

Revised biostratigraphy and correlations of the Middle-Upper Oxfordian in the Americas (southern USA, Mexico, Cuba, and northern Chile)

Ryszard Myczyński, Warsaw, **Federico Olóriz**, Granada, and **Ana B. Villaseñor**, Mexico, D. F.

With 2 figures

MYCZYŃSKI, R., OLÓRIZ, F. & VILLASEÑOR, A. B. (1998): Revised biostratigraphy and correlations of the Middle-Upper Oxfordian in the Americas (southern USA, Mexico, Cuba, and northern Chile). – N. Jb. Geol. Paläont. Abh., **207**: 185–206; Stuttgart.

Abstract: Recent data from Chile, Cuba, southern USA, and Iberia show that the Oxfordian Plicatilis p.p., Transversarium p.p., and Bimammatum Zones are correlated reliably in these areas. Significant for correlations are *Dichotomosphinctes*, close forms to *Gemmellarites*, *Gregoryceras*, and the association of *Euaspidoceras* with *Mirosphinctes* and/or *Praeataxioceras*. Above the lower Bimammatum Zone, *Cubaspidoceras*, *Metahaploceras* and probably *Geyssantia* are of special interest. The general absence of ammonites belonging to the Bifurcatus Zone in Chile, Mexico and southern USA, as well as their endemism in Cuba, cannot yet be conclusively interpreted.

Zusammenfassung: Neue Daten aus Chile, Cuba, den südlichen USA und Iberia gestatten die genaue Korrelation von Plicatilis p.p., - Transversarium p.p. - und Bimammatum-Ammonitenzonen in diesen Gebieten. Wichtig für die Korrelation sind *Dichotomosphinctes*-Formen (die *Gemmellarites* nahestehen), *Gregoryceras* und die Vergesellschaftung von *Euaspidoceras* mit *Mirosphinctes* und/oder *Praeataxioceras*. In Ammonitengesellschaften, die jünger als das frühe Bimammatum-Chron sind, haben wahrscheinlich *Cubaspidoceras*, *Metahaploceras* und *Geyssantia* besondere Bedeutung. Das generelle Fehlen von Ammoniten im Bifurcatus-Chron in Chile, Mexiko und den südlichen USA und deren endemisches Vorkommen in Cuba, läßt sich noch nicht entscheidend erklären.

Introduction

The authors carried out a detailed revision of the Oxfordian ammonite fauna from Chile, Mexico and Cuba, paying special attention to stratigraphy and the comparison with well known European ammonites. The Chilean fauna was interpreted on the basis of a recent paper by GYGI & HILLEBRANDT (1991), as well as on the revision of previous information (STEINMANN 1881, LEANZA 1947, STIPANICIC 1951, 1966, 1969, CHONG et al. 1984). The Oxfordian in Mexico has been analyzed throughout the revision of BURCKHARDT's collection (BURCKHARDT 1912) with the addition of unpublished observations by OLÓRIZ and VILLASEÑOR. Cuban data were compiled from papers by KUTEK et al. (1976), MYCZYŃSKI (1976), WIERZBOWSKI (1976), PSZCZÓŁKOWSKI (1978, 1981, 1987), and interpreted with the addition of unpublished observations made by MYCZYŃSKI and revisions by MYCZYŃSKI and OLÓRIZ.

The updated interpretation on biostratigraphy and correlations in these areas has been especially favored with recent data obtained from the southern USA by YOUNG & OLÓRIZ (1993), who for the first time recognized the genus *Gregoryceras* SPATH (1924), in association with Cuban perisphinctids and haploceratids. Previous interpretations of the Oxfordian ammonites from Chile, Mexico and Cuba did not conclusively explain the difficulty for correlations between these areas, especially due to the absence of the genus *Gregoryceras* in Mexico and Cuba, as well as that of the genus *Vinalesphinctes* SPATH (1931) in the Oxfordian of Mexico. The analysis and detailed comparison of the compiled data improve previous correlations between the areas investigated in the Americas (Fig. 1).

Revised bio-chronostratigraphy and correlations

Chile

The paper by GYGI & HILLEBRANDT (1991) provided improved knowledge and correlation of the Oxfordian in the Americas. This valuable paper noted an interesting fauna of *Gregoryceras* collected stratigraphically in the Cordillera de Domeyko. This fauna is associated with diverse and more or less known perisphinctids, and *Mirosphinctes*, which show particular features typical of the Mexico-Caribbean region. Rightly, GYGI & HILLEBRANDT (1991) chronostratigraphically interpreted the ammonite assemblages recorded, on the basis of the admitted timing for the evolution of *Gregoryceras* in Europe, especially in Switzerland.

With our interest focused on correlations in the Mexico-Caribbean area, the following data by GYGI & HILLEBRANDT (1991) are significant: 1) *Gregoryceras* spp. were collected in deposits belonging to the Transversarium Chron in association with *Ochetoceras hispidum* and perisphinctids [*Peri-*

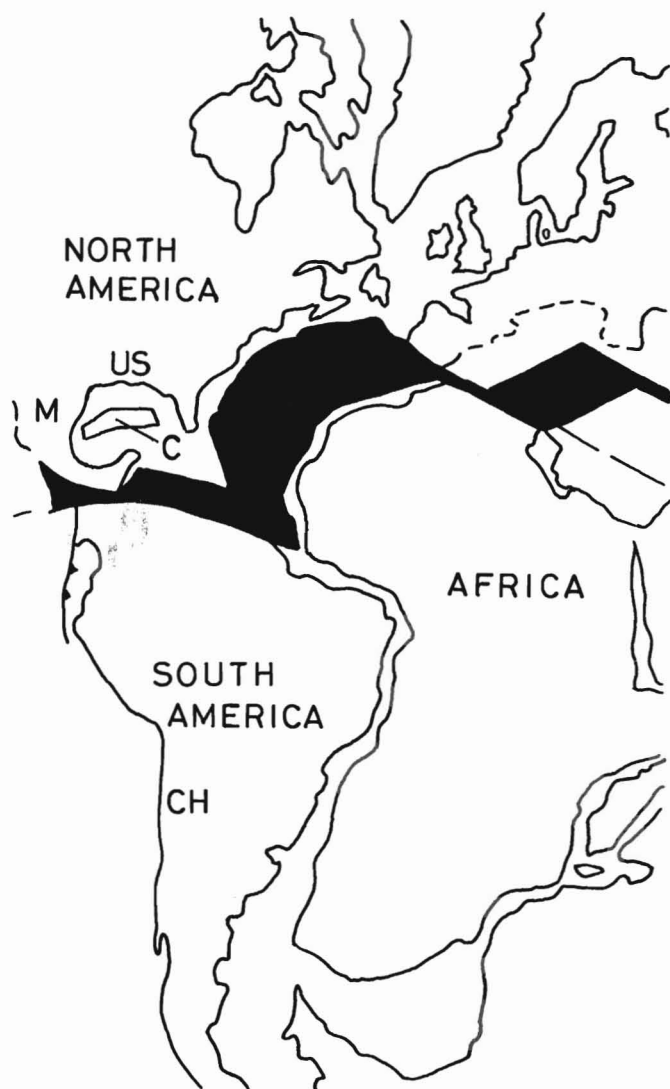


Fig. 1. Paleogeography with location of the areas studied. C (Cuba), CH (Chile), M (Mexico), US (United States).

sphinctes (*Subdiscosphinctes*) *parvulus*] similar to slightly larger European forms [*P. (S.) jelskii* and *kreutzi*]; species such as *G. fouquei* and *G. trapezoidale*, assigned to the Bifurcatus Chron, were not collected in situ; 2) no ammonite assemblage characterizes most of the Bifurcatus Chron;

Perisphinctes (*Antilloceras*) *prophetae* GYGI & HILLEBRANDT (1991, Pl. 2, Fig. 1.4) could be better interpreted as *Roigites prophetae* due to the absence of polygyrate ribs, proverse primaries, and radial external ribs; in addition, its co-specific identity with the Cuban forms of *Perisphinctes plicatoides* illustrated by JUDOLEY & FURRAZOLA-BERMÚDEZ (1968) and WIERZBOWSKI (1976) is not certain. In contrast, *Dichotomosphinctes rotoides* RONCHADZE (in BOURSEAU 1977, Pl. 1, Fig. 6), a species which is also recognized in the Antecedens Chron, is especially close and difficult to differentiate on the basis of ribbing curves.

3) the characterization of the boundary between the Transversarium and Bifurcatus Chrons, or the earliest part of the latter, contains *Gregoryceras* sp., *Vinalesphinctes* cf. *subroigi*, *Subdiscosphinctes acandai* and *Dichotomoceras andium*:

The stratigraphic position of the assemblage presented by GYGI & HILLEBRANDT (1991) in Fig. 6 does not correspond with the chronologic interpretation given on pages 153 and 155 in their paper.

4) the association of *Mirosphinctes* and *Euaspidoceras* clearly above the last record of *Gregoryceras* and below *Orthosphinctes*, *Ochetoceras*, *Lithacosphinctes* and possible *Geyssantia* (= *Idoceras* cf. *neogaenum*), which came from non basal horizons of the Bimammatum or even the early Planula Chron;

Although GYGI & HILLEBRANDT (1991) did not describe *Perisphinctes* (*Pseudodiscosphinctes*) *lucingae* (FAVRE), in their Fig. 10 they included this form which on the account of the known proximity of FAVRE's species with *Ammonites virgulatus* QUENSTEDT, should represent forms with dense and fine ribbing, close to *Praeataxioceras* (similar forms were recognized in Mexico by BURCKHARDT (1912) in his "couches supérieures de l'Oxfordien supérieur" in San Pedro del Gallo area).

Fig. 2. Biochronostratigraphy and correlation chart. Cl (*Clambites*), Cs (*Cubaspinctes*), Cu (*Cubaspidoceras*), Dch (*Dichotomoceras*), Di (*Dichotomosphinctes*), "Ds" (*"Discosphinctes"*), En (*Enayites*), Eu (*Euaspidoceras*), Ge (*Gemmellarites*), Gr (*Gregoryceras*), Gy (*Geyssantia*), Lith (*Lithacosphinctes*), Mh (*Metahaploceras*), Mi (*Mirosphinctes*), Och (*Ochetoceras*), Orth (*Orthosphinctes*), Pr (*Praeataxioceras*), Psw (*Pseudowaagenia*), Sb (*Subnebrodites*), Sd (*Subdiscosphinctes*), Vi (*Vinalesphinctes*).

OXFORDIAN		ZONES		FAD (Δ), LAD (Υ) and main range (I) of selected ammonites in South Europe	N. CHILE		CUBA		MEXICO		SOUTH OF USA																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
		Subzones			Cordillera de Domeyko		Sierra del Rosario	Sierra de los Organos	Sierra Madre Northeastern	Sierra Madre Eastern	Sierra Nevada Motherlode Belt	Cotton Valley Field																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
Upper	Planula	Galar		<div><div><div><div><div>Δ Mh</div><div>Υ Eu</div><div>Υ MI</div></div><div><div>Gy</div><div>Pr</div><div>Cl-Cu</div><div>Psw</div></div></div><div><div><div><div>DI. wartaeformis</div><div>DI. elisabetiformis</div><div>DI. luciaeformis</div><div>DI. aentas</div><div>Gr</div><div>Ge</div></div><div><div>Gr</div><div>Ge</div></div></div></div></div></div>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

Fig. 2 (Legend see p. 188)

and 5) that *Cubaspidoceras* was associated to *Euaspidoceras* in the youngest levels with Oxfordian ammonites in some areas (Cerro Amarillo). Isolate records of *Cubaspidoceras*, probably *Cubaspidoceras carribeanum* according to FÖRSTER & HILLEBRANDT (1984) who illustrated a specimen very close to *Clambites*, are difficult to interpret but according to the closest forms in Europe, they should be Late Oxfordian (Bimammatum Chron) in age.

According to the above, it is assumed that (Fig. 2): 1) the absence of *Gregoryceras* could indicate deposits older or younger than the Transversarium-Early Bifurcatus Chrons in Chile, which represent an Andean sector relatively close to the Mexico-Caribbean area; 2) species already known from the Mexico-Caribbean area, such as *Vinalesphinctes roigi*, *Subdiscosphinctes acandai* and related forms, lived during the earliest Bifurcatus Chron, at least partly; 3) from northern Chile an association is known of *Mirosphinctes* and *Euaspidoceras* together with *Lithacosphinctes* and *Praeataxioceras*, or close forms, which lived during the early Bimammatum Chron; thus, it is possible to expect that *Mirosphinctes* and *Euaspidoceras* could coexist in equivalent horizons in the Mexico-Caribbean area;

The association of *Mirosphinctes* and *Euaspidoceras* with macroconchs (*Lithacosphinctes*-like) perisphinctids and microconchs close to *Praeataxioceras* is known from the early part of the Bimammatum Chron in Europe.

and 4) *Cubaspidoceras* is a characteristic component of the youngest Oxfordian ammonite assemblages that lived before to the Planula Chron, and that no conclusive data exist to prove a younger age for *Cubaspidoceras* in northern Chile.

Southern United States

Few recent references are available for Oxfordian ammonite assemblages in the southern USA. *Dichotomosphinctes* and *Discosphinctes* (s.l.) have been recorded from the California region (cf. JONES in POULTON et al. 1992), but as early as 1961 IMLAY recognized the essential identity of *Dichotomosphinctes* in the Mariposa Fm. (California) with the species recognized by BURCKHARDT (1912) in San Pedro del Gallo (Mexico). We agree with IMLAY's (1961) interpretations, although this author surprisingly assumed a Late Oxfordian age for the species that were previously identified with *Dichotomosphinctes* of the lower beds of San Pedro del Gallo, and "*Discosphinctes*" (here *Praeataxioceras*) from the upper beds of San Pedro del Gallo.

As proposed by BURCKHARDT (1912) and ARKELL (1956), and the revision in this paper, we assume that in the Mariposa Fm. from California the fauna with *Dichotomosphinctes mühlbacheri* (HYATT) and *Dichotomosphinctes* cf. *elisabethaeformis* (BURCKHARDT) belongs to an interval that embraces part

of the Late Vertebrale, Antecedens, and probably Early Transversarium Chrons. The fauna with *Praeataxioceras virgulatiformis* (HYATT) lived during the Bimammatum Chron. The references of IMLAY (1961) to *Idoceras* aff. *planula* (HELH) and *Idoceras* sp. (= *Subnebrodites* / ?*Enayites*), allude to the presence of ammonites of the Planula Chron in the region (Mariposa and Logtown Ridge Fms.), but they could also represent the older intervals of the Bimammatum Chron.

The stratigraphic relationship between the Logtown Ridge and Mariposa Fms. in the Motherlode Belt, as interpreted by JONES (in POULTON et al. 1992), is incompatible with the record of uppermost Oxfordian ammonites at the top of the Logtown Ridge Fm. according to IMLAY (1980), if depositional turnover between them is admitted. Regional tectonics must be responsible for inconsistent stratigraphy in the area.

In the southern United States, data coming from wells are abundant (IMLAY 1940, 1943, 1945, 1980, DICKINSON 1968, IMLAY & HERMAN 1984), and significant information for correlations has recently been obtained (YOUNG & OLÓRIZ 1993). Similar to that known from central and northern Mexico, the oldest Oxfordian ammonite assemblages are dominated by *Dichotomosphinctes*, as shown by IMLAY & HERMAN (1984) from boreholes in Louisiana and Texas. Moreover, these authors agreed with IMLAY (1984) in the recognition of "*Discosphinctes*" cf. *carribeanus*, *virgulatiformis* (= *Praeataxioceras*) within the youngest Oxfordian ammonite assemblages. Therefore, an ammonite assemblage in which *Praeataxioceras* is significant seems to be widely distributed in southern and southeastern United States.

YOUNG & OLÓRIZ (1993) recognized a relatively continuous record of ammonites in the A. J. Hodges No. 1, Pardee-Calloway borehole, with the presence of *Gregoryceras* approximately 100 m below the top of the Smackover Fm. *Euaspidoceras* was recorded toward the top of the Oxfordian succession with ammonites. Among mainly fragmented ammonites, there are frequent haploceratids of Cuban affinity (*Glochiceras*, *Ochetoceras* and/or *Cubaochetoceras*, if the latter exist) in the middle and upper parts of the section; "*Discosphinctes*" (gr. *acandai*, gr. *furrazolai*) is recorded mainly from the lower part. Perisphinctids and possible Passendorferiinae of Tethyan affinity complete the recorded Oxfordian ammonite assemblages. Unfortunately, the record of ammonites was very poor or nonexistent in the transitional levels between the Smackover Fm. and the Cotton Valley Group.

Most of the ammonites studied by YOUNG & OLÓRIZ (1993) undoubtedly belong to the Middle Oxfordian. The presence of *Gregoryceras* should be interpreted as evidence for ammonite assemblages belonging to the Transversarium Chron, according to the closest known record for this genus in the Americas (northern Chile, see GYGI & HILLEBRANDT 1991). The specimen from the Smackover Fm. shows external ribs with a strong rursiradial in-

flexion (about 65°), and slightly flexuous primaries, which is usual in *Gregoryceras* from the middle part of the Transversarium Chron. Secondary for bio-chronostratigraphic interpretations are the relatively poorly known haploceratids of Cuban affinity, the stratigraphic ranges and morphological convergence of which need to be investigated before used in correlations. On the other hand, and if any reliable evaluation is possible, a major trait would be the absence of perisphinctids with a clear Cuban affinity, except for "*Discosphinctes*", which are microconchs that could represent forms with a comparatively wide range or homeomorphs (OLÓRIZ et al. 1990).

MYCZYŃSKI (1994) misinterpreted OLÓRIZ et al. (1990) concerning the presence of *Praeataxioceras* ATROPS (1982) in relation to the record of homeomorphs of *Discosphinctes* ("*Discosphinctes*") in the uppermost Oxfordian in Cuba.

In accordance with our interpretation is the absence of *Gregoryceras* among thousands of ammonites known from Cuba (JUDOLEY & FURRAZOLA-BERMÚDEZ 1968; KUTEK et al. 1976, MYCZYŃSKI 1976, 1994, WIERZBOWSKI 1976). Furthermore, the relative scarcity of *Euaspidoceras* more than 25 m above *Gregoryceras* in the Smackover Fm., resembles the records known from Cuba and Chile. The absence of ammonites with Mexican affinity is also significant. The youngest levels with ammonites from the Smackover Fm. at the A. J. Hodges No. 1 Pardee-Calloway borehole, all seem to indicate that these ammonites mainly lived during the early Bimammatum Chron. If sedimentation was continuous at this site, and our chronological interpretation for the record of *Gregoryceras* is right, a section about 30 m thick between the record of *Gregoryceras* and a possible *Praeataxioceras* could belong mainly to the Bifurcatus Chron.

According to all the above, some data from the southern USA are significant for correlations (Fig. 2): 1) the fauna dominated by *Dichotomosphinctes*, without *Gregoryceras*, could belong mainly to the Antecedens Chron of the Middle Oxfordian, representing the oldest record of the Upper Jurassic with ammonites in the southern margin of the North American Plate; 2) the ammonite assemblage with *Gregoryceras* should belong to the Transversarium Chron; 3) according to existing information the majority of the Bifurcatus Chron could not be unequivocally characterized, and; 4) the assemblage with *Praeataxioceras*, haploceratids, and probably *Subnebrodites* / *?Enayites*, should belong to the Bimammatum Chron, and perhaps to a part of the Planula Chron.

Mexico

The Mexican Oxfordian with ammonites is traditionally known from papers by BURCKHARDT (1912, 1930), IMLAY (1939, 1980, 1984) and CANTÚ-CHAPA (1969, 1971, 1984). CONTRERAS et al. (1988) provide the most recent data

based on field work. OLÓRIZ et al. (1990) recognized that the most widely distributed Tethyan marine biota in areas surrounding the Gulf of Mexico during the Upper Jurassic was during the Oxfordian; these authors interpreted the base of the Zuloaga Group to be Middle Oxfordian, characterized by *Dichotomosphinctes* (OLÓRIZ et al. 1990, Fig. 1), and stated that Mexican ammonites from lateral equivalents to the top of the Zuloaga Limestone belong to the Upper Oxfordian. OLÓRIZ et al. (1990, 1992) selected *Dichotomosphinctes* and *Praeataxioceras* (= Upper Oxfordian "*Discosphinctes*" mainly of the *virgulus* group) as significant ammonites for correlation. CALLOMON (in HILLEBRANDT et al. 1992), evaluating the closest correlation of the Oxfordian ammonite assemblages from Mexico with the European standard, on the basis of published information, proposed an early Middle Oxfordian age (Plicatilis Zone to base of the Transversarium Zone) for ammonite assemblages dominated by *Dichotomosphinctes* in the San Pedro del Gallo area. This author interpreted his M4 horizon of *Ochetoceras mexicanum* to be correlated with the Bimammatum Zone in Europe.

We basically agree with CALLOMON (in HILLEBRANDT et al. 1992) in an early Middle Oxfordian age for ammonite assemblages with *Dichotomosphinctes* in the San Pedro del Gallo area. Field observations by OLÓRIZ and VILLASEÑOR and research in progress, confirmed the prevalence of *Dichotomosphinctes*, and recognized two assemblages represented, respectively, by species described by BURCKHARDT (1912). The lower assemblage shows *lagunitasensis*, cf. *rota*, *durangensis*, cf. *elisabethaeformis*, *promiscus*, and cf. *plicatilis*; and the upper assemblage shows *trichoplocoides*, *wartaeformis*, cf. *chloroolithicus* and cf. *alterneplicatus*. These assemblages basically make parallel the horizons M2 and M3 by CALLOMON (in HILLEBRANDT et al. 1992).

The lower *Dichotomosphinctes* assemblage is made of highly evolute forms, without parabolae, and with dominant bifurcates, although some forms with simple and/or residual ribs exist. These forms are primitive *Dichotomosphinctes*, which have no parabolae making them close to *Otosphinctes*. In our opinion, the closest European species are frequent in ammonite assemblages from the Vertebrale and Antecedens Zones, among which there are *Kranaosphinctes* gr. *promiscus* and *Dichotomosphinctes* aff. *maltonensis* (in BOURSEAU 1977), *Dichotomosphinctes* *rotoides* (in BOURSEAU 1977, or better those forms with more radial ribbing, such as that illustrated by BROCHWICZ-LEWIŃSKI 1976), *P.* (*Dichotomosphinctes*) aff. *buckmani* (in SAPUNOV 1973) and *P.* (*Dichotomosphinctes*) *rotoides* (in SAPUNOV 1979).

The upper *Dichotomosphinctes* assemblage is characterized by tighter coiling, denser and finer ribs, presence of constrictions, and no parabolae. Components of this upper assemblage develops a more evolved *Dichotomo-*

sphinctes-type morphology, in which frequent constrictions make them close to "Mediterranean *Dichotomosphinctes*," for which MELÉNDEZ (1989) proposed the new taxon *Gemmellarites* (Middle Oxfordian). The presence of simple ribs in Mexican forms reinforces this interpretation. The sculpture in these Mexican *Dichotomosphinctes* recalls European species from the Antecedens and basal Transversarium Zones, including *P. (Dichotomosphinctes)* cf. *wartaeformis* (in BOURSEAU 1977), *Discosphinctes aeneas* (in SAPUNOV 1979), *Dichotomosphinctes luciaeformis* and *Gemmellarites trichoplocus* (in MELÉNDEZ 1989). The Mexican fauna, may represent intermediate forms between *Gemmellarites* and *Dichotomosphinctes*, closer to the first genus by frequent simple ribs and constrictions, but also similar to the second genus by whorl-section shapes in the outer whorls ($E/H < 1$).

We consider the group of small perisphinctids with fine, dense, and polygyrate ribbing ("*Discosphinctes*" gr. *virgulatus*) to be significant for correlation of the Upper Oxfordian in the area, due to their wide distribution in the southern margin of the North American Plate. OLÓRIZ et al. (1990) interpreted these ammonites as *Praeataxioceras*, representing a clear example of convergence with the older "*Discosphinctes*" *carribeanus* JAWORSKI, recorded from lower horizons in the Oxfordian Jagua Vieja Member (Jagua Fm.) from Cuba (see JAWORSKI 1940; JUDOLEY & FURRAZOLA-BERMÚDEZ 1968; WIERZBOWSKI 1976). Thus, *Praeataxioceras* permits the correlation of biostratigraphic units characterized by "*Discosphinctes*" (mainly *virgulatus*) in the Huasteca, eastern Sierra Madre (CANTÚ-CHAPA 1969, 1971, 1984), and by "*Perisphinctes*" *virgulatus* associated with *Metahaploceras neohispanicum*, *Ochetoceras canaliculatum*, *Ochetoceras mexicanum* and *Ochetoceras pedroanum* in north-central Mexico, San Pedro del Gallo area (BURCKHARDT 1912). All these records should belong to the Bimammatum Zone, in which *Praeataxioceras* is known from the base (MARQUES 1983). However, we do not discard the possibility that, according to data by IMLAY & HERMAN (1984) from the upper part of the Smackower Fm. in Louisiana and Texas, *Praeataxioceras* reaches horizons which could belong to a part of the Planula Zone in the southern margin of the North American Plate, as occurs in Europe (ATROPS 1982).

Discosphinctes virgulatus, *Euspidoceras* sp., *Ochetoceras* aff. *pedroanum* and *Dichotomosphinctes* sp. characterize the top of the Santiago Fm. at the Tezcapa River according to CANTÚ-CHAPA (1971). This author (CANTÚ-CHAPA 1984) characterized the base of this formation at the Moctezuma River (Huasteca, eastern Sierra Madre) with *P. (Discosphinctes)* sp., *Euspidoceras* (*Paraspidoceras*) sp., *Ochetoceras* aff. *pedroanum*, *O.* aff. *mexicanus* and *Ochetoceras* sp. Although this author never specified the age of these assemblages at the zone level, a correlation with the Bimammatum Zone could be assumed indirectly from his comments (CANTÚ-CHAPA 1984).

on equivalent ammonites in San Pedro del Gallo (BURCKHARDT 1912), despite unclear allusions to *Dichotomosphinctes*. CALLOMON (in HILLEBRANDT et al. 1992) correlated a part of the Bimammatum Zone with its faunal horizon M4, which corresponds to the Mexican ammonite assemblage with *Ochetoceras mexicanum*, a species which is very close to the European *Ochetoceras* (*marantianum* and *semifalcatum* better than *canaliculatum*).

However, the use of *Ochetoceras* for precise correlation in the Americas could be difficult due to morphological convergences, to the still not well-known biostratigraphic ranges, and to the need for a better paleontological knowledge of the genus *Ochetoceras* (see WIERZBOWSKI 1976, GYGI & HILLEBRANDT 1991). As deduced from Chilean, Cuban, and Mexican data, the stratigraphic range of *Ochetoceras mexicanum* BURCKHARDT (1912), and related forms, could include a rather wide interval within the Oxfordian, to which the "capas superiores de San Pedro del Gallo" in Mexico, a part of the Jagua Vieja Member (Jagua Fm.) in Cuba difficult to specify, and the upper part of the Oxfordian succession in the Cordillera de Domeyko in north Chile belong (i.e., a part of the Middle and Upper Oxfordian, with the probable inclusion of the lower part of the Planula Zone). At present, the most precise record of *Ochetoceras mexicanum* is that from the Agua del Carretón section (Chile), where it is associated to "*P.*" *gredingensis* WEGELE and *Orthosphinctes* of the *tiziani* (OPPEL) group which indicate the Bimammatum Zone. In Europe, references to forms similar to *Ochetoceras mexicanum* are found in the upper Middle and Upper Oxfordian.

According to all the above, the following features recognized in the Oxfordian ammonite assemblages from Mexico are of interest for correlations (Fig. 2): 1) the oldest ammonite assemblages are dominated by *Dichotomosphinctes*, among which it is possible to recognize primitive morphotypes characteristic of the Vertebrale-Antecedens Chrons, as well as evolved younger types which are known in European assemblages from the Antecedens-Wartae Chrons; 2) the absence of *Gregoryceras*, that should be interpreted, at least at present, as due to defective sampling or to unfavorable conditions for life and/or preservation of ammonites in deposits mainly corresponding to the Transversarium Chron; 3) very probably for the same reasons, there is a significant absence of ammonites referred to the Bifurcatus Chron, which has been identified neither from the hypothetical record of Tethyan faunas nor from the stratigraphic position of supposed ammonite assemblages dominated by endemic forms; and 4) the assignment to the Bimammatum Chron, and probably to the early Planula Chron, of the younger assemblage with *Praeataxioceras*, *Metahaploceras* and *Ochetoceras*; the local existence of an impoverished assemblage with only *Praeataxioceras* is envisaged.

Cuba

Oxfordian ammonites from Cuba are known from SÁNCHEZ-ROIG (1920), O'CONNELL (1920), JAWORSKI (1940), IMLAY (1942), DE LA TORRE (1960), and JUDOLEY & FURRAZOLA-BERMÚDEZ (1968), but only after papers by the Polish group, especially during 70's, Cuban ammonites were available for modern paleontologic and stratigraphic interpretations. Endemic perisphinctids were interpreted to evidence close relationships between Cuba and Chile during the Middle Oxfordian (MELÉNDEZ & MYCZYŃSKI 1987).

The oldest Oxfordian ammonites from Cuba belong to the San Cayetano Fm. (in Sierra del Rosario) and were described by MYCZYŃSKI & PSZCZÓŁKOWSKI (1976). The fauna studied was scarce and of limited preservation, but these authors rightly assigned an Oxfordian age, somewhat older than that assumed for the Middle Oxfordian assemblages studied by WIERZBOWSKI (1976) and MYCZYŃSKI (1976). Similar to that usually recorded from the southern margin of the North American Plate, ammonite assemblages in the San Cayetano Fm. seem to parallel those two *Dichotomosphinctes* assemblages recorded in the lower beds from San Pedro del Gallo in Mexico. Indeed *Dichotomosphinctes cayetanensis* MYCZYŃSKI is related to the evolute and primitive *Dichotomosphinctes* of the Vertebrale-Antecedens Chron, while *Dichotomosphinctes* or *Gemmellarites* cf. *anconensis* SÁNCHEZ-ROIG and *pichardoi* (JUDOLEY & FURRAZOLA-BERMÚDEZ) could represent more evolved forms of the Antecedens Chron. This interpretation is more precise than that originally made by MYCZYŃSKI & PSZCZÓŁKOWSKI (1976), and is in accordance with the stratigraphic position of this fauna and the extreme rarity of records of some of their components in the Jagua Vieja Member of the Jagua Fm. (e. g., *Dichotomosphinctes anconensis* Sánchez-Roig, see WIERZBOWSKI 1976).

A great part of the Oxfordian ammonites from Cuba belongs to the Jagua Vieja and Pimienta Members of the Jagua Fm. in the Sierra de los Organos, and to the Francisco Fm. and basal Artemisa Fm. in the Sierra del Rosario (Pinar del Río province). A widely distributed lower assemblage is characterized by perisphinctids with strong and relatively distant ribs with a variable tendency to weakening sculpture on venters and flanks during ontogeny (genus *Vinalesphinctes*, see WIERZBOWSKI 1976), as well as by densely ribbed forms in which polygyrate and intercalatory ribs are typical (genus *Cubaspinctes* JUDOLEY & FURRAZOLA-BERMÚDEZ, 1968 sensu WIERZBOWSKI 1976, and the so-called Cuban "*Discosphinctes*"). Other perisphinctids are secondary, but haploceratids (*Ochetoceras* HAUG 1885, the doubtful *Cubaochetoceras* ARKELL 1957, and *Glochiceras* HYATT 1900) are moderately frequent, and Euspidoceratinae (*Euspidoceras* SPATH 1931) scarce.

According to recent revisions by MYCZYŃSKI and OLÓRIZ, upper ammonite assemblages in Cuba are successively dominated by *Euspidoceras* and *Miosphinctes*, and then by *Miosphinctes* and *Cubaspidoceras* ("C." *kuteki* or *C. caribbeanum*). *Cubaspidoceras caribbeanum* MYCZYŃSKI has been recorded above the last appearance of *Miosphinctes* at the Mogote La Mina II section (Sierra de los Organos), but the interpretation of this record is not conclusive. These upper ammonite assemblages are recorded in Sierra de los Organos and Sierra del Rosario. Eastward in the Sierra de los Organos, there is a notable stratigraphic change in the datum plane for the first appearance of the ammonite assemblage with *Cubaspidoceras* (*Cubaspidoceras caribbeanum* MYCZYŃSKI). In fact, eastern outcrops in the Sierra de los Organos show the appearance of *Cubaspidoceras caribbeanum* MYCZYŃSKI almost directly above the *Euspidoceras-Miosphinctes* assemblage in the lowermost part of the Pimienta Member, while to the West these two ammonite assemblages are recorded at the top and bottom of the Pimienta Member, respectively. In the Sierra del Rosario, these two ammonite assemblages are known in the Francisco Fm., with the *Euspidoceras* and *Miosphinctes* assemblage below (in the uppermost horizons with calcareous concretions, "quesos"), and *Cubaspidoceras caribbeanum* MYCZYŃSKI and *Miosphinctes* above. "*Cubaspidoceras*" *kuteki* and *Miosphinctes* of the *pinarensis* group have been recorded at the Macagual section in the Sierra del Rosario.

KUTEK et al (1976) registered badly preserved *Cubaspidoceras* spp. in the basal Artemisa Fm. at the Cinco Pesos section in Sierra del Rosario, and interpreted these specimens as falling into the variability range of *kuteki* and *caribbeanum*. The ammonite assemblage studied by these authors could imply the joint record of "*Cubaspidoceras*" *kuteki* MYCZYŃSKI, *Miosphinctes* and *Cubaspidoceras caribbeanum* MYCZYŃSKI, and would be the only known record of "C." *kuteki* MYCZYŃSKI together with *C. caribbeanum* MYCZYŃSKI in Cuba. These forms of *Cubaspidoceras* spp. were associated with *Miosphinctes* close to the *minensis* group, which is typically registered above *Euspidoceras* and only associated with *C. caribbeanum*.

If the morphology of the *Cubaspidoceras* involved is taken into account, these records more or less coincide with the first appearance of *Pseudowaagenia* at the top of the Bifurcatus-basal Bimammatum Zones in the epioceanic or Mediterranean Tethys (SEQUEIROS & OLÓRIZ 1979, OLÓRIZ et al., in press). SEQUEIROS & OLÓRIZ, (1979) noted rare *Cubaspidoceras*-like specimens in the Upper Oxfordian of the central Betic Cordillera (southern Spain) in epioceanic ammonitico rosso facies. According to MELÉNDEZ (1989) the first record of *Pseudowaagenia* sp. in epicontinental deposits at the Ariño section (Iberian Chain) is just above the last record of *Euspidoceras* at the top of the lower Bimammatum Zone (Hypselum Subzone), and in this section *Clambites* cf. *schwabi* (OPPEL) and *Cubaspidoceras* are

registered from upper horizons in the Bimammatum Zone (Hauffianum Sub-zone) together with *Praeataxioceras* and *Geyssantia*.

The stratigraphic interpretation of the ammonite assemblages recognized in the Oxfordian from Cuba has been difficult due to their particular morphology and ranges. In fact, WIERZBOWSKI (1976) interpreted the lower faunal assemblage as belonging to a "short time interval of the Oxfordian". This author considered that Cuban perisphinctids of this older faunal assemblage were differentiated during the Lower Oxfordian and assigned them a Middle Oxfordian age corresponding to the Transversarium and possible early Bifurcatus Chrons. On the other hand, MYCZYŃSKI (1976) interpreted the upper faunal assemblage as late Middle Oxfordian (Bifurcatus Chron) and possibly early Upper Oxfordian (Bimammatum Chron p.p.).

KUTEK et al. (1976) agreed with WIERZBOWSKI (1976) in the chronostratigraphic interpretation of the lower assemblage, but restricted to the Bifurcatus Chron (late Middle or early Late Oxfordian according to authors) the upper assemblage studied by MYCZYŃSKI (1976), and interpreted a younger age, "but rather not post-Bimammatum", for the horizon with *Mirosphinctes* and *Cubaspidoceras* recorded from the base of the Artemisa Fm.

New biostratigraphic data in the Americas (Chile and Gulf Rim) and in Europe (Spain), together with the revision of traditional information from the Mexico-Caribbean area, allow to improve previous interpretations (Figure 2).

An established fact is that the lower faunal assemblage from Cuba (that above the oldest one with *Dichotomosphinctes*), which is dominated by *Vinalesphinctes* (WIERZBOWSKI 1976) and *Cubaspinctes* (JUDOLEY & FURRAZOLA-BERMÚDEZ 1968; sensu WIERZBOWSKI 1976), has not been recognized outside Cuba, either in Chile, or in Mexico and in the southern USA, areas in which the oldest preserved Oxfordian is correlated with parts of the Vertebrales-Antecedens Chrons. In contrast, *Vinalesphinctes* and *Subdiscosphinctes* (= Cuban "*Discosphinctes*") have been recorded associated to *Gregoryceras* around the base of the Bifurcatus Chron in Chile, although possible new species of *Roigites* are recognized from the base of the Transversarium Chron. Since records of Cuban ammonites are not dominant in Chile, and/or that they would be referred to new species (e.g., *prophetae* in GYGI & HILLEBRANDT 1991), at least at times, together with the fact that *Gregoryceras* has been traditionally admitted to be absent from Cuba, but recently known from the Gulf Rim (YOUNG & OLÓRIZ 1993), we conclude that the Cuban ammonite assemblage characterized by *Vinalesphinctes* and *Cubaspinctes* mainly represents ammonite populations living during the Bifurcatus Chron. The difficulty to characterize most of the Bifurcatus Chron in Chile supports and supplements this interpretation.

For the stratigraphic interpretation of what we have called upper ammonite assemblages, with frequent *Euaspidoceras*, *Mirosphinctes* and species presently included in *Cubaspidoceras*, the biostratigraphic data obtained in the Iberian Plate have been of prime importance. As correctly considered by KUTEK et al. (1976), the biostratigraphic evaluation of the relative significance of the last records of *Euaspidoceras* and *Mirosphinctes* was difficult with data then available. Similarly, known records of forms morphologically close to species included in *Cubaspidoceras* in Europe did not solve the problem. The following adds to the updated stratigraphic interpretation improving preliminary hypotheses by MELÉNDEZ et al. (1988).

The analysis of precise ranges of Cuban ammonites in these upper faunal assemblages (KUTEK et al. 1976, MYCZYŃSKI 1976, and unpublished data from the authors) enables an identification of a lower interval characterized by the record of *Euaspidoceras* with *Mirosphinctes* of the *pinarensis* group, and an upper one characterized by "*Cubaspidoceras*" *kuteki* or *Cubaspidoceras caribbeanum* together with *Mirosphinctes*. Since "*C.*" *kuteki* and *C. caribbeanum* have not been recorded from the same section, the only feasible possibility for the subdivision of this upper assemblage is according to the type of *Mirosphinctes*. Thus, an uppermost horizon with *Cubaspidoceras caribbeanum* and *Mirosphinctes* of the *minensis* MYCZYŃSKI-*niedzwiedzki* Siedmiradzki groups is envisaged. At present, the local record of *Cubaspidoceras caribbeanum* above *Mirosphinctes* in Sierra de los Organos (Mogote la Mina II) cannot be conclusively interpreted as evidence for a younger horizon with only *Cubaspidoceras caribbeanum*.

The known biostratigraphic record in the Iberian Plate shows the existence of *Mirosphinctes* at levels belonging to the Bimammatum Chron. This is a well-known fact in the Betic Cordillera (epioceanic ammonitico rosso) and the Iberian Chain, (epicontinental marl-limestone rhythmites), as demonstrated by SEQUEIROS (1977), SEQUEIROS & OLÓRIZ (1979), MELÉNDEZ (1989), and OLÓRIZ & RODRÍGUEZ-TOVAR (1996). This relieves doubts by KUTEK et al. (1976) with respect to a possible record of *Mirosphinctes* in the Bimammatum Zone; the bio-chronostratigraphic reinterpretation carried out by ATROPS & MARQUES (1986) in Montejunto (Lusitanian Basin, Portugal) is also in accordance with the record of *Mirosphinctes* in the lower Bimammatum Zone. On the other hand, the genus *Pseudowaagenia*, which is close to *Clambites* and *Cubaspidoceras* (MYCZYŃSKI & BROCHWICZ-LEWINSKI 1981), generally appears in the basal Bimammatum Zone in epioceanic deposits in the Betic Cordillera (CHECA & OLÓRIZ 1984, 1986, 1987, CHECA 1985), and rarely in the youngest horizons of the Bifurcatus Zone in Mallorca (OLÓRIZ et al. in press.), but not in older horizons within this zone as presumed by SEQUEIROS (1974, Fig. I-113 only, but not in text) for the central Betic Cordillera. In epicontinental deposits from Iberia, this genus has been re-

corded for the first time from the middle Bimammatum Zone (basal Bimammatum Subzone) in the Iberian Chain (MELÉNDEZ 1989), where *Mirosphinctes* is known from the lower Bimammatum Zone (middle Hypselum Subzone) and *Clambites* cf. *schwabi* (OPPEL) and "*Cubaspidoceras*" cf. *kuteki* and *C. sp.* from the lower (upper Hypselum Subzone) to the uppermost (Hauffianum Subzone) Bimammatum Zone.

According to the above, and taking into account the general disappearance of *Euspidoceras* in the lower Bimammatum Zone (Hypselum Subzone), although exceptions exist (SEQUEIROS & OLÓRIZ 1979), the interval characterized by *Mirosphinctes* and *Cubaspidoceras*, could represent the early Middle Bimammatum Chron (i. e., the younger assemblages studied by MYCZYŃSKI (1976) would represent ammonites that lived during the Early and part of the Middle Bimammatum Chron).

The assumed age for the uppermost interval that we differentiated within the upper faunal assemblages, (i. e., that characterized by *Cubaspidoceras caribbeanum* and the youngest *Mirosphinctes* in Sierra de los Organos and Sierra del Rosario) should be younger than the early Middle Bimammatum Chron. The first record of *Metahaploceras* (MYCZYŃSKI 1994) above the youngest *Mirosphinctes*, could correlate approximately with the first record of *Metahaploceras* in Europe, which takes place within the Bimammatum Chron (SCHAIRER 1972, WIERZBOWSKI 1978, SEQUEIROS & OLÓRIZ 1979, ATROPS & MARQUES 1986, OLÓRIZ et al. in press.). The absence of *Praeataxioceras* and related forms in the upper faunal assemblages in Cuba contrasts with their presence in adjacent areas (Chile, Mexico and southern USA), and could restrict the younger Oxfordian ammonites from Cuba to the middle part of the Bimammatum Chron. According to all the above, we considered that the interval dominated by *Cubaspidoceras caribbeanum* belongs without doubt to the Bimammatum Chron, above the basal horizons, and could reach the middle part of this chron, or even younger horizons when registered clearly above the last record of *Mirosphinctes*.

Conclusions

According to all above, in the studied areas in the Americas it is possible to recognize a first generalized ammonite record around the stratigraphic interval belonging to the late Plicatilis - early Transversarium Chrons during the Middle Oxfordian. This is in accordance with that known from the West Tethys where older Oxfordian deposits are comparatively restricted.

The widespread impoverishment in Oxfordian ammonites occurred during the latest Bimammatum - early Planula Chrons. In the West Tethys this is uncommon and related to a deterioration of life conditions for ammonites in relation to tectonic activity.

The most homogeneous ammonite assemblages lived during the Middle Oxfordian (late Plicatilis-middle Transversarium Chrons), and in a lesser degree during the middle Late Oxfordian (Bimammatum Chron). This coincides with the known record from distant areas elsewhere in the Tethys.

The early Late Oxfordian (Bifurcatus Chron) was a time for increasing endemism in ammonites, when registered; scarce ammonite data from this age could be related to poor life conditions for ammonites and/or incomplete sampling.

Perisphinctidae are the basis for correlation in Middle Oxfordian deposits from the analysed areas in the Americas. *Dichotomosphinctes* and *Gemmelarites*-like (Mediterranean *Dichotomosphinctes*) species ensure biochronostratigraphy and correlation with European Standard Chronozones. The record of *Gregoryceras* is significant to complete or substitute perisphinctid biostratigraphy and of prime importance for correlation even its comparatively restricted distribution (incomplete sampling?).

The subdivision of younger Oxfordian ammonite assemblages (Bimammatum - Planula p.p. Chrons) is based on the association of *Euspidoceras* with *Mirospinctes* and/or *Praeataxioceras*, which characterize the early Bimammatum Chron. Overlying are variable ammonite assemblages in which *Cubaspidoceras*, *Metahaploceras*, and probably *Geyssantia*, are typical before the poorer and discontinuous ammonite record of the final Oxfordian (Planula Chron).

Acknowledgements

This research was supported by projects IN-203792 (DGAPA, UNAM, Mexico), CICYT-PB-0271 (CSIC, Spain and PAN, Poland), and Research Group EMMI (RNM 0178 Junta de Andalucía, Spain). We thank K. YOUNG (Univ. Texas at Austin) for helpful suggestions and comments.

References

- ARKELL, W. J. (1956): Jurassic geology of the world. – 806 S., 102 Abb., 46 Taf., 27 Tab.; London (Oliver & Boyd Ltd.).
- ARKELL, W. J., KUMMEL, B. & WRIGHT, C. W. (1957): Mesozoic Ammonoidea. – In: MOORE, R. (Ed.): Treatise on Invertebrate Paleontology, Part L, Ammonoidea: L80-L490, 434 Abb., Colorado (Geol. Soc. America & Univ. Kansas Press).
- ATROPS, F. (1982): La Sous-famille des Ataxioceratinae (Ammonitina) dans le Kimméridgien inférieur du Sud-Est de la France. Systématique, évolution, chronostratigraphie des genres *Orthosphinctes* et *Ataxioceras*. – Doc. Lab. Géol. Lyon, **83**: 463 S., 64 Abb., 54 Taf.; Lyon.
- ATROPS, F. & MARQUES, B. (1986): Mise en évidence de la Zone à Platynota (Kimméridgien inférieur) dans le massif du Montejunto (Portugal); conséquences Stratigraphiques et paléontologiques – Géobios, **19** (5): 537-547, 3 Abb., 1 Taf.; Lyon.

- BOURSEAU, J.-P. (1977): L'Oxfordien Moyen a nodules des "Terres Noires" de Beauvoisin (Drome); (Ammonitina de la zone à Plicatilis, paléontologie et biostratigraphie; milieu de sédimentation et genèse des nodules carbonatés). – Nouv. Arch. Mus. Hist. natur. Lyon, **15**: 116 S., 31 Abb., 12 Taf., 54 Tab.; Lyon.
- BROCHWICZ-LEWIŃSKI, W. (1976): Oxfordian of the Częstochowa area. I. Biostratigraphy. – Bull. Acad. Polonaise Sci., (Sci. Terre), **24** (1): 37-46, 1 Abb., 10 Taf., 2 Tab.; Warszawa.
- BURCKHARDT, C. (1912): Faunes Jurassiques et Cretaciques de San Pedro del Gallo. – Bol. Inst. Geol. México, **29**: 264 S, 46 Taf; Mexico.
- (1930): Etude synthétique sur le Mésozoïque mexicain. – Mém. Soc. Paléont. Suisse, **49-50**: 280 S., 32 Abb., 17 Tab.; Genève.
- CANTÚ-CHAPA, A. (1969): Estratigrafía del Jurásico Medio-Superior del subsuelo de Poza Rica, Ver. (Area de Soledad-Miquetla). – Rev. Inst. Mexicano Petról., **1** (1): 3-9; Mexico.
- (1971): La serie Huasteca (Jurásico Medio-Superior) del Centro Este de México. – Rev. Inst. Mexicano Petról., **3** (2): 17-40, 1 Abb., 3 Taf.; Mexico.
- (1984): El Jurásico Superior de Tamán. San Luis Potosí, Este de México. – Mem. III Congr. Latinoamericano Paleont.: 207-215, 1 Taf.; México.
- CHECA, A. (1985): Los Aspidoceratiformes en Europa (Ammonitina, Fam. Aspidoceratidae: subfamilias Aspidoceratinae y Physodoceratinae). – 413 S., 42 Taf., Granada (Thesis Univ. Granada).
- CHECA, A. & OLÓRIZ, F. (1984): Significant Mediterranean "*Aspidoceras*" in upper Jurassic biostratigraphy. – In: MICHELSEN, O. & ZEISS, A. (Eds): 2nd International Symposium on Jurassic Stratigraphy: 394-414, 6 Abb.; Copenhagen.
- (1986): Evolutionary trends in Oxfordian and Kimmeridgian Subbetic Aspidoceratinae (Southern Spain). A proposition of Null Hypotheses about the evolutionary course in a highly significant group of Tethyian Upper Jurassic ammonites. – Boll. Soc. Paleont. Italiana, **24** (2-3): 145-159, 3 Abb.; Módena.
- (1987): Oxfordian and Kimmeridgian "*Aspidoceras*" in the Mediterranean. A methodological approach. – Estud. Geol., **43**: 513-520, 3 Abb.; Madrid.
- CHONG, G., BROCHWICZ-LEWIŃSKI, W., MYCZYŃSKI, R., MELÉNDEZ, G. & SEQUEIROS, L. (1984): Stratigraphic value and paleobiogeographic implications of Oxfordian ammonite fauna of Chile. – In: MICHELSEN, O. & ZEISS, A. (Eds): 2nd International Symposium on Jurassic Stratigraphy: 416-427, 2 Abb.; Copenhagen.
- CONTRERAS, B., CORTÉS, A. & GÓMEZ, M. E. (1988): Bioestratigrafía y sedimentología del Jurásico Superior en San Pedro del Gallo, Durango, México. – Rev. Inst. Mexicano Petról., **20** (3): 5-49, 7 Abb., 10 Taf., 4 Tab.; Mexico.
- DE LA TORRE, A. (1960): Fauna de la Formación Cayetano del Jurásico Medio de Pinar del Río. – Mem. Soc. Cubana Hist. Natur., **25** (1): 65-72; La Habana.
- DICKINSON, K. A. (1968): Upper Jurassic stratigraphy of some adjacent parts of Texas, Louisiana, and Arkansas. – U.S. Geol. Surv. Prof. Pap., **594-E**: E1-E25, 13 Abb., 1 Taf., 1 Tab.; Colorado.
- FÖRSTER, R. & VON HILLEBRANDT, A. (1984): Das Kimmeridge des Profeta-Jura in Nordchile mit einer *Mecochirus-Favreina*-Vergesellschaftung (Decapoda, Crustacea-Ichnogenus). – Mitt. Bayer. Staatssamml. Paläont. hist. Geol., **24**: 67-84, 8 Abb., 4 Taf.; München.

- GYGI, R. A. & VON HILLEBRANDT, A. (1991): Ammonites (mainly *Gregoryceras*) of the Oxfordian (Late Jurassic) in northern Chile and time-correlation with Europe. – Schweiz. paläont. Abh., **113**: 137-167, 23 Abb., 9 Taf., 10 Tab.; Basel.
- HAUG, E. (1885): Beiträge zu einer Monographie der Ammonitengattung *Harporceras*. – N. Jb. Min. Geol. Paläont., B-Bd., **3**: 585-722, 11-12 Taf.; Stuttgart.
- HILLEBRANDT, A. VON, SMITH, P., WESTERMANN, G. E. G. & CALLOMON, J. H. (1992): Ammonite zones of the circum-Pacific region. – In: WESTERMANN, G. E. G. (Ed.): The Jurassic of Circum-Pacific: 247-272, 3 Tab.; New York (Cambridge Univ. Press).
- HYATT, A. (1900): Cephalopoda - In: ZITTEL, K. A. & EATSMAN, CH. R. (Eds.): Text-Book of Palaeontology, First English Ed., **1**: 502-592; London.
- IMLAY, R. W. (1939): Jurassic ammonites from Mexico. – Bull. Geol. Soc. America, **50**: 1-78, 7 Abb., 18 Taf.; New York.
- (1940): Lower Cretaceous and Jurassic rocks of southern Arkansas and their oil and gas possibilities. – Arkansas Geol. Surv. Infor. Circ., **12**: 64 S., 26 Taf., 17 Tab.; Arkansas.
 - (1942): Late Jurassic fossils from Cuba and their economic significance. – Bull. Geol. Soc. Amer., **53**: 1417-1478, 4 Abb., 12 Taf.; New York.
 - (1943): Jurassic Formations of Gulf Region. – AAPG Bull. **27** (11): 1407-1533, 14 Abb.; Oklahoma.
 - (1945): Jurassic fossils from Southern States, No. 2. – J. Paleont., **19** (3): 253-276, 1 Abb., 3 Taf.; Oklahoma.
 - (1961): Late Jurassic ammonites from western Sierra Nevada, California. – Geol. Surv. Prof. Paper, **374-D**: D1-D30, 3 Abb., 6 Taf., 3 Tab.; Washington.
 - (1980): Jurassic Paleobiogeography of the Conterminous United States in Its Continental Setting. – Geol. Surv. Prof. Paper, **1062**: 1-134, 33 Abb.; Washington.
 - (1984): Jurassic ammonite successions in North America and biogeographic implications. – In: WESTERMANN, G. E. G. (Ed.): Jurassic-Cretaceous biochronology and paleogeography of North America. Geol. Assoc. Canada Spec. Paper, **27**: 1-12, 6 Abb.; Newfoundland, (Univ. Toronto Press).
- IMLAY, R. W. & HERMAN, G. (1984): Upper Jurassic Ammonites from the subsurface of Texas, Louisiana and Mississippi. – In: VENTRESS, W. P. S., BEBOUT, D. G., PERKINS, B. F. & MOORE, C. H. (Eds.): The Jurassic of the Gulf Rim: 149-170, 5 Abb., 2 Taf.; Texas (GCSSEPM Found. Third Ann. Conf. Proc.).
- JAWORSKI, E. (1940): Oxford-Ammoniten von Cuba. – N. Jb. Min. Geol. Paläont., B-Bd., **83**, Abt. B: 87-137, 3-7 Taf.; Stuttgart.
- JUDOLEY, C. M. & FURRAZOLA-BERMÚDEZ, G. (1968): Estratigrafía y fauna del Jurásico de Cuba. – Publ. Espc. Inst. Cubano Rec. Min. Depto. científ. Geol. Acad. Ciencias Cuba, Depto. Geol., 1-126, 41 Abb., 81 Taf.; La Habana.
- KUTEK, J., PSZCZÓŁKOWSKI, A. & WIERZBOWSKI, A. (1976): The Francisco Formation and an Oxfordian ammonite faunule from the Artemisa Formation, Sierra del Rosario western Cuba. – Acta Geol. Polonica, **26** (2): 299-319, 22 Abb., 20 Taf.; Warszawa.
- LEANZA, A. F. (1947): Ammonites coralinos en el Jurásico de Chile. – Rev. Soc. Geol. Argentina, **2** (4): 285-295, 1 Abb., 1 Taf.; Buenos Aires.

- MARQUES, B. (1983): Oxfordiano-Kimeridgiano do Algarve oriental: estratigrafia, paleobiologia (Ammonoidea) e paleobiogeografia. – 547 S., 77 Abb., 28 Taf.; Lisboa (Thesis Univ. Nov. Lisboa).
- MELÉNDEZ, G. (1989): El Oxfordiense en el sector central de la Cordillera Ibérica (Provincias de Zaragoza y Teruel). – 418 S., 78 Abb., 62 Taf.; Zaragoza-Teruel (Thesis Inst. Fernando El Católico e Inst. Estudios Turolenses).
- MELÉNDEZ, G. & MYCZYŃSKI, R. (1987): Sobre la posición sistemática de los ammonites del Oxfordiense de los Andes Chilenos (Cordillera Domeyko, Chile, Provincia Andina). – *Geogaceta*, **2**: 12-14; 3 Abb.; Madrid.
- MELÉNDEZ, G., SEQUEIROS, L., BROCHWICZ-LEWIŃSKI, W., MYCZYŃSKI, R. & CHONG, G. (1988): Paleobiogeographic relations between Oxfordian ammonite faunas from the Mediterranean, Caribbean and Andean provinces. – In: WIEDMANN, J. & KULLMANN, J. (Eds.): 2nd. International Cephalopod Symposium: Cephalopods Present and Past (SCHINDEWOLF-Symposium): 425-435, 4 Abb; Stuttgart (Schweizerbart).
- MYCZYŃSKI, R. (1976): A new ammonite fauna from the Oxfordian of the Pinar del Rio province, western Cuba. – *Acta Geol. Polonica*, **26** (2): 261-297, 22 Abb., 20 Taf.; Warszawa.
- (1994): Caribbean ammonite assemblages from Upper Jurassic-Lower Cretaceous sequences of Cuba. – *Stud. Geol. Polonica*, **105**: 91 - 108, 3 Abb., 1 Taf.; Kraków.
- MYCZYŃSKI, R. & BROCHWICZ-LEWIŃSKI, W. (1981): Cuban Oxfordian Aspidoceratids: their relation to the European ones and their stratigraphic values. – *Bull. Acad. Polon. Sci., (Sci. Terre)*, **28** (4): 325-330, 8 Taf.; Warszawa.
- MYCZYŃSKI, R. & PSZCZÓŁKOWSKI, A. (1976): The ammonites and age of the San Cayetano Formation from the Sierra del Rosario, western Cuba. – *Acta Geol. Polonica*, **26** (2): 321-329, 4 Abb., 2 Taf.; Warszawa.
- O'CONNELL, M. (1920): The Jurassic ammonite fauna of Cuba. – *Amer. Mus. Nat. Hist., Bull.*, **42** (16): 643-692, 8 Abb, 5 Taf., 8 Tab.; New York.
- OLÓRIZ, F., GONZÁLEZ-ARREOLA, C., LARA-MORALES, L., VILLASEÑOR, A. B. & WESTERMANN, G. E. G. (1992): Significant ammonites and calpionellids for correlations within the Upper Jurassic-lowermost Cretaceous in the southern margin of the North-American Plate. – *Table Ronde Européenne, Paléontologie et Stratigraphie d'Amerique Latine*: 7-9 July, 1992, Abstracts: 38, Lyon.
- OLÓRIZ, F., MARQUES, B. & CARACUEL, J. E. (1996): The Middle-Upper Oxfordian of central Sierra Norte (Mallorca, Spain), and progressing ecostratigraphic approach in the western Tethys. – *Géobios* (in press.)
- OLÓRIZ, F. & RODRÍGUEZ-TOVAR, F. J. (1996): The record of *Miosphinctes frickensis* (MOESCH) in the Upper Oxfordian in the Sierra de Cazorla. – *Geogaceta*, **19**: 94-96, 3 Abb.; Madrid.
- OLÓRIZ, F., VILLASEÑOR, A. B., GONZÁLEZ-ARREOLA, C. & WESTERMANN, G. E. G. (1990): Problems of litho-correlation in the Mexico-Caribbean area and the significance of Upper Oxfordian "*Discosphinctes*". 1st. Oxfordian Meeting, Zaragoza (1988). – *Publ. Seminario Paleont. Univ. Zaragoza*, **2**: 191-204, 1 Abb.; Zaragoza.

- POULTON, T. P., DETTERMAN, R. L., HALL, R. L., JONES, D. L., PETERSON, J. A., SMITH, P., TAYLOR, D. G., TIPPER, H. W. & WESTERMANN, G. E. G. (1992): Western Canada and United States. – In: WESTERMANN, G. E. G. (Ed.): The Jurassic of Circum-Pacific: 29-92, 26 Abb.; New York (Cambridge Univ. Press).
- PSZCZÓŁKOWSKI, A. (1978): Geosynclinal sequences of the Cordillera de Guaniguani-co in western Cuba; their lithostratigraphy, facies development, and paleogeography. – Acta Geol. Polonica, **28** (1): 1-96, 32 Abb., 6 Tab.; Warszawa.
- (1981): El banco carbonatado jurásico de la Sierra de los Organos, Provincia de Pinar del Río, su desarrollo y situación Paleotectónica. – Ciencias de la Tierra y del Espacio, Acad. Ciencias Cuba, **3**: 37-50, 4 Abb.; La Habana.
- (1987): Paleogeography and paleotectonic evolution of Cuba and adjoining areas during the Jurassic-Early Cretaceous. – Ann. Soc. Geol. Poloniae, **57**: 127-142, 5 Abb.; Kraków.
- SÁNCHEZ-ROIG, M. (1920): La fauna Jurásica de Viñales. Republica de Cuba. – Sec. Agric. Comerc. Trab. Bol. Espec.: 1-61, 23 Taf.; La Habana.
- SAPUNOV, I. G. (1973): Ammonites de l'Oxfordien de la partie occidentale des Hauts Plateaux (Algérie). – Publ. Serv. Géol. Algérie, N. S. **44**: 101-137, 2 Abb., 7 Taf., 1 Tab.; Alger.
- (1979): Les Fossiles de Bulgarie. II. 3. Jurassique Supérieur. Ammonoidea. – 263 S., 16 Abb., 59 Taf., 4 Tab.; Sofia (Acad. Bulg. Sci.; V. TZANKOV, ed.).
- SCHAIERER, G. (1972): *Taramelliceras*, *Glochiceras*, *Ochetoceras* (Haplocerataceae, Ammonoidea) aus der platynota-zone (unterstes Unterkimmeridge) der Fränkischen Alb (Bayern). – Mitt. Bayer. Staatssamml. Paläont. hist. Geol., **12**: 33-56, 11 Abb., 2 Taf., 6 Tab.; München.
- SEQUEIROS, L. (1974): Paleogeografía del Calloviense y Oxfordense en el Sector Central de la Zona Subbética. T. I+II. – 636 S., I-122 + II-136 Abb., 32 Taf.; Granada (Thesis Univ. Granada).
- (1977): Presencia de *Miosphinctes* (Ammonitina, Perisphinctaceae) en la zona Subbética (Cordilleras Béticas, España). – Acta Geol. Hisp., **12** (1/3): 35-37, 2 Abb., 2 Taf.; Barcelona.
- SEQUEIROS, L. & OLÓRIZ, F. (1979): El Oxfordense en la zona Subbética. – Cuad. Geol. Univ. Granada, **10**: 463-474, 5 Abb.; Granada.
- SPATH, L. F. (1924): On the Blake collection of ammonites of Kachh, India. – Paleont. Indica, N. S. **9** (1): 1-29; 2 Tab.; Calcutta.
- SPATH, L. F. (1927-1933): Revision of the Jurassic cephalopod fauna of Kachh (Cutch). – India Geol. Surv., Mem. Paleont. Indica, N. S. **9** (2), 1-6.- 945 S., 130 Taf.; Calcutta.
- STEINMANN, G. (1881): Zur Kenntnis der Jura- und Kreideformation von Caracoles (Bolivia). – N. Jb. Min. Geol. Paläont., B.-Bd., **1** (2): 239-301, 4 Abb., 9-14 Taf., 1 Tab.; Stuttgart.
- STIPANICIC, P. N. (1951): Sobre la presencia del Oxfordense Superior en el arroyo de la Manga. – Rev. Asoc. Geol. Argentina, **6** (4): 213-239, 4 Abb., 3 Taf.; Buenos Aires.
- (1966): El Jurásico en Vega de la Veranada (Neuquen), el Oxfordense y el distrofismo divesiano (Agassiz-Yaila) en Argentina. – Rev. Asoc. Geol. Argentina, **20** (4): 403-478, 14 Abb., 15 Taf.; Buenos Aires.

- STIPANICIC, P. N. (1969): El avance en los conocimientos del Jurásico Argentino a partir del esquema de GROEBER. – *Rev. Asoc. Geol. Argentina*, **24** (4): 367-388, 1 Abb., 1 Tab.; Buenos Aires.
- WIERZBOWSKI, A. (1976): Oxfordian Ammonites of the Pinar del Rio province (western Cuba); their revision and stratigraphical significance. – *Acta Geol. Polonica*, **26** (2): 137-260, 23 Abb., 3 Taf.; Warszawa.
- (1978): Ammonites and stratigraphy of the Upper Oxfordian of the Wielun Upland, Central Poland. – *Acta Geol. Polonica*, **28** (3): 299-333, 7 Abb., 10 Taf.; Warszawa.
- YOUNG, K. & OLÓRIZ, F. (1993): Ammonites from the Smackover Limestone, Cotton Valley Field, Webster Parish, Louisiana, U.S.A. – In: ELMÍ, S., MANGOLD, CH. & ALMÉRAS, Y. (Eds.): 3ème Symposium International Céphalopodes Actuels et Fossiles (Symposium F. Roman). – *Géobios, M.S.*, **15**: 401-409, 5 Abb., 2 Taf.; Lyon.

Bei der Tübinger Schriftleitung eingegangen an 4. Juli 1997.

Zum Druck angenommen am 11. August 1997.

Anschriften der Verfasser:

Dr. RYSZARD MYCZYŃSKI, Institute of Geological Sciences, Polish Academy of Sciences, Twarda 51/55, PL-00-818 Warszawa.

Prof. Dr. FEDERICO OLÓRIZ, Departamento de Estratigrafía y Paleontología, Facultad de Ciencias, Universidad de Granada, av. Fuentenueva s/n.; E-18002 Granada.

Dr. ANA B. VILLASEÑOR, Departamento de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México, 04510 México, D.F.