specific and generic composition and faunal spectra do not coincide with the C. cordatum - C. tenuicostatum boundary but with the C. tenuicostatum - P. antecedens boundary, i.e. the boundary passing within the P. plicatilis zone. This is further supported by the results of analyses of similarity of Oxfordian subzones as characterized by ammonite spectra and number of species of other macrofossil groups in common.

As it was noted above, the Lower - Middle Oxfordian boundary is drawn by the majority of authors at the base of the C. tenuicostatum /=C. vertebrale/ subzone. However, there arises the question whether or not it is the best choice?. I would like to note here that similar questions have been put forward by some authors studying Polish Oxfordian. L. Malinowska /1963, 1976, 1980/ proposed to draw the Lower - Middle Oxfordian boundary between the Cardioceras excavatum zone /roughly correspon-

ding to C. tenuicostatum subzone/ and Cawtoniceras tenuiserratum zone /= P. antecedens subzone in the scheme of Cariou et al., 1971/, i. e. along the boundary characterized by major changes in ammonite fauna.

Subsequently Brochwicz-Lewiński /1976/ ascribed zonal rank to the C. tenuicostatum and P. antecedens units, emphasizing that changes in ammonite fauna recorded by him at the C. tenuicostatum - P. antecedens boundary are markedly greater than at the C. cordatum - C. tenuicostatum boundary. In other paper, Brochwicz-Lewiński and Różak /1981/ interpreted the C. tenuicostatum subzone sensu Cariou et al. /1971/ as a horizon in the Lower Oxfordian. In the latter paper the changes in ammonite spectra at the C. tenuicostatum - P. antecedens boundary are interpreted as the major ones in the interval in question.

To sum up, there is growing evidence the major changes from the C. cordatum - P. plicatilis interval are those found at the C. tenuicostatum - P. antecedens boundary. When this is the case, the Lower - Middle Oxfordian boundary drawn at the base of the P. antecedens unit would best match definition of a stage /or substage/ as proposed by d'Orbigny /see Arkell, 1956, Callomon, 1964, Enay, 1966, Rioult, 1971/, i.e. the d'Orbigny concept of "natural subdivisions".

The Lower - Middle Oxfordian boundary drawn at the base of beds with Perisphinctes antecedens Salf. would also more accurately separate two phenomena recorded in the Callovian and Oxfordian:

/1/ Boreal Spread /Arkell, 1956/, i.e. southward expansion of Boreal elements and their subsequent come back - "Boreal Retreat" /Callovian - Early Oxfordian/; and

/2/ Extensive northward migration of Tethyan fauna /Middle Oxfordian/.

The boundary defined in this way also appears easier to identify in Europe and other regions. Tethyan expansion in the Middle Oxfordian resulted in the major changes in ammonite faunas in the scale of the Oxfordian.

These phenomena are traceable not only in Europe and other areas of contact of the Boreal and Tethyan faunas. "Grands Perisphinctes" faunas /Enay, 1980, Enay and Mangold, 1983/ accompanied by oppeliids and aspidoceratids are also well represented in the Andean region, Mexico, Madagascar, Cutch and other regions.

It should be also noted that changes in ammonite fauna at the C. cordatum - C. tenuicostatum boundary, as shown by Arkell /1956/, Enay /1966/, Callomon /1964/, Cariou et al. /1971/ and several other authors, appear minor in comparison with those at the C. tenuicostatum - P. antecedens boundary.

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THE PORTLANDIAN, THE TERMINAL JURASSIC STAGE IN THE BOREAL REALM

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THE PORTLANDIAN, THE TERMINAL JURASSIC STAGE IN THE BOREAL REALM

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Abstract: The Portlandian is preferred as the name for the terminal stage of the Boreal Jurassic. Ten ammonite faunas are described from the north-west European sections, and correlations made with the incomplete sections of Greenland and the USSR.

INTRODUCTION

Recent years have seen a reawakening of interest in Portlandian ammonite faunas in England and France and with it a realisation that the stage contains a larger and more diverse series of faunal assemblages than was previously thought (Buckman 1923-30, Arkell 1933, 1935). Arkell's (1956) division of the stage into three zones now seems very conservative. The expansion of our knowledge of Portlandian faunas leads one to the unavoidable conclusion that the north-west European sections are the most complete in the Boreal Realm. Their minimum of 10 distinct zonal and subzonal faunas have no rival in the much more broken sequences of Greenland, Siberia or the Russian Platform.

In historical terms Portlandian has every right to be considered the senior available name for the terminal Jurassic stage (Brongniart 1829, d'Orbigny 1842-51), its rivals coming much later (Tithonian, Oppel 1865; Volgian, Nikitin 1881). In the Boreal Realm it has priority over the Volgian, a stage based on condensed and broken sequences, latterly modified (Gerasimov & Mikhailov 1966) to include a large part of the Kimmeridgian (see Wimbledon 1980). Apart from its historical status the Portlandian is founded in a type area with many kilometres of accessible sections in coastal cliffs and quarry faces, and its ammonite faunal succession is more complete that that of the Volgian.

The English and French sections are here taken as a standard with which other Boreal sections may be compared. National and/or drafting conventions have tended to conceal major non-sequences in previously produced correlation charts comparing the Portlandian standard with other Boreal sections. I would like to outline the characteristic faunas of the type Portlandian sections and then examine what points of faunal similarity and precise correlation can be derived with Greenland and the USSR. Figure 1 herein shows the equivalence of zones in the late Kimmeridgian - basal Ryazanian interval in N.W. Europe and the Volga Basin.

The Portlandian is here used for all post-Kimmeridgian Jurassic strata (i.e. albani-lamplughi zones) following its redefinition (Wimbledon & Cope 1978, Wimbledon 1980). It is clear that the topmost part of the stage in this way defined overlaps with the Berriasian, as does the Russian Volgian. The zonation of the stage is here refined, and further faunal subdivisions are described.

ZONES AND FAUNAL ASSEMBLAGES

No Portlandian section has thus far produced a complete faunal succession. In England the Dorset sections are most complete, faunal deficiencies being made up by making use of richer but geographically separated faunal assemblages in other southern English counties and northern France.

The following faunal assemblages characterise the stage:

1) albani Zone - Known only in Dorset and the Boulonnais (Wimbledon & Cope 1978, Townson & Wimbledon 1979), it is characterised in Dorset by Progalbanites albani, Epivirgatites nikitini and E. vulgaris in the Massive Bed and Emmit Hill Marls and Epipallasiceras in the Massive Bed. In the Boulonnais Progalbanites albani and related species are found in the Assises de Croi. In association with the distinctive small species of this assemblage are found small Pavlovia spp. and poorly preserved larger forms.

2) glaucolithus Zone - Best known in the rich faunas of the Vale of Wardour but only patchily represented in the basal Glauconitic Beds of the north Wiltshire-Buckinghamshire outcrop (see fig. 2). In Dorset the fauna is easily observed in the extensive sections of Gad Cliff and Hounstout -

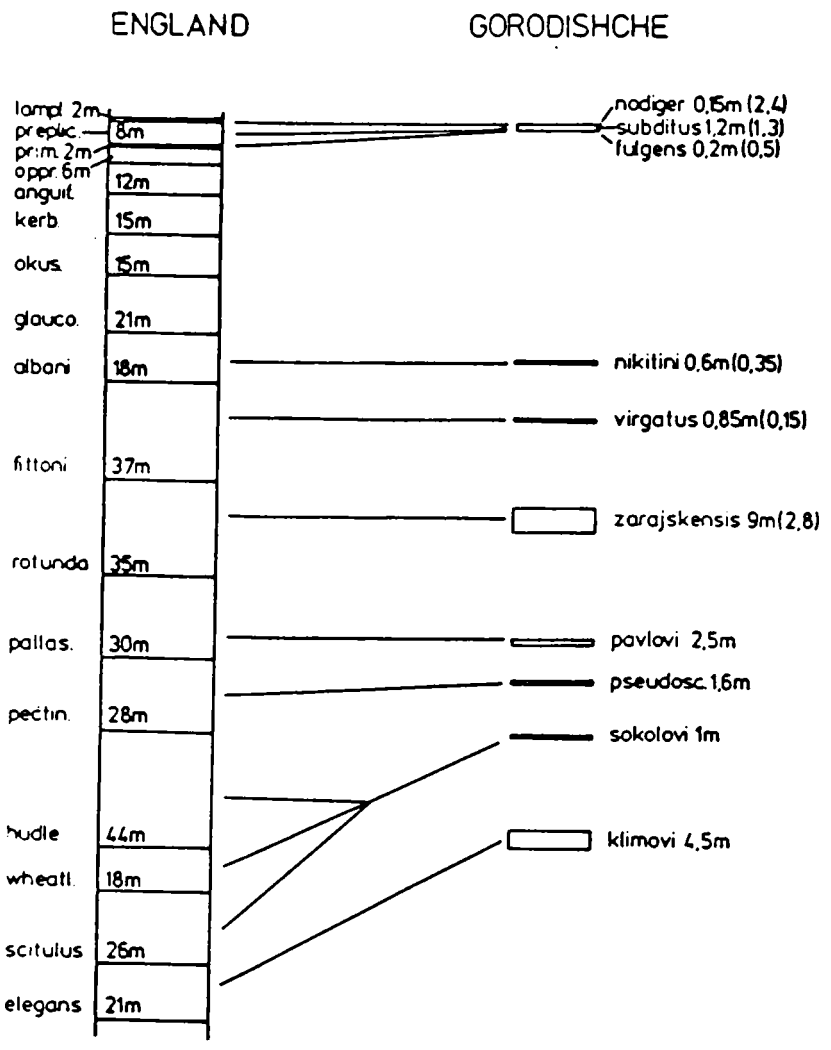

Figure 1. A comparison of Late Jurassic zonal thicknesses in Southern England with equivalent zone at Gorodishche (Volga) (thickness in brackets for Kashpir)

St Aldhelms Head, in the White Cementstone, St Albans Head Marls and lower 'Parallel Bands', but on Portland its presumed distribution within the West Weare Sandstone has yet to be established. The fauna is made up almost exclusively of Glaucolithites species. In the Vale of Wardour giants like G. glaucolithus predominate together with G. aquator and related middle sized species. Less common are a smaller (c. 300mm, microconch?) as yet unnamed species, and a very small, biplicate and collared species perhaps close to the adult of 'Lydistratites' biformis Buckman (1925 pl. 605B) (assigned to

Epivirgatites by Casey 1967). G. caementarius is the lowest species of the assemblage known on the Dorset coast.

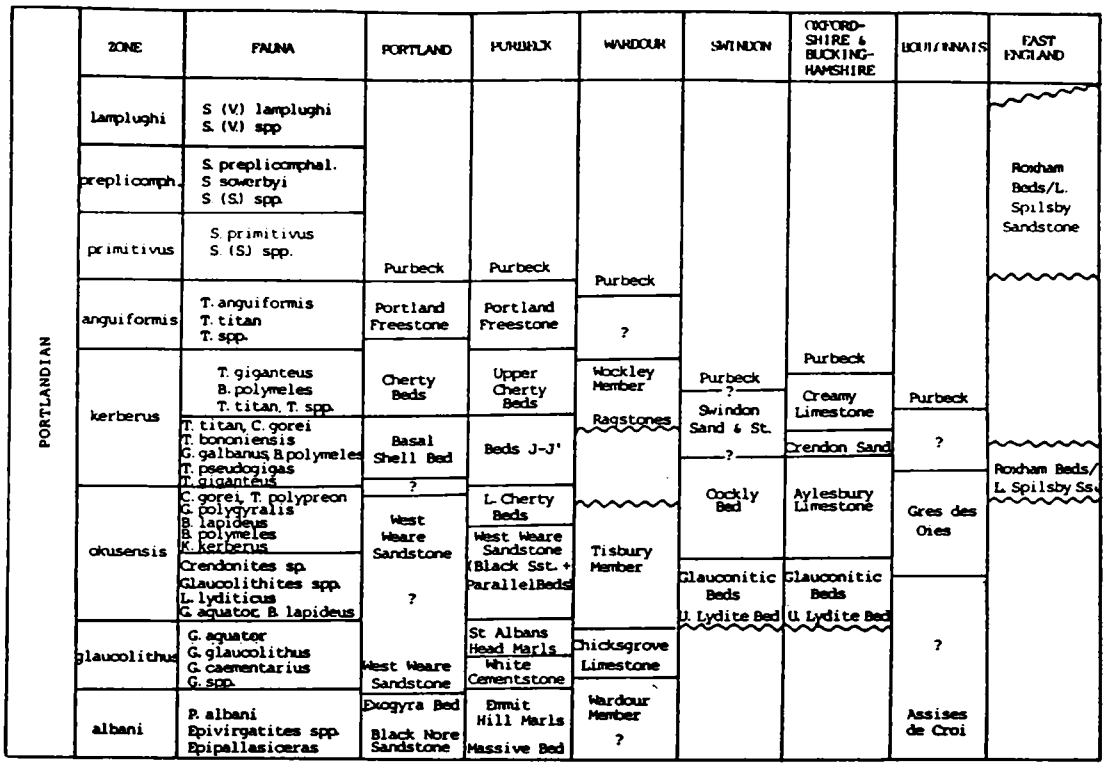

Figure 2. A correlation of Portlandian strata in England and northern France.

3) okusensis Zone - subzone a - Extensive collections made in the Vale of Wardour in the early 1970's indicated that the fauna of the glaucolithus Zone (Wimbledon 1976, Wimbledon & Cope 1978) was distinct and never occurred with forms like Crendonites and Galbanites (typical, for example, of the famous fauna of the Cockly Bed at Swindon). However, further collecting in other districts has shown that there is a degree of overlap between these faunas. This mixed or passage fauna is given expression here by the creation of a lower okusensis subzone.

This is the least well known of the Portland ammonite faunas, occurring in the most inacessible portions of the Dorset coastal cliffs and in the poorly exposed basal beds of some inland sections. Its fauna consists of large and small Crendonites spp. (including forms like C. pregorei) the very distinctive Lydistratites lyditicus Buckman (holotype only, 1922, pl. 353A) 'Behemoth' lapideus Buck., evolute Glaucolithites (e.g. G. cf. aquator and G. cf. polygyralis) and small species like those assigned above provisionally to 'L.' biformus (occurring with Vaumegalites in the Vale of Wardour). With Glaucolithites and early Crendonites there are larger, evolute, strongly ribbed biplicate - triplicate pavlovid types, which predominate in the upper okusensis Zone and persist into the kerberus Zone. This subzonal fauna has been identified from the Glauconitic Beds of the Wheatley-Milton outcrop of Oxfordshire, in the Glauconitic Beds of Swindon where preservation is very poor, and the Tisbury Member (Main Building Stone of Arkell, 1933). In Dorset the distinction of this fauna from those above and below remains a problem.

4) okusensis Zone - subzone b - This is characterised by the rich fauna found in the Cockly Bed of Swindon. Crendonites species (e.g. C. gorei) are the most common element in the fauna. Evolute, strongly biplicate-triplicate ribbed pavlovids (e.g. G. okusensis and 'B.' lapideus) are the dominant larger forms, but even larger Briareites polymeles and Titanites polypreon herald the incoming of the giants of the Portland Sand. Smaller forms, the presumed microconch equivalents of larger species, include 'K. kerberus' Buckman (1926, pl. 520 a&b) and 'Galbanites' mikroloba Buckman. Glaucolithites polygyralis is the last representative of the genus. Besides its occurrence in the Cockly Bed, the fauna is well represented in the dolomites of the topmost Portland Sand (West Weare Sandstone), in the Glauconitic Beds - Aylesbury Limestone of Buckinghamshire and in the Lower Grès des Oies of the Boulonnais whence came the holotype of C. gorei (Salfield). This ammonite assemblage, and possibly that of the kerberus Zone (subzone a), is the fauna described as the 'giganteus/oppressus fauna' of eastern England (Casey 1973) (see below). There it would appear that late Kimmeridgian and Portlandian times are mostly represented by a hiatus terminated finally by the broken deposition of the primitivus-lamplughi Zones. Casey's (1977) record of Epilaugites from the Fordington borehole is interesting, but the specimen figured can not be related to a reliable stratigraphy. Its relation to other ammonite finds is largely conjectural

since it can only be broadly assigned to the Spilsby 'Basement Beds'. If the species is truly associated with the Portland fauna typical of the so-called 'oppressus Zone' in Lincolnshire then it may give a useful indication of the equivalence of a genuine okusensis(-kerberus Zone) fauna there with the vogulicus Zones of Greenland and Siberia (see Greenland correlation below). If the basement beds of Lincolnshire with Epilaugites are of upper okusensis Zone age this would fall into line with the correlation of groenlandicus-anguinus Zone Crendonites in Greenland with those of the lower okusensis Zone in England (see below).

5) kerberus Zone - subzone a - This fauna shows a great diversity of giant Titanites and these (with those of subzone b, see below) are the species which have most often been recorded and collected in the past. Buckman described them under a multiplicity of names, reflecting the variability of the genus. Species include T. giganteus (Sowerby), T. bononiensis (de Loriol) T. pseudogigas (Blake), T. titan Buck. the first three have played a major part in the general confusion which has typified Portlandian stratigraphy in years gone by. Ammonites giganteus Sowerby, a name applied to any Portland Stone ammonite but latterly more particularly to the Portland Freestone giants, was originally based on a type series which apparently straddled three zones (glaucolithus-kerberus). However, it is now restricted to forms in the kerberus Zone (Buckman 1923-30, Wimbledon & Cope 1978). T. bononiensis is, again, a name that has been used indiscriminately by past authors, and used wrongly as an index for the Freestone 'Series' by Salfeld (1914). In the Boulonnais (Middle Grès des Oies), as in Dorset (Basal Shell Bed), the species is associated with other Titanites and Galbanites spp. T. pseudogigas (Blake), with its extreme whorl inflation, is the species which led d'Orbigny to confuse English Portland Stone ammonites with mid-Kimmeridgian Gravesia, and all the consequent confusion amongst continental workers over stage nomenclature. With Titanites occur Briareites polymeles and smaller (c. 300mm) Galbanites (e.g. G. galbanus and G. forticosta) and remnants of the coarsely ribbed species of the okusensis Zone in the form of Galbanites zeta (Buckman). Dominant and distinctive small species are: Kerberites kerberus Buck., Kerberites audax (Buckman) and 'Galbanites' mikroloba Buckman and the last Credonites, C. gorei Salfeld (=C. leptolobatus Buckman) and larger Crendonites spp. The kerberus zone-subzone (a) faunas are best known in Dorset, from the abundant specimens of the Basal Shell Bed on Portland and in the 'West Mainland'

in particular, and in Buckinghamshire, where Buckman obtained the majority of the specimens he figured in Type Ammonites.

6) kerberus Zone - subzone b - With the disappearance of Crendonites species and other smaller forms like K. kerberus the fauna of subzone b is dominated by species of Titanites and Galbanites, but with less diversity in the assemblage than below. B. polymeles, persists in the lower part of the subzone. With the falling-off in numbers Titanites is reduced to T. titan, T. cf. trophon, T. giganteus (in the lower part) and a coarsely ribbed species, T. glottodes, makes its first appearances. Galbanites galbanus and G. forticosta both persist into at least the lower part of the subzone, as does K. audax. This assemblage is common in the Upper Cherty Beds of Dorset, especially on Portland, in the Creamy Limestones of Oxfordshire and Buckinghamshire (e.g. Long Crendon), and in the Wockley Member ('Ragstones' and 'Chalky Series') of Chicksgrove and Chilmark in the Vale of Wardour (Wimbledon 1976). In the Isle of Purbeck the fauna extends apparently up to the 'House Cap' in the Freestone Member, and possibly even higher.

7) anguiformis Zone - This faunal assemblage contains the largest (c. 900mm), most densely ribbed and apparently last Titanites. Previously the fauna was used to characterise a giganteus Zone (='Freestone Series')(Salfeld 1913, Arkell 1933 etc Casey 1963, 1973 and others) but as seen above the giganteus fauna is that of the kerberus Zone (see Wimbledon & Cope 1978). This assemblage is limited in comparison to those of the preceding zones. It includes only Titanites anguiformis Wimbledon and one or two other species of similar, inflated, densely-ribbed giants, with a small (microconch?) species, 300-400mm in diameter (e.g. GSM 74321). Coarser ribbed, less inflated types similar to T. titan appear to persist, from finds in the Titanites Bed - Shrimp Bed in east Dorset. The anguiformis fauna is restricted to Dorset where it is seen to the top of the Portland Beds. Elsewhere in southern England and in northern France, Purbeck deposition commenced prior to anguiformis Zone times (Wimbledon & Hunt 1982). In Dorset, the fauna is best known from the oolites, Roach, Curf and Base Bed Roach of the Isle of Portland. The ammonite fauna of basal Shrimp Bed and the Titanites Bed of the Isle of Purbeck does include some very densely ribbed forms like T. anguiformis but also species more typical of the Cherty Beds of Portland like T. titan, perhaps indicating an intermediate fauna between the kerberus (subzone b) and anguiformis assemblages, rather than the precise equivalents of the

Portland Isle Freestone fauna. The anomalous (in the sense that it consists for the most part of inner whorls) '*oppressus* Zone' fauna (Casey 1973) is not here regarded as any more than an assortment of unassigned and perhaps unassignable inner whorls of larger *Titanites*. The restriction of this 'fauna' to an impersistent horizon (upper Shrimp Bed) in a geographically restricted area makes it of little zonal use. The 'fauna' is not known west or east of St Aldhelms Head. The '*oppressus* Zone', and the fauna it is supposed to contain both in Dorset and in eastern England is fraught with such confusion that its use is not continued herein.

Casey has figured a specimen of '*Paracraspedites*' (1973 pl. 1, fig. 4) from Gorodishche. This specimen and others from the same locality collected by Casey, now in the Geological Survey Museum (London), have atypically feeble ribbing for a Portland Beds ammonite and I feel bear little resemblance to other specimens figured under the same name by that author (plate 1, figs. 1, 2 7 3, plate 6, fig. 1). I believe the specimens figured include at least three distinct and not closely related species. The equation of this mixture of forms with such a nondescript ammonite as the Gorodishche species is a dubious proposition. The fauna of the '*oppressus* Zone' in eastern England is rather different to that in the upper Shrimp Bed. The stratigraphy of the basal Spilby-Sandringham beds is problematic, because so much of the faunal material, including ammonites, is found *ex situ* in glacial erratics. However, there does appear to be a consistent ammonite assemblage made up of *Titanites* spp., *Galbanites*, *Crendonites* and possible *Kerberites*. The presence of this fauna in these beds, however, only allows correlation with the *okusensis* (or *kerberus*) Zone of Dorset etc, i.e. in the Portland section, the topmost Portland Sand or basal Portland Stone, but no higher. The comparison of these '*oppressus* Zone' faunas I intend to describe in a separate publication, but from the above outline I would suggest that this fauna is in fact two faunas of two quite distinct ages in the widely separated areas where Casey first described it.

(8-10) *primitivus* - *lamplughi* Zones - Described by Casey (1973) these Zones have no non-craspeditid fauna persisting from earlier Zones (i.e. pavlovids); a gap is therefore inferred between the *primitivus* and *anguiformis* Zones.

CORRELATIONS WITH THE USSR

The type Volgian totals no more than 24 metres (7.1m lower, 12.95 middle and 4.2m upper Volgian) at Gorodishche and Kashpir on the Volga, equivalent to 338 metres of Upper Kimmeridgian and Portlandian strata in Dorset (see fig.1)

The correlation of the Russian pavlovi subzone with the pallasioides Zone has been well attested by previous authors. The virgatus Zone may equate with the fittoni Zone (see Zeiss 1983). The fulgens-nodiger Zones are here correlated with the primitivus-lamplughi Zones following Casey (1973). The problematic part of the Russian Volgian sequence is the nikitini Zone and the correlation of its faunas with those of western Europe. The Epivirgatites fauna of the albani Zone strongly suggest equivalence of that Zone with the nikitini Zone (see Wimbledon 1980).



Figure 3. A comparison of Upper Kimmeridgian-Portlandian ammonite zones in England, Greenland and the Russian Platform.

Casey (1967) both disputed Mikhailov's use of English generic names and pointed out the incomplete nature of the Volgian. Later (1973) he suggested the Volgian was less incomplete than he had previously inferred and stated that most of the missing western European strata could be equated to a pre-nikitini Zone hiatus. Callomon (Callomon & Birkelund 1982 p. 366) follows Casey in trying to equate some of the nikitini Zone ammonites with Portland Stone species. The question remains; how can the nikitini Zone, only 0.5m thick at Moscow. 0.6m at Kashpir and 0.35m at Gorodishche, be simultaneously equatable with the albani and with some Portland Stone fauna (kerberus-'oppressus' Zone)?

If we turn to the summary of Mesezhnikov (1983) we find as follows: there are apparently variations in the ammonite assemblages within the zone; Lomonossovella, E. lahuseni and E. bipliciformis occur at Moscow, at Kashpir E. nikitini predominates, while at Gorodishche E. bipliciformis and 'Paracraspedites' occur. Thus, E. nikitini and rare Lomonossovella occur below and E. bipliciformis, Paracraspedites and abundant Lomonossovella above. Mesezhnikov states that E. nikitini occurs in both assemblages; thus both contain that species and Lomonossovella spp., and there is faunal continuity. It is difficult to reconcile this state of affairs with the simultaneous correlation by some authors of nikitini Zone Epivirgatites with Epivirgatites spp. in the albani Zone, and nikitini Zone Lomonossovella spp. with the somewhat similar Kerberites, two zones or more higher in the English sequence.

Spath, many years ago, recognised Epivirgatites in Britain, as is evidenced by his notes on specimens in British museums. Casey (1967) reviewed the importance of finds of the genus and Wimbledon & Cope (1978) placed it in the albani Zone faunas of Dorset. Epipallasiceras and poorly preserved Epivirgatites are also found in the Assises de Croi of the French coast from the evidence of more recent collecting. This correlation therefore seems irrefutable. Examination of the suggested equivalence of Lomonossovella and 'Kerberites' mosquensis Mikhailov with English Kerberites becomes more necessary as a consequence. I will therefore compare these species. Lomonossovella lomonossovi, L. michalskii and L. blakei all have shell whorl shapes which differ considerably from K. kerberus Buck. In Lomonossovella specimens larger than 20mm the percentage ratios of umbilical diameter : diameter overlaps the range for K. kerberus. Similarly there is partial overlap in the whorl height:

diameter ratio of the three species with the upper end of K. kerberus' range. When, however, whorl width as a percentage of diameter is examined, the greatest difference is apparent. The Volgian species have a much wider and deeper impressed area, and whorl width: diameter ratios far in excess of any English specimen (4-12% more than the highest English figure). Also the distinctive high ratio of secondary to primary ribs in K. kerberus is not seen in the Lomonossovella species. A typical specimen of K. kerberus (A. triplicatus Blake 1880, refigured Spath 1936, pl. 16, fig. 2) of comparable size to the Lomonossovella holotypes shows a secondary to primary rib ratio (with 16 primary ribs) of 3.6:1. K. kerberus specimens up to 50mm have a ratio which is always above 3:1 and often reaches 4:1. This compares with a Lomonossovella maximum of 2.8:1. (See Ivanov (1979) for Lomonossovella measurements).

Kerberites mosquensis does have a set of shell proportions close to K. kerberus although its whorl height as a percentage of diameter is significantly greater than the English species. K. mosquensis has cruder ribbing than that found in K. kerberus, lacking the spaced, regular strong ribbing of that species, while its secondary:primary rib ratio is only 2.8:1, again, well below any comparably sized K. kerberus (see above).

My conclusion would be that Lomonossovella and 'Kerberites' mosquensis are Pavlovia derivatives, but not closely allied to Portland Stone species. Their stratigraphic association with Epivirgatites makes it difficult to correlate the nikitini Zone fauna on the Russian Platform with any part of the Dorset succession but the lower half of the Portland Sand (albani Zone).

The only outstanding problem of correlation between the Volga and England then, remains the 'oppressus Zone'. As indicated above, there appears little in common between the oppressus Zone faunas in southern and eastern England. The Gorodishche specimen figured as a Paracraspedites (Casey 1973, pl. 1, fig. 4) is dealt with in the relevant part of the description of English faunas. I do not believe that the weakly ribbed individual illustrated by Casey bears any more than a passing resemblance to the British species with which it has been compared. As I have stated, Casey's comparison appears to have been simultaneously with ammonites from different faunal horizons, possibly spanning two or three zones.

The persistent habit of authors in equating modern western European and

Soviet zones on a one to one basis (e.g Mesezhnikov 1983, fig. 17) has the effect of concealing major correlative discrepancies. From the account given above, I would conclude that most of the middle Portland Beds sequence (glaucolithus-anguiformis Zones) finds no equivalent on the Russian Platform (see fig. 1 & 3).

The 'Crendonites' of western Siberia (Zakharov &Mesezhnikov 1974) have been used to correlate middle Volgian sediments there with Crendonites horizons in Greenland and the okusensis Zone of England (Mesezhnikov 1982, Zeiss 1983). The Siberian forms are small, seemingly mature species typified by dominant biplicate ribbing, fading on the later part of the rapidly expanding body-chamber. Such a description does not accord with the diagnosis for a typical Crendonites (e.g. C. gorei Salfield) which is much larger, and has frequent simple ribs and constriction when mature. Accordingly, C. subleslie is not here taken to be congeneric with true Crendonites from the Grès des Oies of Boulogne, Basal Shell Bed or Cockly Bed of England. However, rare specimens, similar to C. subleslie have been collected by the author from the glaucolithus Zone and basal okusensis Zone in Wiltshire. These are as yet poorly known and await further study.

CORRELATIONS WITH GREENLAND

By comparison with England, there is a very large break in Greenland between late Kimmeridgian-lower Portlandian levels and late Portlandian remnants, the latter perhaps only attributable to the primitivus and lamplughi Zones (Wimbledon 1980, Callomon and Birkelund 1982).

Consideration of the faunas 40-46 of Callomon & Birkelund (1982) suggests that they correlate with the Portland Sand faunas of Dorset. Epipallasiceras in their faunas 40-42 invite comparison with that genus in the albani Zone (Emmit Hill Marls) and with as yet poorly known forms in the Assises de Croi of the Boulonnais. Callomon's comparison (op cit 1982 p. 356) of Epipallasiceras from fauna 41 with a Boulogne specimen in the Pellat Collection must be based on an incorrect specimen label. The Lower Grès des Oies does not yield such material, but instead species of the okusensis Zone (see above). Callomon also compares the unique specimen of Behemoth groenlandica Spath with Glaucolithites from the mid-Portland Sand, but a closer match of this species is

with the extremely evolute (non-glaucolithitid) pavlovids of the okusensis Zone. However, its association in Milne Land with a small Pavlovia sp. and Dorsoplanites, and its position lower in the sequence than the Crendonites of faunas 45-47 contraindicates this correlation. The large pavlovids of the lower Portland Sand are very poorly known, and it is probably in that part of the Dorset section, if anywhere, that 'B.' groenlandica and its associated fauna should be sought. The small Crendonites of the anguinus Zone (faunas 45-47) I would correlate with the lower okusensis Zone, This is because the Crendonites of Milne Land are comparatively small (a maximum of c. 110mm), much smaller than a typical C. gorei (c. 150mm) from the upper okusensis Zone (or kerberus Zone), and much smaller than large (macroconch?) individuals of 190mm max. from this level. Smaller, more crudely ribbed Crendonites are found in the uppermost Assises de Croi of France, and in the lower okusensis Zone (Glauconitic Beds) of southern English counties (e.g. C. subgorei Spath 1936, pl. 9, fig. 5, pl. 14, fig. 2). If the Epilaugites vogulicus Zone of the Wollaston Foreland and Siberia and the horizons with Epilaugites sp. in Lincolnshire are time equivalent then the vogulicus Zone in Greenland may be only slightly younger than the Crendonites anguinus Zone and its presumed lower okusensis Zone equivalents.

STAGE NOMENCLATURE

A standard single stage nomenclature for the uppermost Jurassic may never be possible. The base of the Berriasian still awaits definition. I am strongly of the opinion that a dual nomenclature (regardless of whatever names may be used) should be retained for the Tethyan and Boreal Realms. The latest Jurassic ammonite sequence in the Boreal areas of Greenland, Siberia, Russian Platform, Poland, Denmark, Norway, Britain and France have a 'community of character' which requires expression in separate stage status. The Boreal and Tethyan stage schemes may never be accurately integratable except in a few geographically limited areas. For the purposes of day to day practical correlation within Realms these odd areas will be of limited relevance. What will continue to matter is the usefulness of the zonal schemes applied within a Realm. I am not convinced of the desirability of choosing a single stage nomenclature (e.g. Tithonian-Berriasian) and applying this universally. The chronostratigraphical stages are and will continue to be recognised and applied through the use of a series of biostratigraphic zones. If a proposed universal stage name cannot be applied accurately outside its realm of origin it has

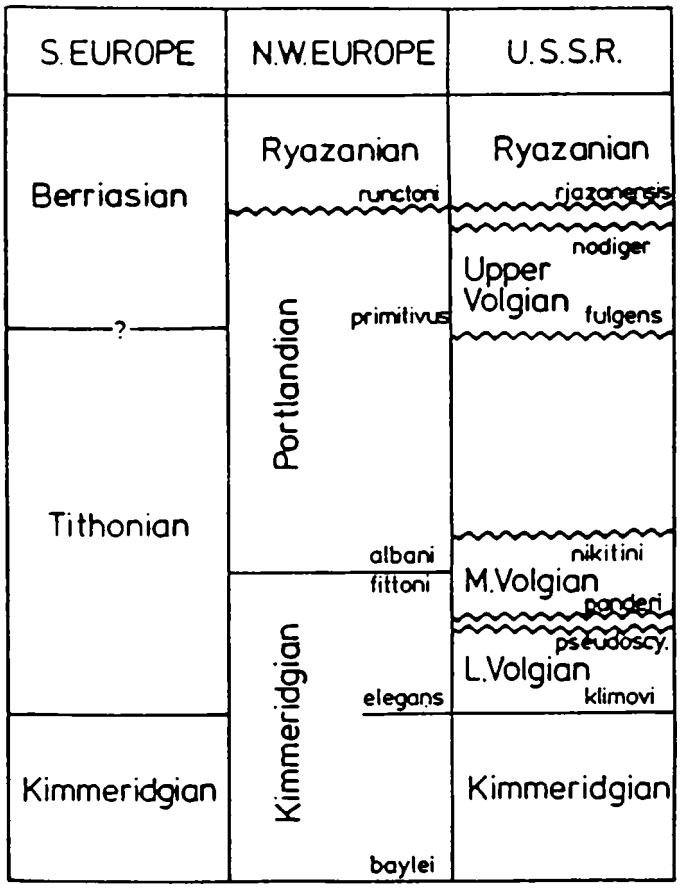

Figure 4. Comparative stage nomenclature across the Jurassic - Cretaceous boundary.

little practical use. One certainly cannot define a stage using the constituent zones of another stage in another realm (see for example Zeiss 1983 fig.1) The immediate problems facing us are problems of accurate correlation within Realms. I propose adoption of a dual system of stage nomenclature in the Tethyan and Boreal Realms, Tithonian-Kimmeridgian and Portlandian-Kimmeridgian (sensu anglico) respectively, the upper limits of both Portlandian and Tithonian to be set when a decision is made on the placing of the base of the Berriasian Stage.

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CONTRIBUTIONS TO THE BIOSTRATIGRAPHY OF THE JURASSIC SYSTEM IN ETHIOPIA

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CONTRIBUTIONS TO THE BIOSTRATIGRAPHY OF THE JURASSIC SYSTEM IN ETHIOPIA

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A survey is given over the composition and vertical distribution of new large fossil collections from Ethiopia. The biostratigraphic subdivision is discussed and a local zonal scheme proposed. The age of the ammonites reaches from Callovian to Tithonian, the faunas contain stephanoceratids, perisphinctids,aspidoceratids and oppeliids. The horizontal and vertical differences in the composition of the fauna are explained by different positions of the sections in the sedimentary basin and by different waves of immigration during Upper Jurassic time.

1. INTRODUCTION

Since the last decade of the 19th century ammonites of the Jurassic and Cretaceous beds of Ethiopia have been recorded by various authors, like Dacqué (1905, 1914), Basse (1930), Scott (1943),Tavani (1948), Valduga (1954), Venzo (1959) and Jordan (1971). Remarks on the occurence of these fossils are mostly given in a rather general form. Of course many questions about the detailed stratigraphy as well as the exact correlation with other sections remained open. Other problems concerning ecology and zoogeography were still in need of precise elucidation; these problems are in many respects connected with the mesozoic paleogeography of eastern Africa and therefore their clearing up seems to be of general interest. - Also the ammonite specialist is confronted with difficult taxonomic and phylogenetic problems, especially when comparing the Ethiopian fauna with the contemporaneous faunas of East Africa, Madagascar, Arabia, Europe, India and Mexico.

The aim of this paper is to report on new large collections carried out about 25 years ago by members of the Elwerath Oil Company, especially Dr. M. Mayr and Dr. H. Hörauf during their field work in Ethiopia.
These collections offered an outstanding possibility to clear up the above mentioned problems since the larger part of the ammonites had been collected bed by bed from well-described sections.

After a first inspection of the material the author published a preliminary report, which presented mainly the results of comparisons between the Ammonite Faunes of Southern Germany and Ethiopia, as far as were concerned the jurassic Ammonites. That paper intended a new approach to the biostratigraphy, ecology and zoogeography of the Ethiopian Jurassic Ammonite Fauna (cf. Zeiss 1971).
Since that time the author tried to study these ammonites of Ethiopia in more details as well as the already published ones and to compare them with various important originals from other countries in order to clear up the taxionomic and phylogenetic position of the Ethiopian Ammonites. At

the present time not yet all problems connected with these researches have been solved. Therefore this paper is an interim report providing more datas on the detailed stratigraphy and distribution of ammonites under study. The ammonites of the Callovian have been already published in 1974, the representatives of the genus Sutneria in 1979, the biostratigraphy and zoogeography of the Aptian ammonites in 1975. Some notes on the dimorphism of Katroliceras were reported already in 1969. This paper was planned to be published within the volume of the Microplaeontological congress in Addis Ababa 1973, but this could be realized at that time only as abstract (Zeiss 1975).

2. ACKNOWLEDGEMENTS

The author's thanks are due to Dr. A. Roll, former Director of the Elwerath Oil Company, for his kindness to offer this valuable material for the scientific study and to present the collection to the Institute of Paleontology of the University of Erlangen as well as for his allowance to publish the results of the researches. The author is also obliged to many collegues who kindly assisted him with the loan of published and unpublished ammonites from Ethiopia, the supply of plaster casts, photographies, informations, rare literature and the allowance to study ammonites in their collections, especially to the late General M.Collignon; Prof. Azzaroli, Dr. D. Torre, Firenze; Dr. R.W. Imlay, Washington, D.C.; Dr. G. Schairer, München and Dr. H. Jaeger, Berlin.

3. CONTRIBUTION TO THE JURASSIC BIOSTRATIGRAPHY OF ETHIOPIA

3.1. Preliminary remarks

All sections, from which Jurassic ammonites have been collected bed-by-bed, belong to a larger region, which is situated about 300 km east and southeast of Addis Ababa, extending from the surroundings of the city of Harar in the North to that of Gabredarre in the South over a distance of about 300 km and expanding in W-E direction over 150 km. The northern area

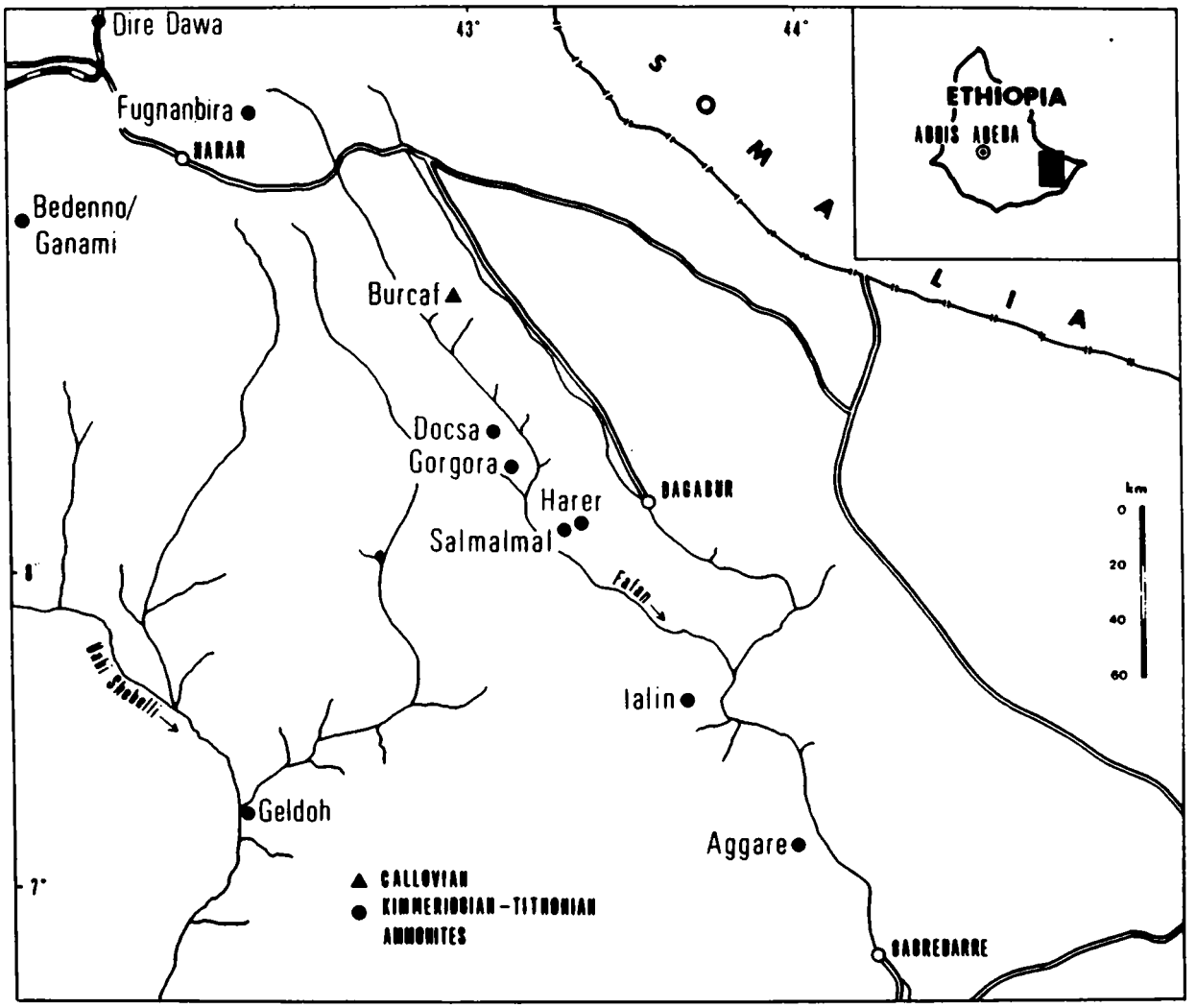

Fig. 1 Localities in SE Ethiopia, where the Elwerath Oil Company collected Jurassic Ammonites.

is part of the "Harar Tablelands" ("altipiani Hararini"), the middle and southern part of the "Ogaden district", see fig. 1. Only one ammonite came from the Blue Nil Valley (NW of Addis Ababa) and seems to be the first ammonite from this region. All localities have been incorporated in a map (fig.1).

It is not the purpose of this paper to report on the lithostratigraphy of the sections. Only for a short information it is here explained that the Hamanlei formation in the sections Dire Dawa and Ialin consists of dark limestones, while in Condudo/Fugnanbira a light coloured calcareous arenite prevails, and in section Bedenno/Ganami a somewhat marly limestone.

The names of the lithostratigraphic units are those applied by the Elwerath Oil Company and they have already been used in a paper of Valduga (1954); these units are considered to be the equivalents of the Antalo Limestone Facies of Northern Ethiopia by Beauchamp (1977, p.336). Further details of the lithostratigraphy and facies can be taken from the paper of Mohr (1971).

3.2. Callovian, Lower and Middle Oxfordian

In the section of Burcaf (SE of Harar) a Pachyerymnoceras has been found rather closely related to P. jarryi as described by Arkell (1954) and figured by Imlay (1970, fig. 1-2) from Jebel Tuwaiq, Central Arabia. Arkell (1954) dated this fauna as Middle Callovian. This may be questioned, as the European Pachyerymnoceras (cf. Douvillé 1912) have been described from the Lamberti-Zone, see also Levy (1983). Also Spath (1928) mentioned a similar form from the Athleta-Lamberti-Zone of Kachh. A second specimen belonging to the same species complex is very close to one of Douvillé paratypes (1912, pl.1, fig.4), it has been found in the Southern Ogaden (Coll. Firenze). These three ammonites apparently indicate an Upper Callovian age; for more details see Zeiss (1974). - In the new collections no ammonites referable to the Lower and Middle Oxfordian have been found.

3.3. Upper Oxfordian, Kimmeridgian and Tithonian

Ammonites of this age constitute the main part of the collections. The sections from where they came are delineated in fig. 2. Sections Condudo, Dire Dawa and Bedenno are situated in the region of Harar, section Docsa, Salmalmal and Gorgora and Harer in the Northern Ogaden, sections Ialin, Geldoh and Aggare in the southern Ogaden district.

In the following record the ammonites from these sections are enumerated with the original numbers of the beds, from which they have been collected.

3.4. The sections and their faunas (see fig.1 and 2, too)

3.4.1. Region of Harar

The sections Condudo/Fugnanbira, Bedenno/Ganami and Dire Dawa are situated in that part of Ethiopia, where the jurassic beds have been paleontologically investigated more thoroughly than in other regions. The results of these earlier researches have been published by Basse (1930), Scott (1943) and Venzo (1959). Farther to the southwest there are the classic localities, from where E. Dacqué described and figured first time jurassic Ammonites from Ethiopia (1905, 1914). All these localities contain prevailing Ammonites of the Lower Kimmeridgian, besides some Upper Oxfordian and Middle Kimmeridgian specimens. Only the locality Burcaf delivered an ammonite of Middle Jurassic age (Upper Callovian), which has already been described by the author in 1974.
Section Condudo/Fugnangbira is situated 20 km NW of Harar, approximately, section Bedenno/Ganami some 60 km WSW of Harar, and section Dire Dawa about 55 km NW of Harar.

3.4.1.1. Section Dire Dawa

Nr. 1220

Orthosphinctes africanus (E. Dacqué)
Orthosphinctes jabolii (S. Venzo)
Discosphinctoides praenuntians (F. Fontannes)
Progeronia spathi (G. Scott)

Fig. 2

Correlation of Upper Jurassic sections from Ethiopia by ammonites

Fig. 2

Subdichotomoceras aff. lacertosum (F. Fontannes)
Crussoliceras sp.
Idoceras aff. balderum (A. Oppel)
Aspidoceras gregoryi L.F. Spath
Aspidoceras lallierianum (A. d'Orbigny)
Aspidoceras liparum (A. Oppel)
Aspidoceras orthocera (A. d'Orbigny)
Aspidoceras subdoguense S. Venzo
Glabrophysodoceras abyssianum G. Scott
Simaspidoceras argobbae (E. Dacqué)
Simaspidoceras hararense G. Scott
Simaspidoceras irregulare (E. Dacqué)
Belemnopsis tanganensis (K. Futterer)

Nr. 1211

Paracenoceras ennianum (E. Dacqué)

The cephalopod fauna from the locality Dire Dawa has delivered five species hitherto unknown from Ethiopia: Aspidoceras lallierianum, A. orthocera, Discosphinctoides praenuntians, Subdichotomoceras aff.lacertosum and Crussoliceras sp.indet.; the other fourteen species have been figured and described already by Dacqué (1905), Basse (1930), Scott (1943), Venzo (1959), and Stevens (1963).
One of the most interesting forms from Dire Dawa is Idoceras aff. balderum, which resembles very much a form described from the Ogaden by Valduga (1954) as "Idoceras cfr.balderum" on the one hand, and on the other an ammonite introduced as a new species by Scott (1943) as "Ringsteadia daua". A restudy of the types of Scott resulted in that the so-called 'Ringsteadia'-species of Scott are belonging to Idoceras, and that 'R.daua' is closer to I.balderum, 'R.africana' to I.hararinum. The specimen from Dire Dawa is somewhat intermediate between the 'species' of Scott and maybe, all these forms belong to one highly variable species. A full restudy of all Idoceras of Ethiopia will be given elsewhere. It is now evident that the 'Ringsteadia' species of Scott cannot prove an Upper Oxfordian age, but belong into the Lower Kimmeridgian. Idoceras aff.balderum and "R.daua", as well as I.cf.

balderum are closest to the group of the narrow-umbilicated I.balderum of Ziegler (1959, p.25, pl.1 fig.3) from the upper part of the Lower Kimmeridgian of Southern Germany.
Other species characteristic of the Lower Kimmeridgian are Orthosphinctes jabolii, Simaspidoceras argobbae, S.harrarense, S.irregulare and Aspidoceras subdoguense (see also Venzo 1959). - Also Curssoliceras has been found only in the upper part of the Lower Kimmeridgian in the submediterranean province of Europe, and the reference specimen of D.praenuntians has also been found in the lower part of the Lower Kimmeridgian (cf. O.F. Geyer, 1961, pl.2 fig.2), while the vertical range of this species comprises the whole Kimmeridgian, with the main occurence in the middle Kimmeridgian. The exact range of S.lacertosum (Fontannes) within the Lower Kimmeridgian is not known.
Judging after bed-by-bed collecting in Southern Germany the following species are represented prevailing in the Middle Kimmeridgian: Aspidoceras lallierianum, A.liparum and A.orthocera.
Due to Scott (1943) Glabrophysodoceras abyssianum and Gl.ganamense, as well as Aspidoceras gregoryi would occur in beds of Lower Kimmeridgian and Upper Oxfordian age, while Lithacosphinctes spathi and L.vokesi would be restricted to those of Upper Oxfordian age. It is not quite evident, on what these age determinations are based. As already the explanations on "Ringsteadia" daua and africana have shown, a revision of Scott's paper is necessary; and probably most of his material has an Lower Kimmeridgian age. - Orthosphinctes africanus was first mentioned from Upper Oxfordian (Dacqué 1910) but the reference form for our specimen was described from the Lower Kimmeridgian (Venzo 1959).
As this analysis of the ammonite fauna from bed 1220 of the Dire Dawa section demonstrates that elements of the Lower Kimmeridgian are prevailing. There are also some middle Kimmeridgian forms. Thus one can suppose that the limit Middle/Upper Kimmeridgian is within the collected range. This is also indicated by some species, which are significant

for the upper part of the Lower Kimmeridgian, like I.aff. balderum. None of the ammonites seems to be characteristic for the Upper Oxfordian.
Belemnopsis tanganensis has a long vertical range (Stevens 1963), reaching from Upper Oxfordian to Middle Kimmeridgian, and not much is known about the vertical range of the endemic P.ennianum.

3.4.1.2. Section Condudo/Fugnanbira

Nr. C

Orthosphinctes jabolii (S. Venzo)
Orthosphinctes tiziani (A. Oppel)
Progeronia pseudolictor (P. Choffat)
Progeronia(?) familiaris multicostata (F. Toula)
Lithacosphinctes cf. vokesi (G. Scott)
Torquatisphinctes similis L.F. Spath
Idoceras hararinum S. Venzo
Aspidoceras binodum (F.A. Quenstedt)
Simaspidoceras irregulare (E. Dacqué)
Aspidoceras aff. supraspinosum E. Dacqué

The following species of this fauna are characteristic for the Lower Kimmeridgian: Idoceras hararinum, Aspidoceras binodum, Simaspidoceras irregulare and Orthosphinctes jabolii. Progeronia pseudolictor is mentioned from the Lower and Middle Kimmeridgian, but the reference specimen for the determination comes from the Lower Kimmeridgian. The age indication for the species Aspidoceras supraspinosum, Torquatisphinctes similis and Progeronia(?)familiaris multicostata has been given in the literature only as 'Kimmeridgian'. Finally two species have been reported from both Upper Oxfordian and Lower Kimmeridgian, Orthosphinctes tiziani and Lithacosphinctes cf.vokesi.

Summarizing all this it can be ascertained rather well that the main part of the more important ammonite species of the locality Condudo/Fugnanbira indicates a Lower Kimmeridgian age. As the rest of the species occurs at least also during

this time, or can be assumed to occur with high probability at least, the Lower Kimmeridgian age of this fauna seems to be rather well established.

3.4.1.3. Section Bedenno/Ganami

Nr. 459 (Bedenno):

Progeronia pseudolictor (P. Choffat)
Epaspidoceras n.sp., cf. bodeni (Wegele)

Nr. 460-462 (Bedenno):

Lithacosphinctes aff. vokesi (G. Scott)
Idoceras aff. dedalum (G. Gemmellaro)
Torquatisphinctes linguiformis (L.F. Spath)
Simaspidoceras argobbae (E. Dacqué)

Samples, collected not in place, but corresponding to the parts defined by Nr. 459-462 in Bedenno section:

Nr. 475-477(Ganami):

Idoceras hararinum S. Venzo
Idoceras aff. balderum (A. Oppel)
Orthosphinctes fontannesi (P. Choffat)
Simaspidoceras aff. argobbae (E. Dacqué)

Nr. 480-484 (Bedenno):

Idoceras sautieri (F. Fontannes)
Simaspidoceras argobbae (E. Dacqué)
Orthosphinctes cf. mombassanus (E. Dacqué)
Lithacosphinctes vokesi (G. Scott)
Progeronia (?) aff. plebeja (M. Neumayr)
Glabrophysodoceras n.sp. (giant form)

The Lower Kimmeridgian aspect of this fauna is similar to that of Dire Dawa and Condudo. The Middle Kimmeridgian and Upper Oxfordian elements are only a few and not very significant. The Lower Kimmeridgian age is proved by Idoceras aff. balderum, I.hararinum, I. aff. dedalum, and Simaspidoceras argobbae. I. sautieri has been found in beds with Streblites

tenuilobatus from Mexico and the Crussol mountain, while in Southern Germany this species has been stated in Middle Kimmeridgian beds. For Ethiopia the distribution of the mediterranean area seems more probably. A similar difference exists between the form of I. aff. dedalum comparable to the Ethiopian specimen, which has been reported as Lower Kimmeridgian of Mexico, whereas the holotype shall come from the Acanthicus Beds of Sicily and could therefore be also of middle Kimmeridgian age (Ziegler 1959). Nevertheless after Arkell (1956, S. 204) this species is of a special value for the correlation of lower Kimmeridgian layers.
Within the perisphinctid species Progeronia pseudolictor (Choffat) is a good guide-fossil for the Lower Kimmeridgian (see Lopez Marques 1983), also the reference form for Orthosphinctes mombassanus came from beds of the same age (Venzo 1959). Too, the other Perisphinctids occur in the Lower Kimmeridgian, but have reported partly also from the Upper Oxfordian and Middle Kimmeridgian.
The new species of aspidoceratids cannot much contribute to the age determination, but don't contradict a Lower Kimmeridgian age. Thus, all in all a Lower Kimmeridgian age for the fauna collected from sections Bedenno/Ganami is well documented.

3.4.2. Northern Ogaden district (region of Dagabur)

All sections lay in a circuit of 50 km west of the locality Dagabur. We begin with the most northern situated section and continue to the south (see fig. 1 and 2).

3.4.2.1. Section Docsa

Nr. 1151:

Progeronia cf. valens (F. Toula)
Orthosphinctes cf. abadiensis (P. Choffat)
Pachysphinctes aff. granti L.F. Spath
Aspidoceras evolutum G. Scott
Aspidoceras aff. evolutum G. Scott

3.4.2.2. Section Gorgora

Nr. 1134:

Progeronia ernesti (P. de Loriol)
Progeronia lictor (F. Fontannes)

Nr. 1138:

Progeronia anabreviceps (E. Dacqué)
Aspidoceras orthocera (A. d'Orbigny)

Nr. 1148:

Aspidoceratid, gen. et sp.n.
Katroliceras n.sp., cf. insigne (F. Toula)

Nr. 1150:

Katroliceras cf. lerense (L.F. Spath)

Nr. 1140:

Aspidoceras binodiferum W. Waagen
Aspidoceratid, gen. et sp.n.

3.4.2.3. Section Harer

Nr. 1112:

Belemnopsis tanganensis (K. Futterer)
Belemnopsis macfadyeni L.F. Spath
Conodicoelites sp.n.
Dicoelites stefaninii L.F. Spath
Dicoelites sp.n.
Hibolites cf. semisulcatus (G. zu Münster)

Nr. 1108:

Katroliceras aff. somalicum (A. Valduga)
Katroliceras sp., cf. waageni L.F. Spath
Katroliceras aff. somalicum A. Valduga
Aspidoceras haynaldi tuberculatum M. Collignon
Aspidoceras sp., cf. wynnei W. Waagen
Aspidoceras aff. melchioris L.F. Spath
Hybonoticeras kachhense (L.F. Spath)
Hybonoticeras aff. kachhense (L.F. Spath)

Hybonoticeras sp.n., aff. beckeri (M. Neumayr)
Lithacoceras cf. fructicans (Th. Schneid)
Pachysphinctes major L.F. Spath
Torquatisphinctes primus L.F. Spath

Nr. 1106 and 1106/a:

Katroliceras aff. acer (M. Neumayr)
Katroliceras sp., cf. acer (M. Neumayr)
Katroliceras cf. katrolense (W. Waagen)
Katroliceras aff. pottingeri (J. de C. Sowerby)
Lithacoceras sp.n., cf. ptychodes (M. Neumayer)
Subplanites cf. rueppellianus (Th. Schneid)

Nr. 1107:

Subplanites scarsellai S. Venzo
Subplanites spathi S. Venzo
Laevaptychus hoplisus rugocinctus-taxoporus F. Trauth
Laevaptychus longus uhlandi A.Oppel
Laevaptychus latus (Parkinson)
Laevaptychus meneghinii rugosus F. Trauth
Laevaptychus latus uhlandi-serioporus F. Trauth
Laevaptychus latus uhlandi-taxoporus F. Trauth
Laevaptychus latissimus vermiporus F. Trauth
Aspidoceras sp., cf. wynnei W. Waagen

3.4.2.4. Section Salmalmal

Nr. Hf. 33:

Simaspidoceras garibaldii (G. Gemmellaro)

Nr. 1104:

Katroliceras somalicum A. Valduga
Hybonoticeras n.sp., aff. beckeri (M. Neumayr)
Sutneria aff. hararinum S. Venzo
Sutneria aff. subeumela (Th. Schneid)
Orthosphinctes anabreviceps (E. Dacqué)
Lithacoceras aff. tantalus (F. Herbich)
Progeronia mombassana (E. Dacqué)
Progeronia (?) cf. metamorpha (M. Neumayr)

Laevaptychus cf. favrei F. Trauth
Lithacoceras sp., cf. haliarchus (M. Neumayr)

Nr. 1105:

Katroliceras somalicum A. Valduga
Katroliceras cf. acer (M. Neumayr)
Katroliceras aff. pottingeri (J. de C. Sowerby)
Lithacoceras dacquéi (E. Basse)
Lithacoceras cf. dacquéi (E. Basse)
Lithacoceras sp., cf. riedense (Th. Schneid)
Lithacoceras sp. n., aff. dacquéi (E. Basse)
Subplanites scarsellai S. Venzo
Torquatisphinctes auritus (L.F. Spath)
Aspidoceras cf. bispinosum (F.A. Quenstedt)

In the section Salmalmal only one ammonite is indicating a Middle Kimmeridgian age, Simaspidoceras garibaldii (Hf. 33). This form corresponds well with another specimen of this species from the southern Ogaden (section Geldoh, bed 407/8), where the species has been found together with ammonites of Middle Kimmeridgian age. From both the proper fossil beds of section Salmalmal the lower one (1104) yielded ammonites very close to the characteristic guide fossils of the mid-european zone of H. beckeri, par example S. aff. subeumela, S. aff. hararina (related to S. pedinopleura of the lower Beckeri-zone) and H. n.sp., aff. beckeri. - They are accompanied by K. somalicum, which occurs in this horizon first time, analogously to Southern Germany, where the first true Katroliceras also appear in the Upper Kimmeridgian. Of the other forms the Progeronia species have been described originally from the acanthicus beds, which in earlier times were considered to comprise the whole time span from the Tenuilobatus to the Beckeri-zone (e.g. M Neumayr 1873). O. anabreviceps and P. mombassana, in general more common in Upper Oxfordian and Lower Kimmeridgian beds are considered to be late-comers in this bed. Thus the fauna of bed 1104 documents well the equivalents of the Hybonoticeras beckeri zone of Europe and mainly the lower parts of this zone.

The upper fossil bed (1105) contains no more Hybonoticeras and Sutneria at all. Instead of them large Katroliceras of the pottingeri/acer group and Lithacoceras are remarkable, K. somalicum and L. dacquéi are numerous. This assemblage seems to be characteristic for the basal beds of the Lower Tithonian of Ethiopia.

The belemnite bed 1112 of section Harer seems to be of the same age as that of section Geldoh 421 in the southern Ogaden, or an age a little younger than this bed; this can be derived from the phylogenetic development of the belemnites (bed 1112), which are somewhat more progressive. All in all a Middle Kimmeridgian age fits well; this bed corresponds therefore probably to bed 1150 of Gorgora section. Beds of an Upper Kimmeridgian age are proved by numerous Hybonoticeras of the beckeri/kachhense group (1108/9); other characteristic fauna elements are L. cf. fructicans K. aff. somalicum and A. haynaldi tuberculatum which have a little larger vertical range. The Lower Tithonian is indicated by the large Lithacoceras and Katroliceras of bed 1106. Compared with the phylogenetic development of the contemporaneous Perisphinctids of the southern German Jurassic one may be convinced that these representatives of a rather large size belong into the middle part of the lower Lower Tithonian. Thus, this fauna would be younger than that of bed Salmalmal 1105 with forms of a smaller size. On the other hand there is a certain possibility that the size differences could be caused by sexual dimorphism: large ammonites of 1106 could correspond with smaller ones of 1105 on behave of sexual dimorphism; therefore it cannot be excluded totally that the two beds have the same age. Further investigations are necessary. The presence of a Subplanites of the rueppelianus group favours more the first interpretation. A very significant assemblage contains bed 1107 with its Subplanites of the scarsellai group and Laevaptychi (higher part of the lower Lower Tithonian). It is remarkable that there are no H. hybonotum specimens in these beds. Specimens described under this name by Valduga (1954) don't belong to this species.- Section Gorgora delivered from bed 1134 and 1138, and probably also from bed 1148

Laevaptychus cf. favrei F. Trauth
Lithacoceras sp., cf. haliarchus (M. Neumayr)

Nr. 1105:

Katroliceras somalicum A. Valduga
Katroliceras cf. acer (M. Neumayr)
Katroliceras aff. pottingeri (J. de C. Sowerby)
Lithacoceras dacquéi (E. Basse)
Lithacoceras cf. dacquéi (E. Basse)
Lithacoceras sp., cf. riedense (Th. Schneid)
Lithacoceras sp. n., aff. dacquéi (E. Basse)
Subplanites scarsellai S. Venzo
Torquatisphinctes auritus (L.F. Spath)
Aspidoceras cf. bispinosum (F.A. Quenstedt)

In the section Salmalmal only one ammonite is indicating a Middle Kimmeridgian age, Simaspidoceras garibaldii (Hf. 33). This form corresponds well with another specimen of this species from the southern Ogaden (section Geldoh, bed 407/8), where the species has been found together with ammonites of Middle Kimmeridgian age. From both the proper fossil beds of section Salmalmal the lower one (1104) yielded ammonites very close to the characteristic guide fossils of the mid-european zone of H. beckeri, par example S. aff. subeumela, S. aff. hararina (related to S. pedinopleura of the lower Beckeri-zone) and H. n.sp., aff. beckeri. - They are accompanied by K. somalicum, which occurs in this horizon first time, analogously to Southern Germany, where the first true Katroliceras also appear in the Upper Kimmeridgian. Of the other forms the Progeronia species have been described originally from the acanthicus beds, which in earlier times were considered to comprise the whole time span from the Tenuilobatus to the Beckeri-zone (e.g. M Neumayr 1873). O. anabreviceps and P. mombassana, in general more common in Upper Oxfordian and Lower Kimmeridgian beds are considered to be late-comers in this bed. Thus the fauna of bed 1104 documents well the equivalents of the Hybonoticeras beckeri zone of Europe and mainly the lower parts of this zone.

The upper fossil bed (1105) contains no more Hybonoticeras and Sutneria at all. Instead of them large Katroliceras of the pottingeri/acer group and Lithacoceras are remarkable, K. somalicum and L. dacquéi are numerous. This assemblage seems to be characteristic for the basal beds of the Lower Tithonian of Ethiopia.

The belemnite bed 1112 of section Harer seems to be of the same age as that of section Geldoh 421 in the southern Ogaden, or an age a little younger than this bed; this can be derived from the phylogenetic development of the belemnites (bed 1112), which are somewhat more progressive. All in all a Middle Kimmeridgian age fits well; this bed corresponds therefore probably to bed 1150 of Gorgora section. Beds of an Upper Kimmeridgian age are proved by numerous Hybonoticeras of the beckeri/kachhense group (1108/9); other characteristic fauna elements are L. cf. fructicans K. aff. somalicum and A. haynaldi tuberculatum which have a little larger vertical range. The Lower Tithonian is indicated by the large Lithacoceras and Katroliceras of bed 1106. Compared with the phylogenetic development of the contemporaneous Perisphinctids of the southern German Jurassic one may be convinced that these representatives of a rather large size belong into the middle part of the lower Lower Tithonian. Thus, this fauna would be younger than that of bed Salmalmal 1105 with forms of a smaller size. On the other hand there is a certain possibility that the size differences could be caused by sexual dimorphism: large ammonites of 1106 could correspond with smaller ones of 1105 on behave of sexual dimorphism; therefore it cannot be excluded totally that the two beds have the same age. Further investigations are necessary. The presence of a Subplanites of the rueppelianus group favours more the first interpretation. A very significant assemblage contains bed 1107 with its Subplanites of the scarsellai group and Laevaptychi (higher part of the lower Lower Tithonian). It is remarkable that there are no H. hybonotum specimens in these beds. Specimens described under this name by Valduga (1954) don't belong to this species.- Section Gorgora delivered from bed 1134 and 1138, and probably also from bed 1148

ammonites of Middle Kimmeridgian age. There are no proofs of the Upper Kimmeridgian, but Lower Tithonian is represented (1150 and 1140) by the large Katroliceras cf. lerense and Aspidoceras binodiferum.- Section Docsa delivered no good guide fossils. But all ammonites from bed 1151 are reported from beds of "Kimmeridgian" age, at least, and in the general habitus the forms found are referable to the Middle Kimmeridgian. Aspidoceras evolutum assumed by Scott (1940) to be derived from Oxfordian beds, seems to belong to the acanthicum/longispinum group of Lower and Middle Kimmeridgian age.

3.4.3. Southern Ogaden district

The sections to be mentioned below lie in the region of approximately 100 km north and 200 km west of Gadredarre (see fig.1).

3.4.3.1. Section Geldoh

Nr. 421:

Sutneria cf. lorioli Zeiss
Belemnopsis macfadyeni L.F. Spath
Belemnopsis tanganensis (K. Futterer)
Conodicoelites sp. n.
Dicoelites stefaninii L.F. Spath

Nr. 412:

Torquatisphinctes jurunensis L.F. Spath

Nr. 408:

Simaspidoceras garibaldii (G. Gemmellaro)

Nr. 407:

Progeronia aff. anabreviceps (E.Dacqué)
Orthosphinctes ciryi M. Collignon
Simaspidoceras garibaldii (G. Gemmellaro)
Modiolus imbricatus J. Sowerby

Nr. 406:

Torquatisphinctes alterneplicatus (W. Waagen)

Nr. 400:

Torquatisphinctes aff. alterneplicatus (W. Waagen)

Nr. 398:

Aspidoceras bertucati M. Collignon
Aspidoceras bispinosum (C. v. Zieten)
Aspidoceras microplum (A. Oppel)
Aspidoceras sesquinodosum (F. Fontannes)
Aspidoceras aff. tuberculatum M. Collignon

Nr. 397:

Aspidoceras bispinosum (C. v. Zieten)
Aspidoceras caletanum (A. Oppel)
Aspidoceras aff. caletanum (A. Oppel)

Nr. 427 and 429 (corresponding to Nr. 397, not in place):

Aspidoceras sp.n. aff. bispinosum (C. v. Zieten)
Aspidoceras gortanii S. Venzo
Aspidoceras microplum (A. Oppel)
Aspidoceras mombasense (L.F. Spath)
Taramelliceras pseudoflexuosum (E. Favre)
Taramelliceras aff. greenackeri (C. Moesch)
Taramelliceras cf. transitorium L.F. Spath

Nr. 378:

Aspidoceras cf. siliceum (F.A. Quenstedt)
Pachysphinctes linguiferus (L.F. Spath)

Nr. 377:

Subplanites cf. indosphinctoides L.F. Spath

Nr. 374:

Hybonoticeras sp.n., aff. kachhense L.F. Spath
Pachchysphinctes aff. granti L.F. Spath
Lithacoceras aff. dacquéi (E. Basse)
Torquatisphinctes aff. modestus (Th. Schneid)

Nr. 370:

Lithacoceras fructicans (Th. Schneid)
Pachysphinctes sp.n., aff. crassus L.F. Spath

Nr. 364:

Torquatisphinctes sp.n., aff. beyrichi (K. Futterer)

3.4.3.2. Section Ialin

Nr. 1210:

Progeronia (?) sp., cf. doguensis (G. Scott)

Nr. 1180:

Aspidoceras aff. wynnei W. Waagen

Nr. 1179:

Lithacoceras dacquéi (E. Basse)
Subplanites scarsellai S. Venzo
Taramelliceras cf. gaetanoi (F. Fontannes)

3.4.3.3. Section Aggare

Nr. 178:

Orthosphinctes (?) aff. aequalis (L.F. Spath)
Orthosphinctes aff. mackinnon-woodi (L.F. Spath)
Parallelodon egertonianus (Stoliczka)

Nr. 174:

Taramelliceras aff. intersistens H. Hölder
Aspidoceras aff. kilindianum E. Dacqué
Parallelodon egertonianus (Stoliczka)
Parallelodon aff. egertonianus (Stoliczka)

Nr. 172:

Discosphinctes choffati M. Collignon
Torquatisphinctes cf. alterneplicatus (W. Waagen)
Torquatisphinctes cf. subdolus (F. Fontannes)

Nr. 169:

Aspidoceras cf. bispinosum (C. v. Zieten)
Aspidoceras haynaldi (F. Herbich)
Discosphinctoides stenocyclus (F. Fontannes)
Sutneria hoelderi Zeiss
Taramelliceras aff. greenackeri (C. Moesch)

Taramelliceras klettgovianum modeli H. Hölder
Taramelliceras cf. pseudoflexuosum (E. Favre)

Nr. 156:

Neochetoceras sp.n., aff. steraspis (A. Oppel)
Taramelliceras prolithographicum (F. Fontannes)

The lowermost fossil bed of section Aggare belongs to the Lower Kimmeridgian, as dated by the two species of Orthosphinctes. The boundary to the Middle Kimmeridgian must lie between bed 178 and 174, as the latter contains T. intersistens, a species characteristic in Southern Germany already for the upper part of the Middle Kimmeridgian. Species indicating a Middle Kimmeridgian age (e.g. Discosphinctes choffati, Asp. cf. bispinosum, Asp. haynaldi, S. hoelderi, T. aff. greenackeri, T. klettgovianum modeli) reach from bed 174 until bed 169. No Upper Kimmeridgian has been proved in this section. The boundary Kimmeridgian/Tithonian can be traced beween bed 169 and 156, the latter yielding typical species (N. sp.n., aff. sterapsis, T. prolithographicum) of Lower Tithonian age (equivalents of the middle and upper part of the zone of Hybonoticeras hybonotum of Southern Germany).-The ammonites found in section Geldoh begin in beds of Middle Kimmeridgian age. Bed 421 belongs to the upper part as suggested by S. cf. Iorioli. The overlying fossil beds contain also ammonites indicating the upper part of the Middle Kimmeridgian (Aspidoceras bispinosum, A. caletanum, A. freneixae, Orthoshinctes ciryi, Taramelliceras aff. greenackeri); the boundary to the Upper Kimmeridgian has to be supposed beween bed 397 and 378. Bed 378 with the first Upper Kimmeridgian ammonites is followed by bed 374 with Hybonoticeras aff. kachhense, which has been also found in section Harer together with H. sp.n., aff. beckeri, a specimen that occurs in section Salmalmal together with S. aff. subeumela, thus well demonstrating an Upper Kimmeridgian age. Above of this horizon follows bed 370 with a faunal assemblage, which belongs with very high probability into the Lower Tithonian: the holotype of L.fructicans comes from the lower part of the Hybonotum Zone of Southern Germany. Also the reference specimens of T.sp.n.,

aff. beyrichi from bed 364 were found by Venzo (1959) in Lower Tithonian beds near Gocti. P.n.sp., aff. crassus is considered to be a younger phylogenetic form also indicating the lower Hybonotum Zone. The specimens of bed 364 are new forms, which were first described by Venzo (1959) under the name 'Subplanites cfr. viperinus' from the Lower Tithonian beds of Gocti, but have nothing to do with that species of mid-Tithonian age.-There are only a few ammonites collected in the section Ialin. The lower fossil bed (1210) delivered a very badly-preserved ammonite which can be allocated into the Lower Kimmeridgian, while the upper fossil beds (1179/1180) indicate a Lower Tithonian age by the ammonites found there.

3.5. Conclusions

Summarizing the results above discussed a provisional zonal scheme for the Ethiopian Jurassic has been proposed. Due to the particularities of the Ethiopian Jurassic faunal elements (cf. Zeiss 1971) it seemed preferable to use specific index fossils for this region. Of course, if further collections yield more specimens of index fossils already known from other jurassic provinces it will be possible to use such ones.

3.5.1. Upper Callovian

Two ammonites collected from beds of this age belong to the genus Pachyerymnoceras. The next related forms are known from the lamberti-/athleta zone of France and India. Arkell (1954) puts a similar faunal assemblage from Central Arabia in the Middle Callovian, the reason for doing so was obviously the argument that the jarryi group belongs to the Middle Callovian genus Erymnoceras, neglecting the fact that the type specimen of the group had been described from the lamberti zone. Later-on (Imlay 1970) published also ammonites of this age from Central Arabia but he correctly replaced E. jarryi to the genus Pachyerymnoceras. One would like to add that also the other species described by Arkell, E. philbyi, belongs to the same genus Pachyerymnoceras. Imlay also reported species of Rollierites and Erymnocerites, which were described originally

from the Coronatum and lower Athleta beds. Thus, it cannot be excluded completely that the lower parts of the Callovian fossil beds of Jebel Tuwaiq belong to the Middle Callovian, whereas the beds immediately situated below the Tuwaiq Mountain Limestone as well as those within this complex seem to contain only Upper Callovian forms. Studies of larger material could perhaps clear up the problem more precisely, which has been discussed elsewhere in more details (Zeiss 1974). For the present purpose it seems preferable to establish a zone of Pachyerymnoceras philbyi Arkell, representing the upper Callovian and perhaps to some degree the Middle Callovian of Ethiopia and the Arabian Peninsula and its neighbourhood. It is well caracterized by a Pachyceras and Pachyerymoceras assemblage. Other elements have been listed by Levy (1983, p.54). The third ammonite, a Pachyceras cf. lalandeanum (d'Orbigny), thus fits well in this time span.

3.5.2. Oxfordian

With the possible exception of some perisphinctids no ammonites indicating an Oxfordian age are in the new collection. A revision of the ammonites to be said to come from Oxfordian deposits by earlier authors is necessary and has been started. Up to its final completion no zonal subdivision can be proposed of course.

3.5.3. Lower Kimmeridgian

The Lower Kimmeridgian is characterized by Idoceratids (hararinum/balderum group), Perisphinctids (pseudolictor group), Aspidoceratids (Glabrophysodoceras, Physodoceras) and the peculiar Simaspidoceras (argobbae/-irregulare group). The latter genus seems to be the most characteristic faunal component (present in all new as well as in many of the older localities), and thus one of its species has been elected as local zonal index: S. argobbae. Apparently this group is a parallel development to the group of A. uhlandi, which may also belong to Simaspidoceras but has a more restricted time span

(only the upper part of the Lower Kimmeridgian).

While Idoceras balderum has been found in Ethiopia, the Crussoliceras are scarcely known. Nor any of the typical Lower Kimmeridgian Ataxioceratids or Sutneriids have been found, but the I. hararinum group could be representative for the middle and lower part of the Lower Kimmeridgian (cf. Zeiss 1971, p. 537). - The fossil beds of Dire Dawa and Condudo are apparently some meters thick, thus it can be supposed that faunal elements of the lower, middle and upper parts are now gathered together in one sample. Especially their mixture with Middle Kimmeridgian ammonites may be explained by this fact.

3.5.4. Middle Kimmeridgian

Middle Kimmeridgian ammonites are rather easy to identify with characteristic european species of this substage. With respect to the absence of the index fossils themselves, the Aulacostephanoceratids, some other indexes had to be chosen for the local zonal subdivision of the Middle Kimmeridgian substage in Ethiopia: Aspidoceras liparum for the lower part and Sutneria eumela for the upper part. Both species groups are common and characteristic Middle Kimmeridgian forms in Europe as well as in Ethiopia. The zone of S.eumela may be subdivided in a lower subzone, named after the indo-madagassian species T.alterneplicatus and in an upper subzone, named after the mid-european Aspidoceras bispinosum. The associated fauna shows closer relationship to the european forms than those of the Lower and Upper Kimmeridgian (see also Zeiss, 1971, tab.1)

3.5.5 Upper Kimmeridgian

The sections with Upper Kimmeridgian ammonites contain the typical Katroliceras species (not Crussoliceras!) of East Africa. The presence of species of Sutneria (hararinum/subeumela group) and Hybonoticeras (beckeri/kachhense group), certain Perisphinctids and Aspidoceratids prove the equivalents of the beckeri zone of the mid-/southern european and indian province. The kachhense group seems to represent the most characteristic

group and has therefore given preference as local zone index above other species.

3.5.6. Lower Tithonian

The Lower Tithonian ammonites are in part comparable to european species (like Lithacoceras fructicans, L.riedense, N.steraspis, T.lithographicum) or indian forms like Aspidoceras binodiferum. But Hybonoticeras of the hybonotum zone has not been found,nor Gravesia.
More numerous and characteristic are Sublanites (scarsellai and spathi group);the first of these forms has been elected therefore as index. Also Lithacoceras of the dacquéi group are well represented but appear already in the Upper Kimmeridgian. Other significant faunal elements are the big Katroliceras not having been described until hitherto. The Tithonian ammonites so far collected indicate only the presence of the lower zone of the Tithonian, that of H.hybonotum. There is no evidence for the presence of ammonites of the higher zones of the Tithonian stage (see Zeiss 1971, tab. 2) in Ethiopia until now, while the beds of this age may be represented by the upper part of the Gabredare formation (see fig.2).

4. SOME REMARKS ON THE PALEOZOOGEOGRAPHY

As already has been pointed out the Ethiopian ammonite fauna of the Jurassic shows some remarkable differences with respect to their composition in time and area (Zeiss 1971). In the region of Harar in the North we find an assemblage of Perisphinctidae (mainly Lithacoceratinae, 59 %, and Idoceratinae, 12,70 %) and Aspidoceratidae (Aspidoceratinae, 29 %); proceeding southward the northern Ogaden delivered Perisphinctidae (Lithacoceratinae, 60 %, Sutneriinae, 5 %), Aspidoceratidae (Aspidoceratinae, 22 %, Hybonoticeratinae, 9 %) and Oppeliidae (Taramelliceratinae and Streblitinae, 2 %). Going still farther to the south the number of Perisphinctids is reduced in the southern Ogaden to 36 %, Lithacoceratinae, Katroliceratinae and Sutneriinae have still 4 %, Aspidoceratinae increase to

38 %, Oppeliids to 20 % and Hybonoticeras is also reduced to 2 %.

Alltogether the most important facts are: From north to south we observe an reduction in the number of Perisphinctids, the appearing of Sutneriinae, Hybonoticeratinae and Oppelliids in more southern situated regions as well as an increasing amount of Oppeliids to the south. We observe also in the northern region thick-shelled bivalvia (including oysters); the belemnites have been found with some exceptions mostly southward, and the sediments become thicker to the south.

From these observations one can conclude, following Géczy and Ziegler, as it has been done by Zeiss (1968) for the Lower Tithonian of Southern Franconia: that with increasing depths of water the ammonite fauna change their composition. This means in our Ethiopian example, that in Lower Kimmeridgian time the nothern region belonged to parts of the margins of the former sedimentary basin, while the more one goes to regions situated to the south - the more one reaches the inner parts of the basin. Going farther to Kenya, Tanzania and Madagascar also Phylloceratids have been found assumed to indicate the deeper parts of the Jurassic basin (or open sea), see also Zeiss (1971). Concerning the different composition of the Ethiopian ammonite faunas in time (Zeiss 1971, fig.7-10), this may be explained by different phases of development of the Jurassic ammonite faunas of Ethiopia:

In upper Callovian time Ammonites immigrated from Central Arabia into the Ethiopian Jurassic sea. No further development of this immigration is known. - The Middle Oxfordian ammonites immigrated obviously independently, probably from India (Kachh).

In Lower Kimmeridgian (and perhaps already in Upper Oxfordian) time a new immigration can be observed, which brought new forms that have developped a large number of local forms giving this fauna the typical "Ethiopian" habitus.

The Middle Kimmeridgian fauna generally shows similar features, but a strong reduction of the "Ethiopian" elements.

Apparently the connections to the regions of immigration have become better and thus facilitated exchange with S-Europe and E-Africa.

Considering the Lower Tithonian assemblage (as well as the Upper Kimmeridgian one) we can note still better seaway connections with Europe and India (Kachh) at all, whereas the exchange with East Africa and Mexico has had always the same amount.

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(The papers were received after the manuscript had been finished but are quoted here as they provide very useful data for correlation between Ethiopia, Kenia and Tansania. A compilation of all that new data is planned to be published in future.)

OCCURRENCE OF MARINE JURASSIC BIVALVES IN EASTERN NORTHEAST CHINA AND ITS SIGNIFICANCE ON THE NONMARINE JURASSIC-CRETACEOUS BOUNDARY IN EAST AND CENTRAL ASIA

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Gu Zhiwei, Sha Jingeng, Li Zishun & Yu Jingshan

No less than 150 species of marine Jurassic bivalves occurred in the eastern Heilongjiang province, China. Within the Longzhaogou group, the Mesosaccella morrisi-Entolium demissum assemblage was recognized in the Bathonian-Callovian ammonitebearing formation. Upwards, the coal-bearing Yunshan formation yields abundant Oxfordian or late Callovian to Kimmeridgian or early Volgian bivalves and also the Late Mesozoic Siberian plant Acanthopteris onychioides. The marine intercalations in the Chengzihe formation, especially in its lower part or the Shihebei formation of the coal-bearing Jixi group contain nearly 15 species common to those in the Yunshan formation besides the Kimmeridgian zonal fossil Buchia tenuistriata. These prove the Jurassic age of the whole Jixi group and likewise of the international nonmarine Jehol or Witim fauna because 6 molluscan species of the fauna have been obtained from the Upper Jixi group and the Shitouhezi formation in the Hegang coal basin.

1. OCCURRENCE OF THE BIVALVES

The marine Jurassic bivalves discovered in the eastern Northeast China amount to more than 150 species belonging respectively to 62 genera and 30 families. They are distributed on the coal-bearing Longzhaogou and Jixi groups of the eastern Heilongjiang province but far more than half of these species were collected from the Longzhaogou group. They contain faunas of almost a widespread type with numerous Boreal-Pacific elements. The faunas are

composed of brachiopods, gastropods, bivalves, ammonites, ostracodes, etc.. The fossil lists of bivalves and the derived conclusions in the present paper are mainly summarized from their separated prelimilary studies belonging to the different teams in which the present authors participate.

The Longzhaogou group occurring in the southern slope of Wanda hills in eastern Hilongjiang province consists of the middle and Late Jurassic strata. It is composed of sandstone, siltstone, argillite and conglomerate totally of approximately 4000 meters in thickness. In the nonmarine formations, thin coal beds and effusive rocks may be interbedded, The group overlies unconformably on the Permian system or Palaeozoic granites and is in turn overlain by the Lower Cretaceous effusive Dongshan formation. According to its lithology and fossil assemblages, the group is divided into the Peide, Qihuling Yunshan and Zhushan formations in ascending order. Both the Peide and Zhushan formations are terrestrial, occassionally with mega- or micro-floral fossils, the Peide formation containing a species of questionable Modiolus(see the correlation chart).

The Qihulin formation is characterized by dark grey to black mudstone and siltstone intercalated with tuff and sandstone. It measures generally 400-600 meters in thickness. It yielded more than 40 species of fossil bivalves. These bivalves may be collectively called Mesosaccella morrisi-Entolium assemblage. Judging from the bivalves Palaeonucula makitoenses Hayami, Nuculana(Prosaccella) aff. yatsushiroensis Tamura, Camptonectes wandaensis Gu sp.nov., Goniomya cf. literata (Sow.), Thracia shokawensis Hayami and the ammonite Arctocephalites, the Qihulin formation seems to be of an age of Bathonian to early Callovian.

The Yunshan formation appears 2600-2800 meters in thickness and conformable with underlying Qihulin formation. It is characterized by marine and nonmarine alternating clastic sediments with intercalations of thin coal seams (esp. in the upper part) and tuff or tuffaceous breccia (esp. in the lower part). It contains more than 90 species of bivalves among which Aguillerella aff. kobyi Loriol , Arctotis aff. intermedia Bodylevsky , Entolium aff. japonnicum Kurata et Kimura , Camptonectes (C.) aff. lens (Sow.)

Buchia cf. spitiensis (Holdhaus), B. cf. tenuistriata(Lahusen), B. orbicularis (Hyatt), Gryphaea (Bilobissa) aff. dilobotes Duff, Deltoideum delta (Smith), Liostrea aff. gryphaeata (Schlotheim), L. cf. plastica (Trautschold), Nanogyra nana (J. Sow.), Astarte (A.)extensa (Phillips), Corbula aff. attenuata Lycett, Pleuromya uniformis (Sow.) and Thracia depressa (J. de C.Sow.) deserve to be mentioned. These bivalves are partly either associated or alternated with the plants Coniopteris saportana (Heer), C. cf setacea (Prenada), Acanthopteris gothani Sze, A. onychioides (Vass. et K.-M), A.szei Cao sp. nov in the Yunshan formation. Based on the bivalves, the Yunshan formation seems to be of an age from Oxfordian to Kimmeridgian or at most to early Volgian. These bivalves would be divided into assemblages after the biostratigraphical profiles would have been further examined.

In addition, Upper Jurassic marine bivalves were obtained in areas outside Wanda hills. In the vicinity of Donganzhen, northy of the Raohe district, Buchia fischeriana (d'Orb.), B. aff. subokensis(Pavlow), B. cf. okensis (Pavlow) and B. sp. occur in the Donganzhen formation which may be of the latest Jurassic age or the uppermost part of the Longzhaogou group but its exact relationship with the group remains obscure. Further northwards, in the north of the river Songhuajiang (=Sungari) Arctotis sp., Buchia mosquensis (Buch), B. rugosa (Fischer), Pleuromya uniformis (Sow.) and palaeotaxodonts are found to be associated with ammonite fragments and abundant Dinoflagellate assemblages in a drilling hole northwest of the Suibin city. Based on Buchia mosquensis etc., the fossile horizon may be of early Volgian age and in the Upper Longzhaogou group, but its exact position in the group needs also to be fixed.

In the above-cited marine Jurassic bivalves, Atctotis, Buchia, Praebuchia and mytilus aff. commaeformis Zakh. evidently belong to the Boreal fauna in accordance with the ammonite Arctocephalites while Palaeonucula makitoensis Hayami, Grammatodon aff. takiensis Kimura, Entolium aff. japonicum Kurata et Kimura and Thracia shokawensis Hayami connect themselves with the Pacific fauna. However, in both the Qihulin and Yunshan formation there are more widespread Jurassic bivalves such as Entolium demissum (Phillips), Camptonectes (C.) aff. lens (Sow.), Gryphaea (Bilobissa) aff. dilobotes Duff, Nanogyra nana (Sow.) and Pleur-

omya uniformis (Sow.). Among these species, N. nana is worthy of special notice for it occurred not only in Europe but also in India and East Africa. Their occurrence in the Jurassic of the eastern Northeast China would lead to palaeozoographical interests of geologists and palaeontologists.

The Jixi Group is distributed mainly in the Jixi, Muling, Boli, Shuangyashan and Hegang coal basins of the easterh Heilongjiang province. It was long considered as a terrestrial coal-bearing rock group and was divided into three formations, namely the Didao, Chengzihe and Muling formations in ascending order. Most geologists classified the Jixi group into the Jurassic until 1959 when some palaebotanists and palaeopalynologists debated about the Early Cretaceous age of the Upper Jixi group. However, more and more marine intercalations and bivalves therein have been discovered in the Chengzihe formation since 1974. These marine or coastal Jurassic bivalves occurred already up to the upper part of the Chengzihe formation and summed hitherto nearly 20 species and approximately 15 species of them are in common with those obtained in the Longzhaogou group. Among these species Mytilus aff. commaeformis Zakharov, Buchia tenuistiata (Lahusen), Deltoideum delta (Smith), Nanogyra nana (J.Sow), Astarte(A.) diphorme Li et Yu sp. nov., Sinopsammobia ovalis Li, Yu, Yao et Gu gen. et sp. nov., S. longzhaogouensis Li, Yu, Yao et Gu gen. et sp. nov., Filosina subovalis Yao, J. Chen et Gu sp. nov. and Eocallista boliensis Gu sp. nov. are in common with those attained in the Upper Yunshan formation while only one species of Palaeoneilo is in common with that of the Qihulin formation. Not only the Yunshan formation has been determined to be of an age from Oxfordian to Kimmeridgian or at most to Early Volgian but also Buchia tenuistriata can be generally considered as a Kimmeridgian or Lower Kimmeridgian zone fossil in northeastern Asia. In addition, in the Chengzihe formation occura abundantly the genus Ferganoconcha which is also a Jurassic or Triasso-Jurassic fresh water bivalve. Therefore, unless these fossil bivalves were erroneously identified, the Chengzihe formation can be correlated with the Upper formation and dated undoubtedly as of the Late Jurassic or Kimmeridgian age.

Furthermore, there are six molluscan species of the fresh water Jehol or Witim fauna to be found in the middle and Upper part of the Jixi group at the present time, In the Jixi basin,

Unio grabaui Mart. and U. cf. obrutschewi Mart. were obtained from the Chingzihe formation while Sphaerium subplanum (Reis), S. selenginense (Mart.) and Bellamya cf. clavilithiformis (Gr.) were procured from the Muling formation. Outside the Jixi basin, Neomiodon? yixianensis(Gu) have been gotten from the Shitouhezi formation of the Hegang basin and the Dongdaling formation of the Muling basin. Both the latter two formations can be correlated with the Chengzihe formation or at least with the middle-upper Jixi group of the Jixi basin. Moreover, according to the conformable contact with its underlying Chengzihe formation, the Muling formation of the Jixi group can be correlated with the Zhushan formation of the Longzhaogou group. Therefore, it seems more reasonable to consider the Muling and Zhushan formations as of the Latest Jurassic age so far as their conformable contacts with the Chengzihe and Yunshan formations are concerned.

2. SIGNIFICANCE

Since t. Kobayashi et. al. 1942 revised the nonmarine Jurassic-Cretaceous boundary in East and Central Asia as demarcated by A. W. Grabau 1923-1928 and American "Central Asiatic Expedition" 1922-1935, this boundary appeared to be a long standing problem. In the problemthe most critical is the age of the Jehol fauna, (Witim fauna, including Lycoptera, Ephemeropsis, Eosestheria, etc.) and its corresponding flora in the north. Many Chinese and Soviet palaeontologists still considered this fauna as an Early Cretaceous fauna whereas others regarded it as of the Jurassic or Late Jurassic-Early Cretaceous age.

Despite of the comparable forms between the micro- and megafloral assemblages of the Upper Jixi or Longzhaogou groups with those of the Nikan group in the Soviet Suchan basin, the marine invertebrates in these groups illustrate that the Nikan group is younger than the Valnginian (Александри-Садова 1958)Where as the Longzhaogou and Jixi groups including the Chengzihe, Muling wnd Zhushan formations formations are older than the Valanginian.

The Chengzihe and Muling formations in the Upper Jixi group were usually correlated with the coal-bering formations in the Upper Jehol group of western Liaoning. The existence of the fresh Water Ferganoconcha spp. and 6 molluscan soecies of the Jehol fauna in the Jixi group make additional evidences to confirm not only such correlation but also their Jurassic age because strata

of these fresh-water bivalves are either alternating with the marine intercalations in the Kimmeridgian Chingzihe formation or correlative with the upper or middle-upper Jixi group. Ferganoconcha spp. (=Arguniella spp.) in the Jask formation of the Chechum (Чечумская) group in Lower Lena river of north Siberia together with the correlative relation between the Jask formation and the Turga formation in Soviet Transbaikalian region* seem to give further supports to the Jurassic age of the Jehol or Witim fauna.

Based on the marine invertebrates especially the ammonite Arctocephalites (Cranocephalites). the Longzhaogou group can be safely correlated with the marine Middle-Upper Jurassic of the coastal region in Soviet Far East and the Yakutsk formation and Chechum group in northern-Siberia, only the base of the Yakutsk formation being more or less lower. Keeping the horizon of Arctocephalites or other corresponding marine invertebrates in Mind as a criterion, it can be seen that the notable Middle Jurassic unconformable of disconformable stratigraphocal breaks are rather consistent in wide regions from the northern Siberia through the Baikal region, Northeast China and Soviet Far East to Japanese Islands (Крымгольц и др 1972, Колесников 1964, Sato et al.1963). This wide-spread stratigraphical break or early Yanshanian movement appears to constitute a concrete proof to validate the general biostratigraphical and lithostratigaphical correlatin between the Tranabaikal group as well as the Jehol group with the Longzhaogou group. Should the age of the Jehol or Witim fauna be Early Cretaceous, then the early Yanshanian movement would take place at the end of the Jurassic or at least in the late Jurassic. However, it is very hard to believe that nearly the same movement could take place in the Middle Jurassic in both the north (North or Central Siberia) and South (Soviet Far East or Japanese Islands) regions but at the end of the Jurassic or within the Late Jurassic in the central region (Northeast China to Transbakalian region). Therefore, these verifies that the Jurassic age of the Jehol or Witim fauna is correct.

*Ch.m. Kolesnikov 1964 correlated the Jask formation with the Lower Turga formation. Yet the authors think it is more appropriate to correlate the whole Turga with the Jask because the Witim as well as the Jehol fauna is palaeontologically much united.

The typical nonmarine Lower Cretaceous can be represented by the formation with TPN(Trigonioides-Plicatounio-Nippononaia) naiad faunas. As summarized by T. Kobayashi 1983, TPN fossil naiads range from the Lower (corresponding to Neocomian) to Middle (corresponding to Aptian-Turonian) epochs of the tripartite nonmarine Cretaceous. It is not likely that TPN faunas especially the genus Trigonioides began their geological history from the Aptian as recently suggested by Guo Fuxiang. The most important constituent member of TPN fauna is T but not N or Nippononaia ryosekiana. Therefore the KEP(Koreanaia-Nippononaia (Eonippononaia)-Plicatounio) naiad fauna with P and N but without T cannot be considered as a canstitutional fauna of the TPN faunas because there is no T in the fauna. The KEP fauna can be classified into the Late or Middle-Late Jurassic faunas because in western Liaoning and southeastern Gansu these fossil naiads are associated with the Jehol fauna and in western Yunnan with Peregrinoconcha which occurs in an intercalation in the marine Middle Jurassic in southwestern Qinghai. The occurrence of T and P in the vertical or much tilted beds of the Solemya-bearing Xiachengzi formation in the southeasternmost Heilongjiang province appears to prove their earlist Cretaceous or Valanginian age since the Valanginian beds are well developed in Soviet Far East closely neighboring with the southeastern Heilongjiang province of China and the Solemya-bearing Early Cretaceous water might come from the east.

Therefore, it seems more reasonable to demarcate the nonmarine Jurassic-Cretaceous boundary in East and Central Asia between the formations with the Jehol fauna and TPN fossil naiads separately.

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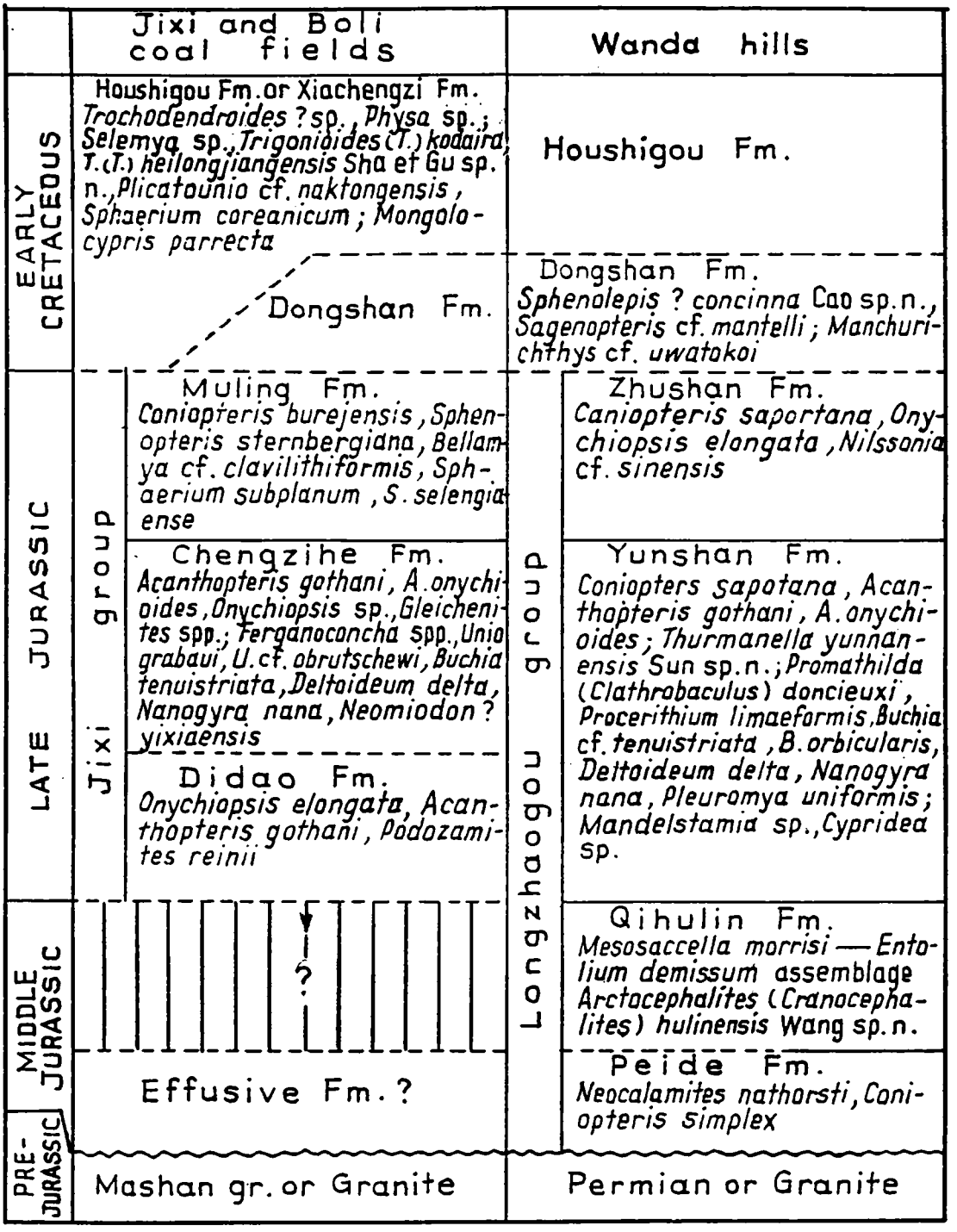



ISBN 87 981848 1 4
ISBN 87 981848 3 0 (Bd 1-3)