Para Manuel de Andrés

Atti II Conv. Int. F.E.A. Pergola, 87	Pallini *et alii cur.*	pp. 405-415 1 tav., 3 figg.	Tithonian stratigraphy of Western Cuba

Tithonian stratigraphy in the Sierra de Los Organos, Western Cuba: correlation of the ammonite and microfossil zones

RYSZARD MYCZYŃSKI & ANDRZEJ PSZCZÓLKOWSKI

Institute of Geological Sciences, Polish Academy of Sciences, Al. Zwirki i Wigury 93, 02-089 Warszawa, Poland

RIASSUNTO

Sono state distinte 5 zone ad ammoniti e 3 zone a microfossili nel Titonico di Sierra de los Organos (Cuba). Viene proposta, nel Titonico inferiore, per la parte superiore della zona a Saccocoma, *la sottozona a* Colomisphaera spp.-Cadosina parvula. *Questa sottozona a microfossili corrisponde alla Zona a* Mazapilites spp. *e alla parte inferiore della Zona a* Pseudolissoceras *spp.*, Virgatosphinctes *spp. e* "Subplanites" *sp. La Zona a* Chitinoidella *viene qui correlata con la parte superiore della suddetta Zona ad ammoniti, così come con la Zona a* Lytohoplites carribeanus *del Titonico inferiore e con la parte basale della zona soprastante a* Proniceras, Durangites, Kossmatia *e* Corongoceras. *La Zona a* Crassicollaria *del Titonico superiore corrisponde alla parte principale della Zona a* Proniceras, Durangites, Kossmatia *e* Corongoceras *e alla Zona a* Protancyloceras hondense-Vinalesites rosariensis. *A Cuba la Zona a* Chitinoidella *non può essere considerata come equivalente del Titonico medio. Per questo motivo nel presente lavoro verrà impiegata una suddivisione bipartita del Titonico.*

ABSTRACT

Five ammonite zones, as well as three microfossil zones and three subzones have been distinguished in the Tithonian of the Sierra de los Organos in western Cuba. The Lower Tithonian Colomisphaera *spp.*-Cadosina parvula *Subzone is proposed for the upper part of the* Saccocoma *Zone. This microfossil subzone corresponds to the* Mazapilites *spp. Zone and to the lower part of the* Pseudolissoceras *spp.*, Virgatosphinctes *spp. and* "Subplanites" *sp. Zone. The* Chitinoidella *Zone is correlated herein with the upper part of the last mentioned ammonite zone, as well as with the Lower Tithonian* Lytohoplites carribeanus *Zone, and the lowermost part of the higher* Proniceras, Durangites, Kossmatia *and* Corongoceras *Zone. The Upper Tithonian* Crassicollaria *Zone corresponds to the bulk of the* Proniceras, Durangites, Kossmatia *and* Corongoceras *Zone, and to the* Protancyloceras hondense-Vinalesites rosariensis *Zone. In Cuba, the* Chitinoidella *Zone cannot be considered as the equivalent to the Middle Tithonian. For this reason, the bipartite division of the Tithonian stage is used in this study.*

KEY WORDS

Biostratigraphy, ammonite zone, microfossil zone, subzone, correlation, Tithonian, Sierra de los Organos, Cuba.

INTRODUCTION

As yet, the biostratigraphic zonations for the Tithonian based on the ammonite fauna and microfossils were not compared in Cuba. Some observations concerning the co-occurrence of the ammonites and calpionellids were made by Kreisel & Furrazola-Bermúdez (1971) and Pop (1976). Recently, a new biostratigraphic subdivision based on ammonite assemblages has been proposed for the Tithonian in the Sierra de los Organos, western Cuba (Myczyński, 1987). It made possible the correlation of the ammonite assemblages with the microfossil zones.

In the present paper, the ammonite biostratigraphy has been elaborated by the first author (R. Myczyński), and the microfossils have been studied by the second (A. Pszczólkowski).

PREVIOUS WORK

Some Tithonian ammonites were collected by R.E. Dickerson, E. Alemán, A. Martinez and W.H. Butt in the Sierra de los Organos (cf. Dickerson & Butt, 1935). These ammonites were studied by Imlay (1942). That collection contained some specimens of *Hildoglochiceras* and *Parodontoceras* found in the Vinales area (cf. Imlay, 1942). Nevertheless, the bulk of the ammonite fauna studied by Imlay (1942) came from the Sierra del Rosario and from central Cuba. Later on, the Tithonian ammonites of the Sierra de los Organos were investigated by Judoley & Furrazola-Bermúdez (1965, 1968), Housa & Nuez (1972, 1973, 1975), and Housa (1974). One of the authors of the present paper (R. Myczyński) has studied the Tithonian ammonites of the Sierra de los Organos in the years 1972-1986, initially for the 1:250.000-scale geological map of the Pinar del Río Province, and then as a part of a separate study on the ammonite biostratigraphy of the Upper Jurassic and Lower Cretaceous in western Cuba.

The Tithonian microfossils of the Pinar del Río Province were studied by Furrazola-Bermúdez (1965) and later on by Kreisel & Furrazola-Bermúdez (1971), and Furrazola-Bermúdez & Kreisel (1973). These authors recognized the following microfossil zones: *Chitinoidella, Crassicollaria* and *Calpionella* (lower part). Pop (1976) has distinguished *Crassicollaria* Zone in the Tithonian limestones of the Sierra de los Organos ("Artemisa Formation") in the San Vincente and Hacienda El Americano sections. Pszczólkowski (1978) has correlated the middle and upper parts of the El Americano Member of the Guasasa Formation with the *Chitinoidella* and *Crassicollaria* Zones, respectively. Moreover, in the last mentioned work the Tithonian/Berriasian boundary has been placed at the limit of the *Crassicollaria* and *Calpionella* Zones for the first time in Cuba.

LITHOSTRATIGRAPHY

The Late Jurassic sediments of the Guasasa Formation in the Sierra de los Organos (Fig. 1) belong to the San Vicente and El Americano Members (Tab. 1). The San Vicente Member (Herrera, 1961) consists of thick-bedded or massive, grey to black limestones, frequently dolomitized and sometimes with nodules or lenses of black chert.

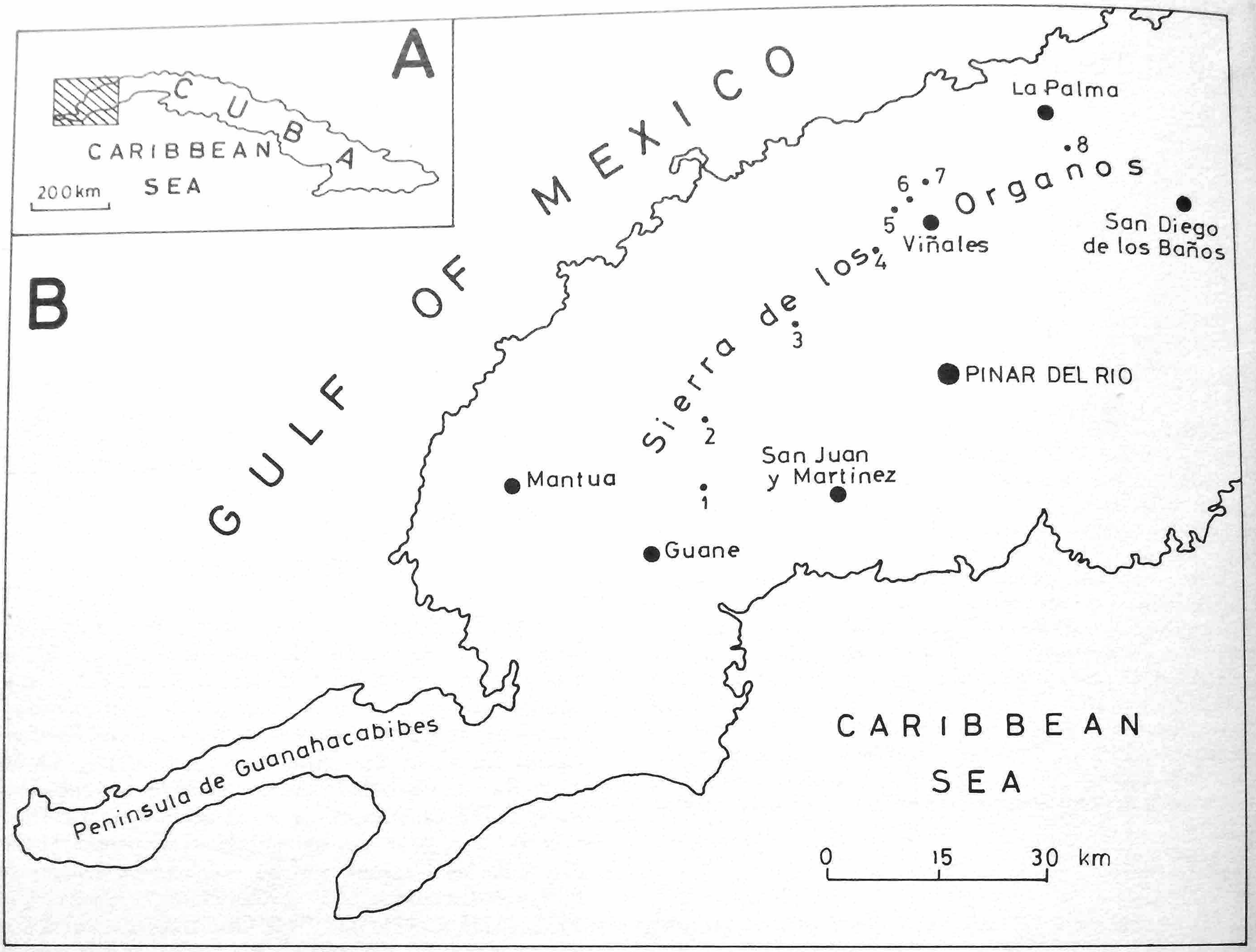

Fig. 1 - A: Location map of the study area in Cuba marked by oblique lines and presented also in Fig. 1 B; B - Sketch map showing location of the studied Tithonian sections in the Sierra de los Organos, Pinar del Río Province: 1 - section located south of Punta de la Sierra and north of Guane, 2 - Mal Paso section located north of Guane, 3 - Sierra de Cabezas section, 4 - Sierra del Infierno section, 5 - Valle del Ancón section, 6 - Sierra de Vinales section, 7 - San Vicente section, 8 - Hacienda El Americano section.

The micritic *Favreina*-bearing limestones predominate in the lower part of the member, while algal and/or oncolitic calcarenites are frequent in the upper part. In some sections of the upper part of the San Vicente Member there are some horizons of micritic, laminated limestones up to several meters thick. The San Vicente Member attains 650 m in thickness. Its age has been defined as the Late Oxfordian-lowermost Tithonian (Pszozólkowski, 1978).

The El Americano Member (Housa & Nuez, 1972) comprises bedded dark-grey to black limestones, sometimes with thin interbeds of marly limestone. Some limestone beds are partly dolomitized. There are some ammonitic coquinas with phosphatic fish detritus in the upper part of the Member. Thickness of the El Americano Member varies from 20 to 45 meters in the studied sections. These limestones have been assigned to the Tithonian, except for the lowermost part of this stage (Housa, 1974; Pszzólkowski, 1978). Transition from the El Americano Member to the Tumbadero Member (Herrera, 1961) is gradual. The latter member consists of thin-bedded micritic limestones and biomicrites, frequently laminated, with interbeds of black chert. Thickness of the Tumbadero Member limestones attains 50 meters. Age of this lithostratigraphic unit is Berriasian (Pszczólkowski, 1978).

AMMONITE ZONES

MAZAPILITES SPP. ZONE

The *Mazapilites* spp. Taxon-range-zone is the oldest ammonite biostratigraphic unit in the Lower Tithonian of the Sierra de los Organos (Tab. 1). The following ammonite genera are represented in this Zone: *Mazapilites* Burckhardt, 1919, (Pl. 1, fig. 1), *Protancyloceras* [(*P.* sp. aff. *gracile* (Oppel), Pl. 1, fig. 2], *Nebrodites* Burckhardt, 1912, *Lithacoceras* Hyatt, 1900, and *Pseudolissoceras* Spath, 1925. The horizon with *Mazapilites* has been distinguished by Housa & Nuez (1975). Thickness of the sediments assigned to this zone does not exceed 1 meter in the Hacienda El Americano area (Fig. 1 B, section 8). The lower boundary of the *Mazapilites* spp. Zone is placed at the base of the El Americano Member. The thick-bedded to massive limestones of the San Vicente Member are barren of ammonites. The upper boundary of this zone is indicated by disappearance of the genus *Mazapilites*. The ammonite zone under consideration has been recognized only in the easternmost part of the Sierra de los Organos. In the western part of this region, the *Mazapilites* spp. Zone is poorly documented (cf. Myczyński, 1987). In the Sierra de Cabezas area (Fig. 1 B, section 3) one specimen of *Lithacoceras* sp. has been collect-

STAGES	AMMONITE ZONES (ASSEMBLAGES) (after Myczyński, 1987)	MICROFOSSIL ZONES AND SUBZONES		FORMATION	MEMBER
LOWER BERRIASIAN	"Parodontoceras"	Calpionella	C. elliptica	SAN CAYETANO	TUMBADERO
			C. alpina		
TITHONIAN UPPER	Vinalesites rosariensis Protancyloceras hondense	Hildoglochiceras (Salinites) Parodontoceras	Crassicollaria		EL AMERICANO
	Proniceras Durangites, Kossmatia and Corongoceras		intermedia		
			T. remanei		
	Lytohoplites carribeanus		Chitinoidella		
TITHONIAN LOWER	Pseudolissoceras spp. Virgatosphinctes spp. and "Subplanites" sp.		Colomisphaera spp., Cadosina parvula	GUASASA	SAN VICENTE (UPPER PART)
	Mazapilites spp.	Saccocoma			
UPPER KIMMERIDGIAN ? ?					

Table 1 - Correlation of the Tithonian ammonite and microfossil zones in the Sierra de los Organos, western Cuba. The lithostratigraphic units are also shown (not to scale).

ed, together with *Pseudolissoceras* sp. These ammonites seem to indicate the *Mazapilites* spp. Zone, although the index taxon has not been found in this area.

PSEUDOLISSOCERAS SPP., *VIRGATOSPHINCTES* SPP. AND *"SUBPLANITES"* SP. ASSEMBLAGE-ZONE.

Besides the index taxa the following ammonites occur in this Lower Tithonian zone: *Phylloceras* spp., *Lytoceras* sp., *Neochetoceras* spp., *Pseudoinvoluticeras* (*P. mozambicum* Collignon group), *Pachysphinctes* sp., *Aulacosphinctoides* spp. (Pl. 1, fig. 7), and *Torquatisphinctes* spp. In the lowermost part of this zone the specimens of *Protancyloceras* (*P. gracile* (Oppel) group) were also found. *Pseudolissoceras* (Pl. 1, fig. 6), is more frequent in the lower part than in the upper one of this zone. Thickness of the strata assigned to the *Pseudolissoceras* spp., *Virgatosphinctes* spp., and *"Subplanites"* sp. Zone varies from 2.5 meters in the Hacienda El Americano section to a maximum of 10 meters in some other sections. The lower boundary of this zone is defined by appearance of the genera *Virgatosphinctes* Uhlig, 1910 and *"Subplanites"* sp., and the absence of *Mazapilites*. Its upper boundary is placed directly below the bed containing *Lytohoplites carribeanus* Imlay, 1942, where *Virgatosphinctes, Pseudolissoceras* and *"Subplanites"* are not yet present. The zone under consideration is better documented in the easternmost part of the Sierra de los Organos, than in other areas of this region.

LYTOHOPLITES CARRIBEANUS TAXON-RANGE -ZONE

The *Lytohoplites carribeanus* Zone is the highest Lower Tithonian zone in the Sierra de los Organos (Tab. 1). This zone has been distinguished in the Hacienda El Americano section, where it contains ammonites of the genus *Lytohoplites* Spath, 1925 as the most characteristic faunal element, with the index species *L. carribeanus* Imlay, 1942. The upper part of the zone under consideration includes also some ammonites of the genus *Parodontoceras* Spath, 1923 and the subgenus *Hildoglochiceras (Salinites)* (cf. Cantu Chapa, 1968 and Myczyński, 1987), as well as bivalves *Buchia*.

The lower boundary of the *L. carribeanus* Zone corresponds to the first occurrence of the index taxon, whereas the upper one is located above the last appearance of this species. The latter boundary is additionally indicated by the presence of frequent specimens of *Hildoglochiceras (Salinites)* and Himalayitinae in the lowermost part of the next zone. The *L. carribeanus* Zone is only 0.8 meter thick in the Hacienda El Americano section and its ammonite fauna is distinctly less numerous in comparison with the two older Lower Tithonian zones.

PRONICERAS, DURANGITES, KOSSMATIA AND CORONGOCERAS ASSEMBLAGE-ZONE

The Upper Tithonian *Proniceras, Durangites, Kossmatia* and *Corongoceras* Assemblage-zone has been recognized directly above the *L. carribeanus* Zone (Tab. 1). In addition to the index taxa, the former zone includes *Hildoglochiceras (Salinites)* (Pl. 1, fig. 3), *Himalayites* (Pl. 1, figs. 4, 5), *Micracanthoceras, ? Aulacosphinctes, "Haploceras", Phanerostephanus, Parodontoceras, Hemisimoceras* and abundant bivales *Buchia*. The stratotype of this biostratigraphic unit has been designated in the Hacienda El Americano section. The *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone has been distinguished in the eastern part of Sierra de los Organos. Thickness of the strata assigned to this zone varies from 1,5 to 13 meters in the studied sections. The lower boundary is defined by the first occurrence of *Corongoceras, Kossmatia* and *Durangites* (Pl. 1, fig. 8), and the upper one is indicated by disappearance of index fossils. The ammonites are frequently damaged (coquinas), and the ranges of the individual taxa are difficult to establish within this zone.

In the southwestern part of the Sierra de los Organos, for example in the Guane area (Fig. 1 B, sections 1 and 2), the recognition of the *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone may be difficult due to relatively rare occurrences of the index taxa. In this area *Hildoglochiceras (Salinites)* and *Parodontoceras* are the dominant taxa for the Upper Tithonian ammonite succession.

PROTANCYLOCERAS HONDENSE-VINALESITES ROSARIENSIS ACME-ZONE

The youngest ammonite assemblage in the Tithonian of the Sierra de los Organos belongs to the *Protancyloceras hondense-Vinalesites rosariensis* Acme-zone. The uncoiled ammonites prevail in this assemblage. *Protancyloceras* spp. occurs in the lower part of the *P. hondense-V. rosariensis* Zone 1.5 meter thick, whereas *Vinalesites* is known from its upper part 6.5 meter thick. The lower boundary of this zone is indicated by the first abundant occurrence of *P. hondense* (Imlay, 1942), and *P. catalinense* (Imlay, 1942). The upper boundary was designated on the basis of the disappearance of *Vinalesites rosariensis* (Imlay, 1942). In the *P. hondense-V. rosariensis* Zone few specimens of *Hildoglochiceras* were also found. The number of ammonite taxa and the frequency of specimens are distinctly lower in this zone as compared to the older *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone. In the Hacienda El Americano and Valle del Ancón sections (Fig. 1 B, sections 5 and 8), the top of the *P. hondense-V. rosariensis* Zone correlates with the boundary of the El Americano and Tumbadero Members. However, in the Sierra del Infierno section (Fig. 1 B, section 4), the upper boundary of this zone occurs in the lowermost part of the Tumbadero Member. The Lower Berriasian sediments of this member contain rare ammonites assigned to *"Parodontoceras"* sp. (Myczyński, 1987).

MICROFOSSIL ZONES

SACCOCOMA PARTIAL-RANGE-ZONE

Until now, the *Saccocoma* Zone has not been distinguished in Cuba. The index fossil (*Saccocoma*, sp. - Pl. 1, figs. 13, 14) is abundant, and sometimes rock-forming, in the upper part of this zone (Tab. 2). Besides index taxon, the following microfossils have been recognized in the *Saccocoma* Zone: *Colomisphaera carpathica* (Borza, 1964) (Pl. 1, fig. 16), *C. cieszynica* Nowak, 1968, *C. pulla* (Borza, 1964) (Pl. 1, fig. 15), *Cadosina parvula* Nagy, 1966 (Pl. 1, fig. 22), *Cadosina* cf. *fusca* Wanner, 1940 (Pl. 1, figs. 20, 21), *Globochaete alpina* Lombard, and *Globochaete*-like microorganisms (Pl. 1, figs. 9-11). Some benthonic Foraminifera and algal fragments occur in the lower part of this zone. Its lower boundary is indicated

by appearance of the index fossil in the upper part of the San Vicente Member. In the Sierra de Vinales section (Fig. 1 B, section 6), the specimens of *Saccocoma* were observed 50 meters below the top of the San Vicente Member. The upper boundary of the *Saccocoma* Zone is marked by the first occurrence of *Chitinoidella*. *Saccocoma* fragments were also recorded in the Upper Tithonian sediments of the Sierra de los Organos (Tab. 2), nevertheless, these planktonic crinoids are distnictly less frequent above the *Saccocoma* Partial-range-zone.

Thickness of the sediments assigned to the *Saccocoma* Zone reaches 75 meters in the studied sections. This biostratigraphic unit comprises the lower part of the Lower Tithonian, and probably, the Upper Kimmeridgian

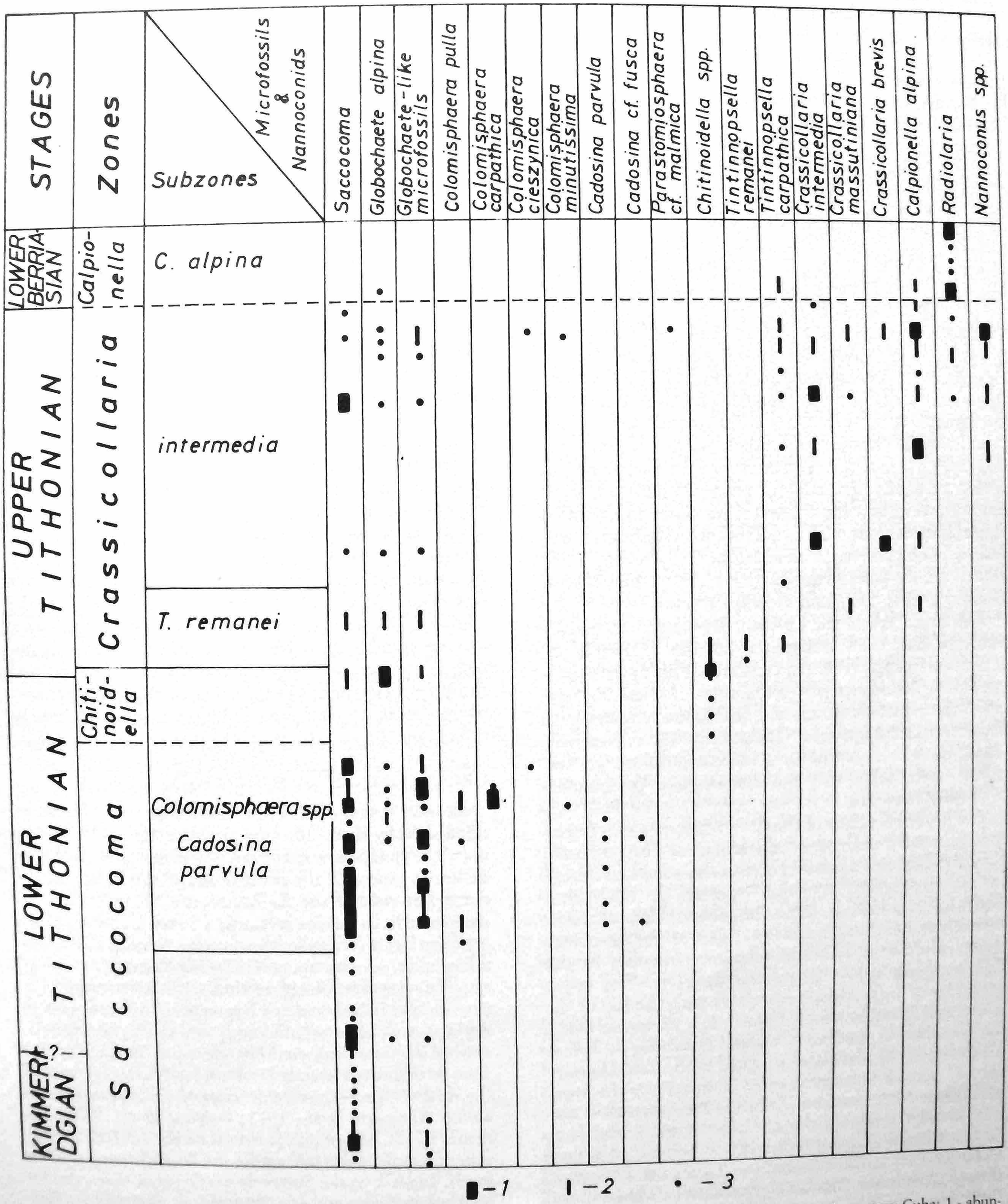

Table 2 - Occurrence of microfossils in the studied samples of the Tithonian limestones from the Sierra de los Organos in western Cuba: 1 - abundant, 2 - frequent, 3 - less frequent or rare.

(Tab. 1). In Europe, the *Saccocoma* Partial-range-zone has been established in Romania (Dragastan *et al.* 1975). According to these authors, the *Saccocoma* Zone is of Kimmeridgian age in the Eastern Carpathians, but correlates with the Upper Kimmeridgian and the Lower Tithonian on the Moesian platform. In the Western Carpathians, Borza (1969, 1984) has not distinguished the *Saccocoma* Zone, although he recognized *Saccocoma* sp. as characteristic microfossil for the Kimmeridgian and Tithonian, with its acme during Kimmeridgian-Lower Tithonian time.

COLOMISPHAERA SPP.-*CADOSINA PARVULA* ASSEMBLAGE - SUBZONE

This subzone is a new biostratigraphic unit in the Sierra de los Organos and in Cuba in general. The *Colomisphaera* spp. - *Cadosina parvula* Subzone corresponds to the upper part of the *Saccocoma* Zone (Tab. 1). The following taxa are diagnostic for this subzone: *Colomisphaera pulla* (Borza, 1964) (Pl. 1, fig. 15), *C. carpathica* (Borza, 1964) (Pl. 1, figs. 16, 17), and *Cadosina parvula* Nagy, 1966 (Pl. 1, fig. 22). Moreover, *Saccocoma* sp. (Pl. 1, fig. 14), *Colomisphaera cieszynica* Nowak, 1968, *C. minutissima* (Colom., 1935), *Cadosina* cf. *fusca* Wanner, 1940 (Pl. 1, figs. 20, 21), *Globochaete alpina* Lombard and *Globochete*-like microfossils, are also present. The *Globochaete*-like microfossils (Pl. 1, figs. 9-11) differ from *G. alpina* Lombard by radial arrangement of their calcite crystals. Contrary to *G. alpina*, these microfossils frequently do not reveal a distinct dark cross in polarized light, although few specimens may show this feature. Some forms under consideration are similar to microorganisms described as *Stomiosphaera colomi* Durand Delga, 1957 (Pl. 1, fig. 9) and *S. moreti* Durand Delga, 1957 (Pl. 1, fig. 11) (cf. Durand Delga, 1957 and Nowak, 1968).

The stratotype of the *Colomisphaera* spp. - *C. parvula* Subzone has been designated in the Hacienda El Americano section (Fig. 1B, section 8). This subzone contains dark limestones with ammonites. Typical microfacies include biocalcisiltites and fine biocalcarenites with abundant *Saccocoma* and *Globochaete*-like microfossils (Pl. 1, fig. 12). *Colomisphaera* and *Cadosina* are less frequent, nevertheless they are characteristic components of these limestones.

The lower boundary of the *Colomisphaera* spp. - *C. parvula* Subzone is defined by appearance of *Colomisphaera pulla* and *Cadosina parvula*. There is also a marked change in the frequency of other species of the genus *Colomisphaera* Nowak, 1968. In general, *Colomisphaera* is poorly represented in the lower part of the *Saccocoma* Zone, whereas it becomes relatively frequent in the *Colomisphaera* spp. - *C. parvula* Subzone. The upper boundary of this subzone correlates with the top of the *Saccocoma* Zone; however, *C. pulla* may disappear below the boundary of the *Saccocoma* and *Chitinoidella* Zones. Thickness of the limestones assigned to the *Colomisphaera* spp.- *C. parvula* Subzone is up to 20 meters, in the lower part of the El Americano Member. This subzone is correlated with the middle part of the Lower Tithonian.

According to Borza (1984), in the Western Carpathians *Colomisphaera pulla* occurs in the lowermost Tithonian, *C. carpathica* in the Kimmeridgian-Middle Tithonian, and *Cadosina parvula* is known from the Oxfordian to the Middle Tithonian.

CHITINOIDELLA ZONE

In Cuba, the *Chitinoidella* Zone has been distinguished by Kreisel & Furrazola-Bermúdez (1971) in the Pinar del Río Province. In the Sierra de los Organos, this zone was recognized in the middle part of the El Americano Member (Pszczólkowski, 1978). During the present study, few specimens of *Chitinoidella bermudezi* (Furrazola-Bermúdez, 1965) and *Ch.* cf. *cubensis* (Furrazola-Bermúdez, 1965) have been found in the lowermost part of the *Crassicollaria* Standard Zone. For this reason, the *Chitinoidella* Zone seems to be a Partial-range-zone, i.e. the range of its index taxon (genus *Chitinoidella* Doben, 1963) probably comprises also the basal part of the *Crassicollaria* Zone.

In the *Chitinoidella* Zone the following microorganisms have been identified: *Chitinoidella boneti* Doben, 1963 (Pl. 1, fig. 23), *Ch.* cf. *boneti* Doben, 1963 (Pl. 1, fig. 24), *Ch.* cf. *bermudezi* (Furrazola-Bermúdez, 1965) (Pl. 1, fig. 26), *Chitinoidella* sp. (Pl. 1, fig. 25), *Saccocoma* sp., *Globochaete alpina* Lombard and *Globochaete*-like microfossils. The lower boundary of this zone is defined by the first occurrence of the index taxon, nonetheless, sometimes it is not easy to recognize because of the scarcity and/or poor preservation of the loricae of *Chitinoidella* in the lowermost part of the zone. Its upper boundary is indicated by appearance of the first Calpionellidae with fully hyaline lorica, of the genera *Tintinnopsella* and *Crassicollaria*.

The pelmicrosparites, biomicrites and micritic limestones with ammonites, fish phosphatic debris, and microorganisms constitute the bulk of the *Chitinoidella* Zone sediments. Their thickness attains from 2 to 5 meters in various sections. According to Kreisel & Furrazola-Bermúdez (1971) and Furrazola-Bermúdez & Kreisel (1973), the *Chitinoidella* Zone corresponds to the Middle Tithonian. In the bipartite division of the Tithonian accepted herein, this zone correlates with the higher part of the Lower Tithonian and the lowermost part of the Upper Tithonian (Tab. 1). The stratigraphic position of the *Chitinoidella* Zone will be discussed farther on in this paper.

CRASSICOLLARIA STANDARD ZONE

In the Pinar del Río Province this zone has been distinguished by Kreisel & Furrazola-Bermúdez (1971), and later by Pop (1976) and Pszczólkowski (1978) in the Sierra de los Organos. In the present study, the limestones of the upper part of the El Americano Member, 7 to 20 meters thick in various sections, are included in the *Crassicollaria* Zone. These limestones comprise ammonitic coquinas, micrites with ammonites and calpionellids, as well as pelmicrites and biocalcisiltites with *Saccocoma*, calpionellids and fish phosphatic fragments. The lower boundary of the *Crassicollaria* Zone is defined by the appearance of *Tintinnopsella* and *Crassicollaria*. The top of this zone is delimited mainly by morphological change and the relative increase in the frequency of *Calpionella alpina* (cf. Allemann & al., 1971; Remane & al., 1986; Remane, 1986), and to minor extent on the basis of extinction of *Crassicollaria intermedia*, *Cr. massutiniana*, and *Cr. brevis*. Indeed, in the Sierra de los Organos these species of *Crassicollaria are less frequent at the Crassicollaria/Calpionella* Zones boundary, but according to Pop (1976) specimens of *Cr. massutiniana* and *Cr. intermedia*

occur even in the upper part of the *Calpionella* Standard Zone, in the Valle del Ancón section.

TINTINNOPSELLA REMANEI SUBZONE

In few samples taken from the upper part of the El Americano Member, the following taxa have been found to occur together: *Chitinoidella bermudezi* (Furrazola-Bermúdez, 1965), *Ch.* cf. *cubensis* (Furrazola-Bermúdez, 1965), *Chitinoidella* sp., *Crassicollaria* sp., *Tintinnopsella remanei* Borza, 1969, and *T.* cf. *carpathica* (Murgeanu & Filipescu, 1933). In this assemblage the specimens of *Tintinnopsella* spp. are dominant, the representatives of other two genera being less frequent. The above-mentioned microfossil assemblage has been included to the *T. remanei* Subzone. This subzone was established in Europe (Remane & al., 1986), in the lower part of the *Crassicollaria* Standard Zone, as the equivalent to the A1 Subzone of Remane (1964). Until now, the *Crassicollaria* Zone remained undivided into subzones in Cuba.

The younger assemblage consisting of *Crassicollaria* cf. *massutiniana, Crassicollaria* sp., *Tintinnopsella* sp. and *Calpionella alpina* (small forms) has been assigned to the upper part of the *T. remanei* Subzone. The latter comprises the limestones 1 to 3 (?) meters thick in the eastern part of the Sierra de los Organos. However, it may be difficult to find this subzone in those sections where the Tithonian sediments are thin.

CRASSICOLLARIA INTERMEDIA SUBZONE

The *Crassicollaria intermedia* Subzone is considered here in accordance to its definition given by Remane & al. (1986). In the Sierra de los Organos, this subzone includes the limestones of the upper part of the El Americano Member (Tab. 1). Besides th index taxon, the following calpionellids were found in the *Cr. intermedia* Subzone: *Crassicollaria massutiniana, Cr. brevis, Cr.* cf. *parvula, Tintinnopsella carpathica, Calpionella alpina* (Pl. 1, fig. 27). There are also present: *Saccocoma* sp., *Parastomiosphaera* cf. *malmica* (Borza, 1964), *Colomisphaera minutissima* (colom, 1935), *cieszynica* Nowak, 1968 (Pl. 1, fig. 19), *C.* cf. *carpathica* (Borza, 1964) (Pl. 1, fig. 18) and *Nannoconus steinmanni* Kamptner, 1931, Radiolaria, *Globochaete alpina* Lombard, and *Globochaete*-like microorganisms. *Saccocoma* is frequent in some samples only, for example, in those taken from the San Vicente section (Fig. 1 B, section 7), whereas radiolarians appear in the upper part of the *Cr. intermedia* Subzone (Tab. 2).

Base of the *Cr. intermedia* Subzone has been defined by appearance of large forms of *C. alpina* (cf. Remane & al., 1986), and in addition, by the acme of the genus *Crassicollaria*. The top of the subzone correlates approximately with the El Americano/Tumbadero Members boundary (Tab. 1), but in the Sierra del Infierno section the oldest sediments of the Tumbadero Member belong to the uppermost Tithonian. In the lower part of the Tumbadero Member, the radiolarian microfacies becomes dominant, whereas calpionellids are often poorly preserved.

CORRELATION OF THE AMMONITE AND MICROFOSSIL ZONES

In the Sierra de los Organos, the Lower Tithonian ammonite Zones *Mazapilites* spp., and *Pseudolissoceras* spp., *Virgatosphinctes* spp. and "*Subplanites*" sp. correlate with the upper part of the *Saccocoma* Zone and the lower part of the *Chitinoidella* Zone (Tab. 1). The *Colomisphaera* spp. - *C. parvula* Subzone corresponds to the *Mazapilites* spp. Zone and to the bulk of the *Pseudolissoceras* spp., *Virgatosphinctes* spp. and "*Subplanites*" sp. Zone. The uppermost part of the latter zone must be coeval to the lower part of the *Chitinoidella* Zone, as in some sections *Pseudolissoceras* occurs together with *Chitinoidella boneti* (Myczyński, 1987). Moreover, in the southwestern area of the Sierra de los Organos (north of Guane), *Torquatisphinctes* has been found together with *Chitinoidella* sp.

The higher, Lower Tithonian *Lytohoplites carribeanus* Zone corresponds to a part of the *Chitinoidella* Zone. The latter zone reaches up to the lowermost Upper Tithonian, because of the co-occurrence of *Chitinoidella* with *Micracanthoceras* and *Hildoglochiceras (Salinites).*

The Upper Tithonian *Crassicollaria* Zone corresponds to the bulk of the *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone, as well as to the younger *P. hondense-V. rosariensis* Zone (Tab. 1). The lower boundary of the *Crassicollaria* Zone occurs somewhat above the base of the *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone. The calpionellid *T. remanei* Subzone is compared here with the lower part of this ammonite zone. The *Cr. intermedia* Subzone is correlated with the upper part of the same ammonite zone, and with the *P. hondense-V. rosariensis* Zone. However, the upper boundaries of the *Crassicollaria* and the *P. hondense-V. rosariensis* Zones could not be compared accurately because of scarcity of ammonites and poorer preservation of calpionellids at the El Americano/Tumbadero Members limit. For this reason, and taking into account the co-occurrence of *Protancyloceras* cf. *hondense* and *P.* cf. *catalinense* with *Substeueroceras* and *Parodontoceras* in Mexico (Imlay, 1980), one cannot rule out a possibility that a part of the *P. hondense-V. rosariensis* Zone in the Sierra de los Organos corresponds to the *Substeueroceras-Proniceras* assemblage of Imlay (1980) or to the *Substeueroceras-Berriasella* assemblage of Verma & Westermann (1973) in Mexico.

Rare ammonites assigned to "*Parodontoceras*" sp. (Myczyński, 1987) have been found in the Lower Berriasian limestones of the Tumbadero Member. This distinct impoverishment of macrofauna is accompanied by a quantitative and/or qualitative change of various microfossils (Calpionellidae, Radiolaria, Saccocoma, Stomiosphaeridae). Above the Tithonian/Berriasian boundary, a marked development of the radiolarian-rich microfacies is the characteristic feature of the Lower Berriasian sediments of the Tumbadero Member (Tab. 2). Similar changes in macro- and microfossil record were observed by the present authors near the Tithonian/Berriasian boundary in the Sierra del Rosario of western Cuba.

PROBLEM OF THE MIDDLE TITHONIAN IN CUBA AND THE LOWER/UPPER TITHONIAN BOUNDARY IN THE SIERRA DE LOS ORGANOS

In Cuba, the *Chitinoidella* Zone was considered as the equivalent to the Middle Tithonian (Kreisel & Furrazola-Bermúdez, 1971; Furrazola-Bermúdez & Kreisel, 1973; Pszczólkowski, 1978). In Europe, the Middle Tithonian includes 3 ammonite Zones: *semiforme, fallauxi,* and *ponti* (Zeiss, 1986; Kutek & Wierzbowski, 1986). These ammonite zones have been recognized neither in Cuba, nor

in Mexico. In Spain, the *Chitinoidella* Zone is correlated with the ammonite Zones *fallauxi, ponti* and (partly) *microcanthum* (Enay & Geyssant, 1975), or *admirandum-biruncinatum, Burckhardticeras* and *Simplisphinctes* (Oloriz & Tavera, 1979, 1983).

In the Sierra de los Organos, the *Chitinoidella* Zone corresponds to the uppermost part of the *Pseudolissoceras* spp., *Virgatosphinctes* spp. and "*Subplanites*" sp. Zone, the *L. carribeanus* Zone and to the lowermost part of the *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone. These ammonite assemblages cannot be correlated exactly with the Mediterranean zones of Europe, because of contrasting biostratigraphic subdivisions based upon different taxa. It appears, therefore, that the Tithonian biostratigraphic scheme for the Sierra de los Organos (Tab. 1) may be compared with the Mediterranean zonations only approximately, and rather by means of microfossils than of ammonites. Since the *Chitinoidella* Zone does not correlate exactly with the Middle Tithonian in the Mediterranean region (Spain), this microfossil zone cannot correspond to the Middle Tithonian in Cuba. For these reasons, the authors use bipartite division of the Tithonian in the present study, in agreement with some earlier works concerning the Tithonian of the Gulf of Mexico region (Verma & Westermann, 1973; Imlay, 1980).

In western Cuba, the Lower/Upper Tithonian boundary has been defined by appearance of the first Himalayitinae (*Corongoceras, Durangites, Micracanthoceras, Himalayites*) (Myczyński, 1987). This faunal change was a widespread phenomenon and therefore offers some possibilities of biostratigraphic correlation between distant regions. In the Sierra de los Organos, the above-mentioned boundary is enhanced by the abundance of *Hildoglochiceras* (*Salinites*) although the first representatives of this taxon have appeared somewhat earlier, in the upper part of the *L. carribeanus* Zone. The Lower/Upper Tithonian boundary, as defined in the Sierra de los Organos, may correspond to the same one at the base of the *Simplisphinctes* Zone in the Betic Cordilleras of Spain (Oloriz & Tavera, 1979, 1983), but may be somewhat older, as well. At the moment, the accurate correlation of this boundary in western Cuba and the Mediterranean region is not possible. Nevertheless, the base of the *Crassicollaria* Standard Zone offers additional possibility to compare the biostratigraphic subdivisions of the above-mentioned areas. In the Betic Cordilleras, the base of this calpionellid zone is placed at the boundary of the *Simplisphinctes* and *Transitorius* Zones (Oloriz & Tavera, 1983). As explained above, in the Sierra de los Organos the base of the *Crassicollaria* Zone occurs in the lowermost part of tha *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone. Therefore, one may suppose that the lower part of the latter zone in western Cuba corresponds to the *Simplisphinctes* and *Transitorius* Zones in Spain.

CONCLUSIONS

1. Five ammonite zones have been distinguished in the Tithonian of the Sierra de los Organos, western Cuba (Myczyński, 1987). In the same area, three microfossil zones and three subzones has been recognized (Tab. 1).
2. The *Colomisphaera* spp.- *Cadosina parvula* Subzone of the Early Tithonian age is proposed for the upper part of the *Saccocoma* Zone. In some sections, the Upper Tithonian *Crassicollaria* Standard Zone may be divided into two subzones, namely *T. remanei* and *Cr. intermedia*.
3. Two Lower Tithonian ammonite Zones *Mazapilites* spp. and *Pseudolissoceras* spp., *Virgatosphinctes* spp. and "*Subplanites*" sp. correspond to the *Colomisphaera* spp.-*C. parvula* Subzone and to the lower part of the *Chitinoidella* Zone. The upper part of the last mentioned microfossil zone is correlated with the Lower Tithonian *L. carribeanus* Zone and the lowermost part of the Upper Tithonian *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone.
4. The Upper Tithonian *Crassicollaria* Zone correlates with the bulk of the *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone and with the *P. hondense-V. rosariensis* Zone.
5. In Cuba, the *Chitinoidella* Zone cannot be considered as the equivalent to the Middle Tithonian, as defined in Europe. For this reason, the bipartite division of the Tithonian stage is used in this study.
6. In the Sierra de los Organos, the Lower/Upper Tithonian boundary has been defined by appearance of Himalayitinae and abundant *Hildoglochiceras (Salinites)*.

ACKNOWLEDGMENTS

The authors are grateful to Docent Jerzy Lefeld for improving the English translation of the manuscript. The study was carried on within the 03.04 CPBP Programme, project 1.3.1.

REFERENCES

ALLEMANN, F., CATALANO, R., FARÈS, F. & REMANE, J., 1971 - Standard calpionellid zonation/Upper Tithonian-Valanginian/ of the western Mediterranean province: Proceed. II Plankt. conf., Roma 1970, 2, 1337-1340.

BORZA, K., 1969 - Die Mikrofazies und Mikrofossilien des Oberjuras und der Unterkreide der Klippenzone der Westkarpaten: 9-131, pp. 88 pls., Vydav. Slov. Akad. Vied, Bratislava.

BORZA, K., 1984 - The Upper Jurassic-Lower Cretaceous parabiostratigraphic scale on the basis of Tintinninae, Cadosinidae, Stomiosphaeridae, Calcisphaerulidae and other microfossils from the West Carpathians: Geol. Zborn., Geol. Carp., 35: 539-550.

CANTU CHAPA, A., 1968 - Sobre una Asociación Proniceras-Durangites "Hildoglochiceras" del Noreste de México: Inst. Mex. Petról. Sección Geologia, Monog. 2: 10-26, 2 pls.

DICKERSON, R. E. & BUTT, W. H., 1935 - Cuban Jurassic: Am. Assoc. Petrol. Geol., Bull., 19: 116-118.

DRAGASTAN, O., MUTIU, R. & VINOGRADOV, C., 1975 - Les zones micropaléontologiques et la limite Jurassique-Crétacé dans les Carpates orientales (Monts de Haghimas) et dans la plateforme moesienne: Mém. Bur. Rech. Géol. Min., 86: 188-203.

DURAND DELGA, M., 1957 - Quelques remarques sur les Fibrosphéres. Publ. du service de la carte géol. de l'Algérie (nouvelle série), Bull., 13: 155-164.

ENAY, R. & GEYSSANT, J., 1975 - Faunes d'ammonites du Tithonique des chaines bétiques (Espagne méridionale): Mém. Bur. Rech. Géol. Min., 86: 39-55.

FURRAZOLA-BERMÚDEZ, G., 1965 - Tres nuevas especies de Tintinidos del Jurásico Superior de Cuba: I.C.R.M., Publ. Esp., 2: 1-29, 4 pls.

FURRAZOLA-BERMÚDEZ, G. & KREISEL, K., 1973 - Los tintinidos fósiles de Cuba: Rev. Technol., 11: 27-45, 5 pls.

HERRERA, N., H., 1961 - Contribución a la Estratigrafía de la Provincia de Pinar del Río: Rev. Soc. Cub. Ing., 61: 22-44.

HOUSA, V., 1974 - Informe final sobre los trabajos de campo realizados para el estudio bioestratigráfico y la recolección de los ammonites de Tithoniano y Cretácico Inferior en algunas localidades en la provincia de Pinar del Río, Cuba: (Unpubl. rept. Inst. Geol. Paleont. Acad. Cienc. Cuba, La Habana).

HOUSA, V. & NUEZ, M., L., 1972 - Hallazgo de ammonites del Kimmeridgiano en Hacienda El Americano (Pinar del Río): Actas Acad. Cienc. Cuba, Inst. Geol., 2: 14-16.

HOUSA, V. & NUEZ, M., L., 1973 - Las faunas de ammonites del Tithoniano y del Infracretaceo de Cuba: Actas Acad. Cienc. Cuba, Inst. Geol., 3: 18-19.

HOUSA, V. & NUEZ, M., L., 1975 - Ammonite fauna of the Tithonian and lowermost Cretaceous of Cuba: Mém. Bur. Rech. Géol. Min., 86: 57.

IMLAY, R., W., 1942 - Late Jurassic fossils from Cuba and their economic significance: Bull. Geol. Soc. America, 53: 1417-1478, 12 pls.

IMLAY, R., W., 1980 - Jurassic Paleobiogeography of the Conterminous United States in Its Continental Setting: Geol. Surv. Prof. Paper, 1062: 1-127.

JUDOLEY, C., M., & FURRAZOLA-BERMÚDEZ, G., 1965 - Estratigrafía del Jurásico Superior de Cuba: Publ. Esp. I.C.R.M., 3: 1-26.

JUDOLEY, C., M. & FURRAZOLA-BERMÚDEZ, G., 1968 - Estratigrafía y fauna del Jurásico de Cuba: 1-126 pp., 81 pls. Inst. Cub. Recur. Minerales.

KREISEL, K. & FURRAZOLA-BERMÚDEZ, G., 1971 - Notas preliminares sobre la distribución de tintinidos en Cuba: Publ. Espec., 5: 1-24.

KUTEK, J. & WIERZBOWSKI, A., 1986 - A new account on the Upper Jurassic stratigraphy and ammonites of the Czorsztyn succession, Pieniny Klippen Belt, Poland: Acta Geol. Pol., 36: 289-316.

MYCZYŃSKI, R., 1987 - Tithonian ammonite biostratigraphy of western Cuba. (in press.).

NOWAK, W., 1968 - Stomiosferidy warstw cieszyńskich (kimeryd-hoteryw) polskiego Ślaska Cieszyńskiego i ich znaczenie stratygraficzne / Stomiosphaerids of the Cieszyn Beds / Kimmeridgian-Hauterivian / in the Polish Cieszyn Silesia and Their Stratigraphical Value /: Ann. Soc. Géol. Pologne, 38/2-3/: 275-334, 6 pls.

OLORIZ, F. & TAVERA, J. M., 1979 - El transito Tithonico Inferior - Tithonico Superior en las Cordilleras Béticas /Zona Sub - Bética/: Tecniterrae, 29: 1-10.

OLORIZ, F. & TAVERA, J. M., 1983 - Correlation of the Tithonian in Central Sector of the Betic Cordilleras/Spain/ in the Light of Recent Studies: Bull. Acad. Polon. Sci, Sér. Sci. Terre, 30/3-4/: 145-156.

POP, G., 1976 - Tithonian-Valanginian Calpionellid zones from Cuba: D.S. Sedint., 62: 237-266.

PSZCZÓLKOWSKI, A., 1978 - Geosynclinal sequences of the Cordillera de Guaniguanico in western Cuba; their lithostratigraphy, facies development, and paleogeography: Acta Geol. Polon., 28/1/: 1-96, 6 pls.

PSZCZÓLKOWSKI, A., 1981 - El banco carbonatado jurásico de la Sierra de los Organos, Provincia de Pinar del Río: su desarrollo y situación paleotectónica: Cien. Tierra Espa., 3: 37-50.

REMANE, J., 1964 - Untersuchungen zur Systematik und Stratigraphie der Calpionellen in den Jura-Kreide-Grenzschichten des Vocontischen Troges: Palaeontogr., 123 /1-3/: 1-57, 6 pls.

REMANE, J., 1986 - Calpionellids and the Jurassic-Cretaceous boundary: Acta Geol. Hung., 29 /1-2/: 15-26.

REMANE, J., BORZA, K., NAGY, I., BAKALOVA-IVANOVA, D., KNAUER, J., POP, G. & TARDI-FILÁCZ, E., 1986 - Agreement on the subdivision of the standard calpionellid zones defined at the IInd Planktonic Conference, Roma 1970: Acta Geol. Hung., 29 /1-2/: 5-14.

VERMA, H. M. & WESTERMANN, G. E. G., 1973 - The Tithonian /Jurassic/ Ammonite fauna and stratigraphy of Sierra Catorce, San Luis Potosi, Mexico: Bull. Amer. Paleont., 63 /227/: 107-320, 56 pls.

ZEISS, A., 1986 - Comments on a tentative correlation chart for the most important marine provinces at the Jurassic/Cretaceous boundary: Acta Geol. Hung., 29 /1-2/: 27-30.

Plate I

Fig. 1 - *Mazapilites zitteli* Burckhardt, 1906; *Mazapilites* spp. Zone, Lower Tithonian, Hacienda El Americano section; x 1.5.

Fig. 2 - *Protancyloceras* sp. aff. *Protancyloceras gracile* (Oppel in Zittel, 1870); *Mazapilites* spp. Zone, Lower Tithonian, Hacienda El Americano section; x 1.3.

Fig. 3 - *Hildoglochiceras (Salinites) grossicostatum* Imlay, 1939; *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone, Upper Tithonian, Hacienda El Americano section; x 1.

Fig. 4,5 - *Himalayites* sp.; *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone, Upper Tithonian, Hacienda El Americano section; Fig. 4 × 1.3, Fig. 5 × 2.5.

Fig. 6 - *Pseudolissoceras zitteli* Burckhardt, 1903; *Pseudolissoceras* spp., *Virgatosphinctes* spp. and *"Subplanites"* sp. Zone, Lower Tithonian, Hacienda El Americano section; × 1.8.

Fig. 7 - *Aulacosphinctoides* sp. cf. *A. infundibulum* Uhlig, 1910; *Pseudolissoceras* spp., *Virgatosphinctes* spp. and *"Subplanites"* sp. Zone, Lower Tithonian, Hacienda El Americano section; × 1.2.

Fig. 8 - *Durangites* sp.; *Proniceras, Durangites, Kossmatia* and *Corongoceras* Zone, Upper Tithonian, Hacienda El Americano section; × 1.5.

Fig. 9 - 11 *Globochaete*-like microfossils from the upper part of the *Saccocoma* Zone (*Colomisphaera* spp.-*Cadosina parvula* Subzone), Lower Tithonian, Hacienda El Americano section; Fig. 9 × 210, Fig. 10 × 175, Fig. 11 × 265.

Fig. 12 - Biocalcisiltite with *Saccocoma* and *Globochaete*-like microfossils. Upper part of the *Saccocoma* Zone, Lower Tithonian, Hacienda El Americano section; × 36.

Fig. 13 - *Saccocoma* sp.; upper part of the *Saccocoma* Zone, Lower Tithonian, Hacienda El Americano section; × 36.

Fig. 14 - *Saccocoma* sp. - section of the secundibrachial plate; *Colomisphaera* spp. - *Cadosina parvula* Subzone, Lower Tithonian, Hacienda El Americano section; × 50.

Fig. 15 - *Colomisphaera pulla* (Borza, 1964); *Colomisphaera* spp. - *Cadosina parvula* Subzone, Lower Tithonian, Hacienda El Americano section; × 440.

Fig. 16 - *Colomisphaera carpathica* (Borza, 1964); *Colomisphaera* spp.-*Cadosina parvula* Subzone, Lower Tithonian, Hacienda El Americano section; × 270.

Fig. 17 - *Colomisphaera carpathica* (Borza, 1964); *Colomisphaera* spp.-*Cadosina parvula* Subzone, Lower Tithonian, Hacienda El Americano section; × 250.

Fig. 18 - *Colomisphaera* cf. *carpathica* (Borza, 1964); upper part of the *Crassicollaria* Zone, Upper Tithonian, Sierra de Vinales section; × 270.

Fig. 19 - *Colomisphaera cieszynica* Nowak, 1968; *Crassicollaria* Zone, Upper Tithonian, Sierra de Vinales section; × 364.

Fig. 20 - *Cadosina* cf. *fusca* Wanner, 1940; *Colomisphaera* spp.-*Cadosina parvula* Subzone, Lower Tithonian, Hacienda El Americano section; × 280.

Fig. 21 - *Cadosina* cf. *fusca* Wanner, 1940; *Colomisphaera* spp.- *Cadosina parvula* Subzone, Lower Tithonian, Hacienda El Americano section; × 190.

Fig. 22 - *Cadosina parvula* Nagy, 1966; *Colomisphaera* spp.-*Cadosina parvula* Subzone, Lower Tithonian, Hacienda El Americano section; × 190.

Fig. 22 - *Cadosina parvula* Nagy, 1966; *Colomisphaera* spp.-*Cadosina parvula* Subzone, Lower Tithonian, Hacienda El Americano section; × 270.

Fig. 23 - *Chitinoidella boneti* Doben, 1963; *Chitinoidella* Zone, Sierra del Infierno section; × 280.

Fig. 24 - *Chitinoidella* cf. *boneti* Doben, 1963; *Chitinoidella* Zone, Sierra del Infierno section; × 250.

Fig. 25 - *Chitinoidella* sp.; *Chitinoidella* Zone, Sierra del Infierno section; × 280.

Fig. 26 - *Chitinoidella* cf. *bermudezi* (Furrazola-Bermúdez, 1965); *Chitinoidella* Zone, Sierra del Infierno section; × 320.

Fig. 27 - *Calpionella alpina* Lorenz, 1902; *Crassicollaria intermedia* Subzone; Sierra de Vinales section; × 200.

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26

27