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TITHONIAN STRATIGRAPHY AND MICROFACIES IN THE SIERRA DEL ROSARIO, WESTERN CUBA[2]

(Figs 1 - 10; Pls I - IV)

Abstract. The *Parakeratinites* sp. horizon and three ammonite zones – *Pseudolissoceras* spp., *Lytohoplites carribeanus* and *Himalayites (Micracanthoceras)* - *Corongoceras* are distinguished in the Tithonian sections of Sierra del Rosario, Western Cuba. These ammonite zones correlate with three microfossil zones: *Saccocoma*, *Chitinoidella* and *Crassicollaria*. The *Saccocoma*-Didemnidae microfacies is common in the Lower Tithonian deposits of Sierra del Rosario. During the Late Tithonian, radiolarian microfacies developed in all stratigraphic sequences of the Cordillera de Guaniguanico. The succession of microfacies indicates deepening of the northern (Cuban) part of the Proto-Caribbean basin from the lowermost Tithonian through the Berriasian. Endemic and Indo-Pacific taxa became the dominant components of the Late Tithonian ammonite fauna. Evidently, the connection of the Proto-Caribbean basin with the Pacific Ocean improved during this time.

Key words: Sierra del Rosario, Cuba, Tithonian, biostratigraphy, microfacies, fossils.

INTRODUCTION

The authors present results of the study concerning stratigraphy and microfacies of the Tithonian limestones in the Sierra del Rosario, Western Cuba (Fig. 1). The study is a continuation of earlier work carried out in the Sierra de los Organos (Myczyński & Pszczółkowski, 1990). The ammonite biostratigraphy has been elaborated by the first author (R. Myczyński), and the microfacies have been studied by the second one (A. Pszczółkowski).

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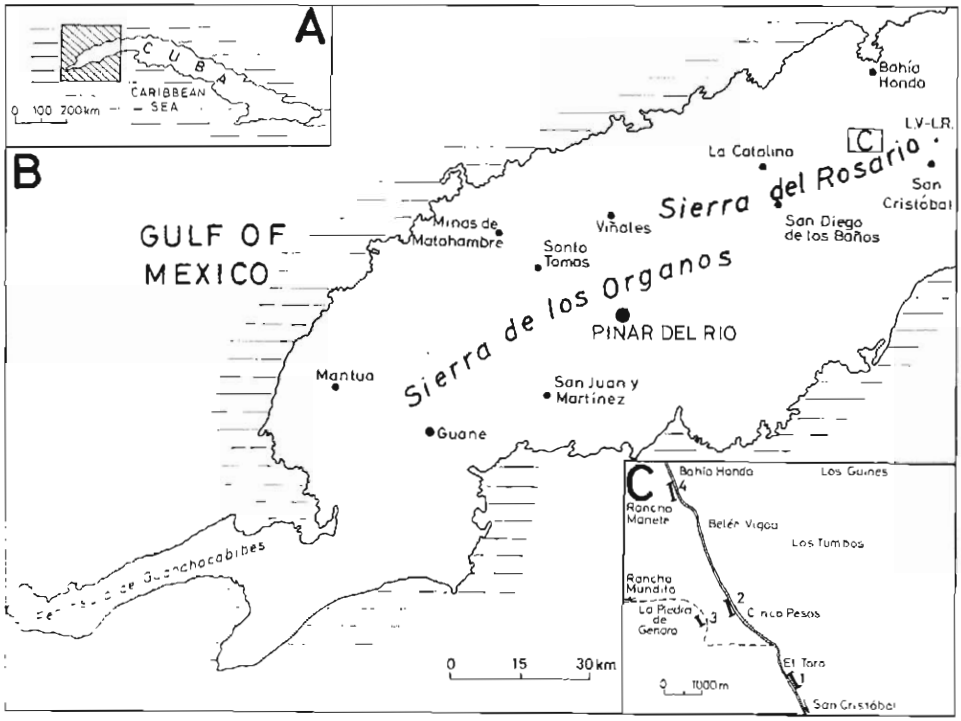


Fig. 1 **A.** Position of the investigated area in Cuba; **B.** Simplified map of the Pinar del Río Province and location of the studied sections in the central part of Sierra del Rosario

L.V.-L.R. – La Villa - La Revuelta section (north of San Cristóbal), *rectangle* – see C; **C.** Studied sections located along and near the road from San Cristóbal to Bahía Honda: 1 – El Toro section; 2 – Cinco Pesos section; 3 – La Piedra de Genaro section; 4 – Rancho Manete section

PREVIOUS WORK

Lithostratigraphy and facies of the Upper Jurassic rocks in the Sierra del Rosario have been studied by Pszczółkowski (1971, 1978, 1988). Imlay (1942), Judoley & Furrazola-Bermúdez (1968), Houša (1974) and Myczyński (1989, 1990) elaborated Tithonian ammonites from the Sierra del Rosario. Myczyński (1989) introduced a new biostratigraphical scheme for the Tithonian deposits of the Cordillera de Guaniguanico, based on ammonites. This scheme, with some modification, is applied in the present paper.

Furrazola-Bermúdez (1965) was the first to study the Tithonian microfossils in the Sierra del Rosario. In the Cinco Pesos section, he has described three new species of microfossils, originally included in the genera *Tintinnopsella* and *Calpionella* (Furrazola-Bermúdez, 1965), later attributed to the genus *Chitinoidella* (Kreisel & Furrazo-

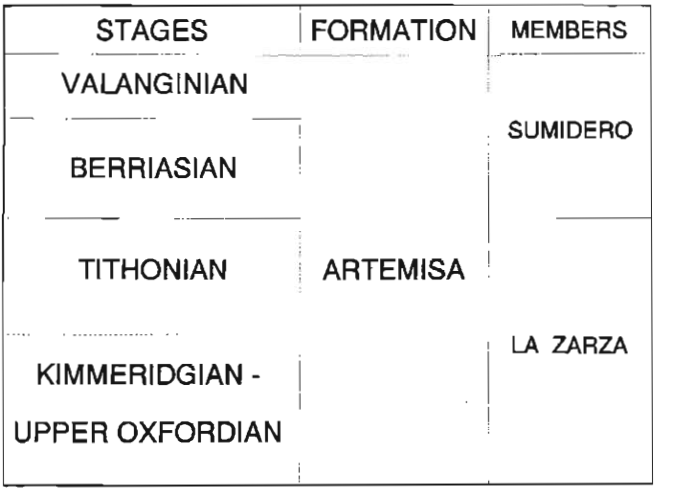


Fig. 2 Subdivision and age of the Artemisa Formation in the Sierra del Rosario (Western Cuba)

la-Bermúdez, 1971). The age of strata containing *Chitinoidella* spp. has been defined as the Middle Tithonian (Kreisel & Furrazola-Bermúdez, 1971). Furrazola-Bermúdez & Kreisel (1973) described a new species of the genus *Chitinoidella* from the Sierra del Rosario area.

LITHOSTRATIGRAPHY

In the Sierra del Rosario, Upper Jurassic limestones occur in the southern and northern stratigraphic sequences (Pszczółkowski, 1978, 1988). These limestones belong to a lower part of the Artemisa Formation (Lewis, 1932; Herrera, 1961; Judoley & Furrazola-Bermúdez, 1968). This formation, of Late Oxfordian to Valanginian age (Fig. 2), is subdivided into the La Zarza, the San Vicente and the Sumidero members (Pszczółkowski, 1978). The San Vicente Member (Upper Oxfordian - Kimmeridgian) occurs in some sections of the southern sequence only and will not be described in the present paper.

In the southern sequence of Sierra del Rosario, a lower part of the La Zarza Member consists of black to dark-grey bedded limestones, sometimes with thin interbeds of shales, siltstones and sandstones. Black ammonite-bearing limestones of Tithonian age are present in an upper portion of the Member. Locally, the ammonite shells form coquinas. There are also a few shelly beds composed of aptychi. The total thickness of the Tithonian deposits in the studied sections is about 40 m. The limestones of the upper part of the La Zarza Member pass into lighter-coloured limestones interbedded with chert of the Sumidero Member (Berriasian - Valanginian).

In the northern sequence of Sierra del Rosario, there are massive, laminated dolostones and dolomitic limestones in the lower part of the Artemisa Formation. In the vicinity of Soroa, these carbonates have the status of an informal lithostratigraphic unit. In some sections, they laterally grade into bedded limestones of the lower part of the La Zarza Member. Dark-grey and black ammonite-bearing limestones of the upper part of the La Zarza Member gradually pass into ammonite-free black limestones interbedded with radiolarian chert of the Sumidero Member.

DESCRIPTION OF STUDIED SECTIONS

Cinco Pesos section

The section is located north of Cinco Pesos, near the road running from San Cristóbal to Bahía Honda (Fig. 1). Black, sometimes laminated, thin to medium bedded limestones (0.05 - 0.4 m) are present in the lowermost part of the section (Fig. 3). Higher up the limestones contain thin intercalations of calcareous shale. The first ammonites were found in the middle part of the section, 11 to 14 m above its base: *Protancyloceras hondense* (Imlay), *"Parodontoceras" butti* Imlay and *"P". antilleanum* Imlay (Fig. 3). Frequent specimens of *Chitinoidella* spp. are also present.

After a 3-m break in the outcrop, dark-grey bedded limestones 5 m thick appear in the upper part of the section. They yielded one specimen of *Corongoceras* sp. and several taxa of calpionellids: *Calpionella alpina* Lorenz, *Crassicollaria intermedia* Durand Delga and *Tintinnopsella carpathica* Murgeanu et Filipescu.

The strata exposed in the Cinco Pesos section belong to the Lower Tithonian: upper part of the *Saccocoma* Zone and *Chitinoidella* Zone, as well as to the Upper Tithonian (lower part of the *Crassicollaria* Zone). Furrazola-Bermúdez (1965) recorded from this section a cooccurrence of *Chitinoidella* spp. with the following ammonite taxa (identified by C. M. Judoley): *Virgatosphinctes cristobalensis* Imlay, *Corongoceras filicostatum* Imlay and *Micracanthoceras* sp. The uppermost part of the *Chitinoidella* Zone thus may correspond there to the earliest Late Tithonian. This could not be confirmed by the present authors; it is possible that in 1965 some other strata were exposed, now being covered (between 14 and 17 m above base of the section shown in Fig. 3).

La Piedra de Genaro section

The section (Fig. 4) is situated along a new road from Cinco Pesos to Rancho Mundito (now Niceto Pérez), north of the El Ferretero hill. The section is composed of three, closely located outcrops shown as one section in Fig. 1. The Tithonian limestones dip 25° - 40° to the north. Black, laminated, bedded limestones with *Protancyloceras hondense* (Imlay) and *Phylloceras pinarense* Imlay occur in the lower part of the section (Fig. 4). In the middle part, black limestones with thin intercalations of ammonite coquinas are present. These beds yielded some specimens of *"Parodontoceras" antilleanum* Imlay, *Phylloceras pinarense* Imlay, *Glochiceras (?Lingulaticeras)* sp.

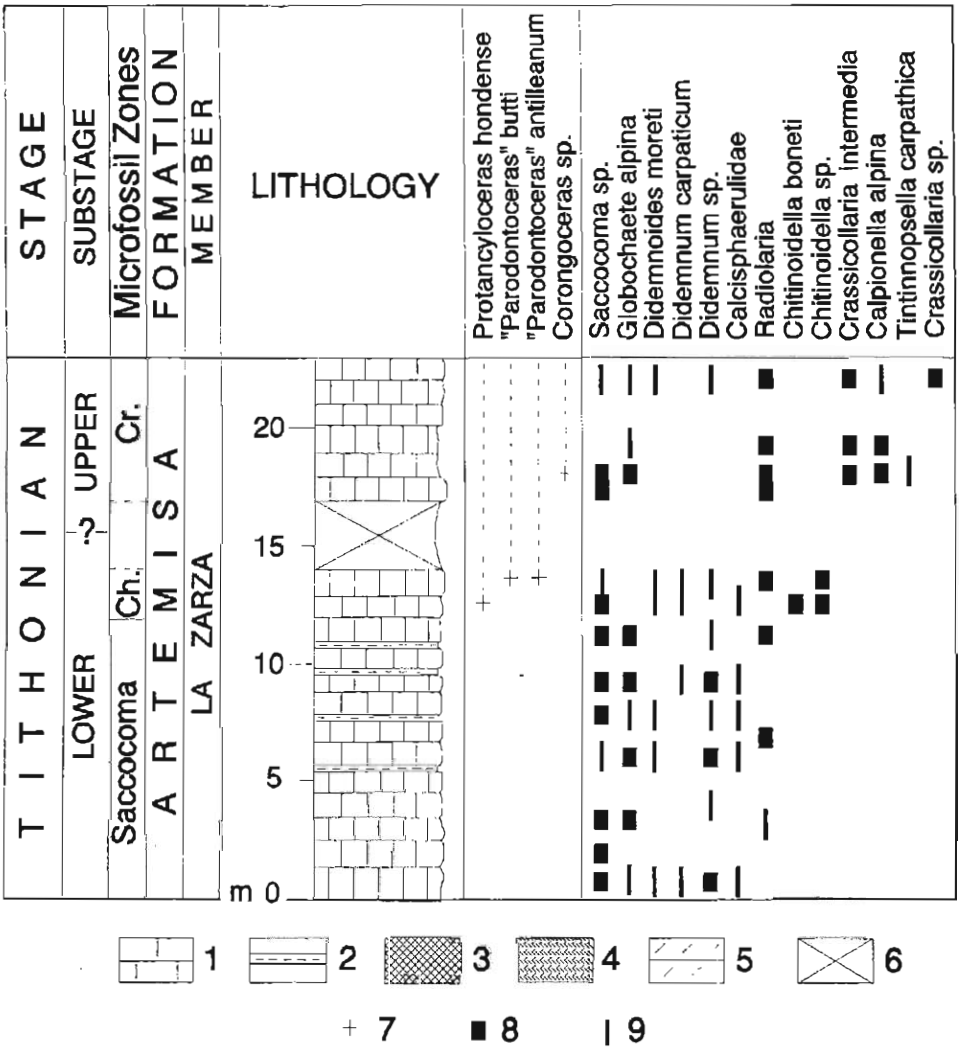


Fig. 3 Lithostratigraphic column of the Tithonian deposits exposed in the Cinco Pesos section (for location see Fig. 1)

1 – limestones; *2* – thin intercalations of shale; *3* – radiolarian cherts; *4* – dolomitic limestones; *5* – partly dolomitized, ammonite-bearing limestones; *6* – break in the outcrop; *7* – location of ammonites and bivalves (*Buchia*); *8* – occurrence of frequent microfossils in thin sections; *9* – occurrence of infrequent microfossils in thin sections; *Ch.* – *Chitinoidella* Zone; *Cr.* – *Crassicollaria* Zone

(Pl. II, 2, 4, 8b, 10), *Lytohoplites carribeanus* Imlay (Pl. I, 4), *Vinalesites rosariensis* (Imlay), *Protancyloceras* sp. (Pl. I, 5b) and *Pseudolissoceras zitteli* (Burckhardt) (Pl. II, 5). Specimens of *"Parodontoceras"*, as well as small ammonites identified as *Glochiceras* sp., prevail in this assemblage.

Higher up in the section, the following ammonites have been collected: *Taramelliceras (Parastreblites)* sp. (Pl. II, 1, 3, 9), *Lytohoplites carribeanus* Imlay, *Virgatos-*

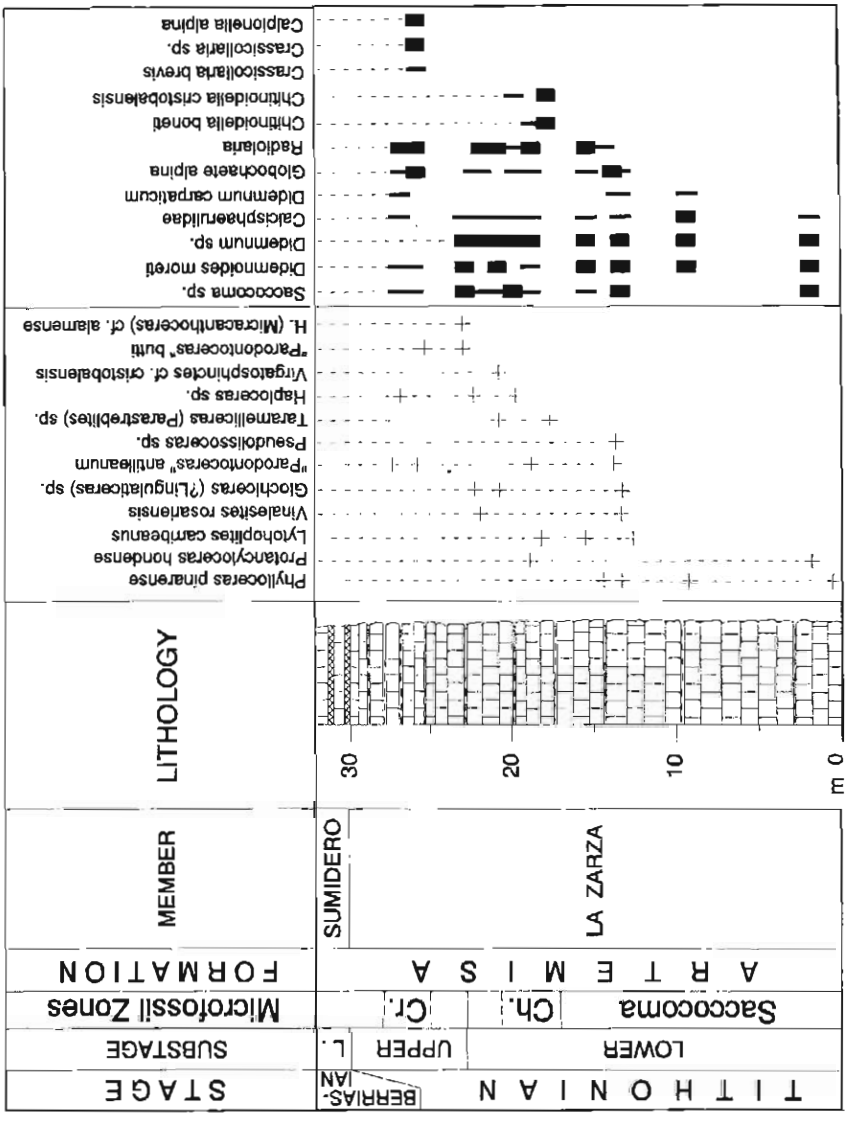


Fig. 4 Generalized lithostratigraphic column of the Tithonian deposits in the La Piedra de Genaro section (for location see Fig. 1). Explanations as in Fig. 3; *Ch.* – *Chitinoidella* Zone; *Cr.* – *Crassicollaria* Zone

phinctes cf. *cristobalensis* Imlay, *Vinalesites rosariensis* Imlay, *Protancyloceras hondense* (Imlay) and *Haploceras* sp. The bivalves *Buchia* sp. and microfossils identified as *Chitinoidella cristobalensis* (Furrazola-Bermúdez) and *Ch.* cf. *boneti* Doben occur together with *Taramelliceras (Parastreblites)* sp. In the slightly younger beds, *Himalayites (Micracanthoceras)* cf. *alamense* Imlay (Pl. II, 11) and *"Parodontoceras" butti* Imlay have been found. The ammonites are infrequent in the uppermost Tithonian strata; the few specimens recorded in this part of the section belong to *"Parodontoceras" butti* Imlay, *"P". antilleanum* Imlay (Pl. I, 5a) and *Haploceras* sp. (Pl. II, 8a).

The presence of *Lytohoplites carribeanus* Imlay indicates the Early Tithonian age of the limestones occurring in the middle part of the section (Myczyński, 1989). The strata which yielded *Himalayites (Micracanthoceras)* cf. *alamense* Imlay belong to the Upper Tithonian, as is also indicated by calpionellids (*Crassicollaria brevis* Remane, *Crassicollaria* sp. and *Calpionella alpina* Lorenz). In the discussed section, the Upper Tithonian limestones of the La Zarza Member are 7 m thick.

El Toro section

The section is located on the east side of the road from San Cristóbal to Bahía Honda, on the northern slope of the El Toro hill (Fig. 1). The limestones exposed belong to the upper part of the La Zarza Member. This is the upper part of the stratotype of the Artemisa Formation (Judoley & Furrazola-Bermúdez, 1968) and also of the La Zarza Member (Pszczółkowski, 1978). The studied part of the section does not include limestones cropping out in the road-cutting between the La Zarza and El Toro hills (Myczyński, 1989, fig. 11; "Cinco Pesos section" or MR-28). In that part of the section, a few specimens of *Parakeratinites* sp. have been collected (previously identified as *"Virgatosphinctes"* sp.: Myczyński, 1989, Pl. 12: 4), and *Schaireria* sp.

Bedded limestones 32 m thick (Fig. 5) are exposed east of the road. Dark-grey and black biomicrites and biocalcisiltites, often fine-banded and with thin intercalations of ammonite coquinas, occur in the lower part of the section. They yielded: *Pseudolissoceras* cf. *zitteli* (Burckhardt), *"Parodontoceras" butti* Imlay (Pl. I, 1a), *"P." antilleanum* Imlay, *Vinalesites rosariensis* (Imlay) (Pl. I, 1b), *Protancyloceras hondense* (Imlay) (Pl. I, 3), *Virgatosphinctes* sp., *Lytohoplites* sp. and *Glochiceras (?Lingulaticeras)* sp. About 11 m above the base of the section, the limestones yielded *Neochetoceras* sp. and *Buchia* aff. *okensis* (Pavlow).

Still higher up in the section (18 - 23 m above its base), dark-grey biocalcisitites and biomicrites contain *Protancyloceras hondense* (Imlay) and *"Parodontoceras"* spp. From the succeeding limestone beds (27 to 28 m above the base) specimens of *"Parodontoceras" antilleanum* Imlay and *Vinalesites rosariensis* (Imlay) have been collected. Grey and grey-brown radiolarian limestones, containing unidentifiable molds of small ammonites, terminate the El Toro section.

Dark-grey and black ammonite-bearing limestones belong to the Lower Tithonian, while the age of the succeeding radiolarian limestones is uncertain (Late Tithonian?).

La Villa - La Revuelta section

The section (Fig. 6) is situated in the eastern part of the Sierra del Rosario, west of Soroa (Fig. 1). It comprises Tithonian limestones 24 m thick, dipping to the NW.

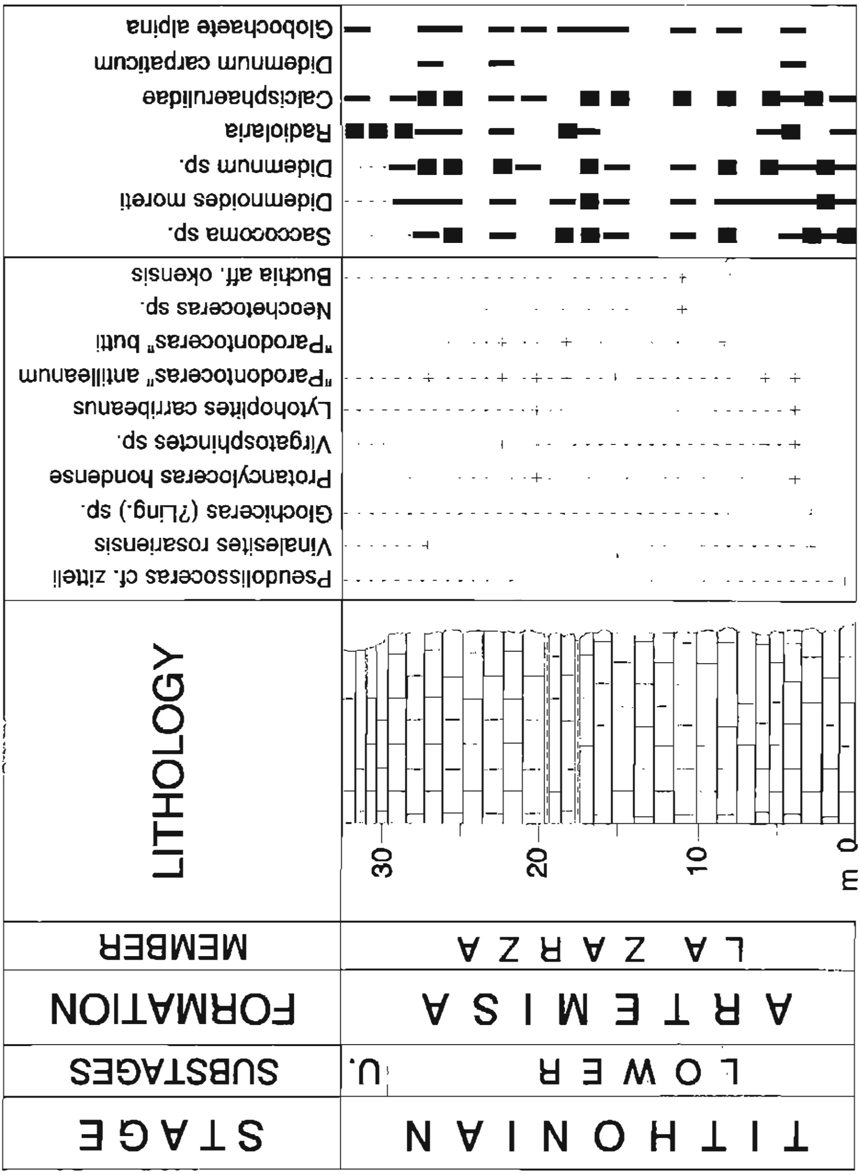


Fig. 5 Lithostratigraphic column of the Tithonian deposits in the El Toro section (for location see Fig. 1). Explanations as in Fig. 3

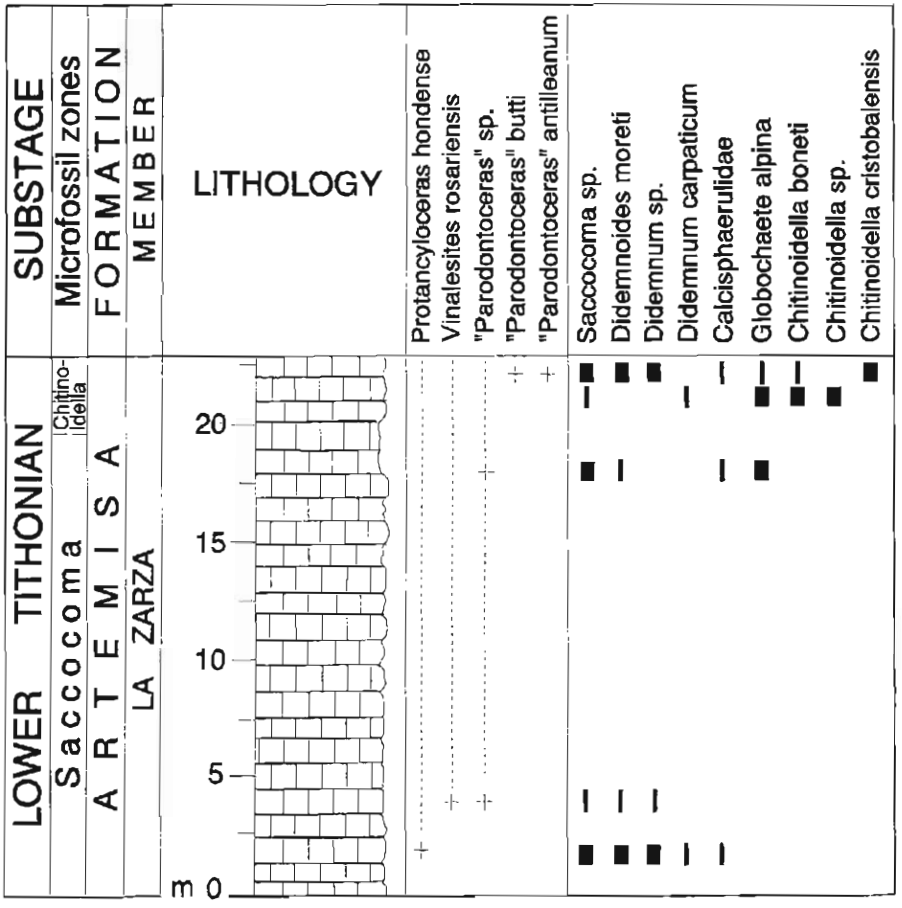


Fig. 6 Lithostatigraphic column of the Tithonian deposits exposed in the La Villa - La Revuelta section (for location see Fig. 1). Explanations as in Fig. 3

The black limestones with *Protancyloceras hondense* Imlay occur in the lower part of the section. They underlie similar bedded limestones containing *Vinalesites rosariensis* (Imlay) and *"Parodontoceras"* sp. Pinkish limestones with *"Parodontoceras"* spp. and *Chitinoidella* spp. are present in the topmost part of the studied section.

The limestones exposed in the La Villa - La Revuelta section are of Early Tithonian age. The ammonites *Protancyloceras hondense* (Imlay) and *"Parodontoceras"* sp. have been recorded already about 20 m below the beds containing *Chitinoidella* spp.

Rancho Manete section

The Upper Jurassic deposits cropping out in the Rancho Manete section (Fig. 7), belong to the northern sequence of the Sierra del Rosario. The oldest strata are exposed on the southeastern slope of the Rancho Manete hill (Fig. 1). These are black, laminated, frequently dolomitized limestones about 40 m thick devoid of ammonites (only the uppermost part of these limestones is shown in Fig. 7). In thin section,

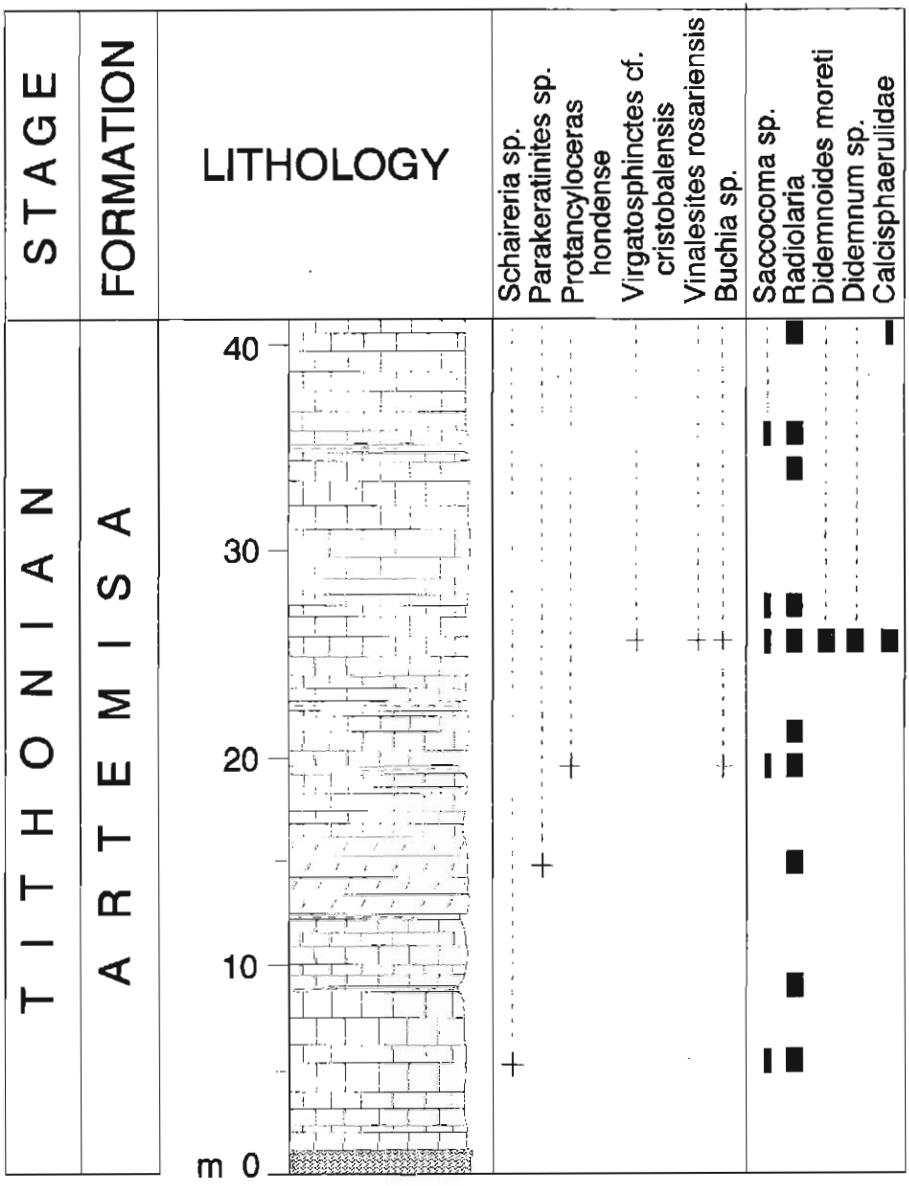


Fig. 7 Lithostratigraphic column of the Tithonian deposits exposed on the south-eastern slope of the Rancho Manete hill, west of the road from San Cristóbal to Bahía Honda (for location see Fig. 1). Explanations as in Fig. 3

alternation of light and dark microsparitic laminae is observed; the latter contain pyrite and dolomite rhombohedra. Microfossils (*Globochaete alpina* Lombard and Calcisphaerulidae) occur infrequently in some laminae. The age of the dolomitic limestones is probably Kimmeridgian - Early Tithonian, as inferred from their stratigraphic position.

There follow black, laminated biomicrites about 12 m thick with scarce ammonites (*Schaireria* sp.). They are succeeded by black, dolomitic limestones containing

ammonites *Parakeratinites* sp. (Pl. II, 7). Still higher up, there appear black laminated limestones with *Protancyloceras hondense* (Imlay) and *Buchia* sp. in the lower part, and *Virgatosphinctes* cf. *cristobalensis* Imlay, *Vinalesites rosariensis* (Imlay) and *Buchia* sp. in the upper part (Fig. 7).

The ammonite-bearing limestones of the lower part of the studied section are of Early Tithonian age. The limestones of the upper part of the section (from 27 to 42 m above its base), may belong to the Upper Tithonian, however, ammonites and calpionellids have not been found there. The Upper Tithonian limestones pass into dark-grey to black laminated limestones of Berriasian age.

La Catalina section

The La Catalina section belongs to the southern sequence of the Sierra del Rosario and is located in the western part of this mountain range (Fig. 1). The authors collected ammonites from this section in 1971-1973, and the cross-section showing the succession of the ammonite assemblages was published by Myczyński (1989, fig. 9). The limestones 18 m thick of the upper part of the La Zarza Member are exposed in the section. They contain ammonites of the late Early Tithonian and also of the Late Tithonian. The lower part of the section yielded *Lytohoplites carribeanus* Imlay, *Protancyloceras hondense* (Imlay) and *Vinalesites rosariensis* (Imlay). There are three ammonite assemblages in the upper part of the section: the lower containing *Dickersonia* sp., *P. hondense* (Imlay) and *V. rosariensis* (Imlay), the middle containing *Hildoglochiceras (Salinites)* sp., *V. rosariensis* (Imlay) and *"Parodontoceras" butti* Imlay and the upper one consisting of specimens of *"Parodontoceras"* spp. only.

CHARACTERISTICS OF AMMONITE ZONES

Parakeratinites sp. horizon

This is the lowermost faunal horizon recognized in the Lower Tithonian limestones of Sierra del Rosario. The ammonites *Parakeratinites* sp. and *Schaireria* sp. are characteristic fossils. The horizon with *Parakeratinites* sp. occurs in the Rancho Manete section only. Specimens of the genus *Parakeratinites* Zeiss, 1968, have not been found in other sections dealt with in the present paper. However, a specimen described as *"Virgatosphinctes"* sp. (Myczyński, 1989, p. 100, pl. 12, fig. 4) belongs to *Parakeratinites* sp. Another specimen of *Parakeratinites* has been collected in the outcrop El Mameyal (*"Virgatosphinctes"* sp. = *Parakeratinites* sp. – Myczyński, 1989, p. 100, outcrop MR-24, pl. 12, fig. 2). The ammonites in this horizon occur in a few limestone beds less than 3 m thick.

In Europe, the ammonites included to the genus *Parakeratinites* Zeiss, 1968, are known from the Early Tithonian *Albertinum* Zone, or, more exactly, from the upper part of the *Hybonotum* Zone possibly to the lowermost part of the *Verruciferum* Zone (Olóriz, 1978). The *Albertinum* Zone corresponds to the *Darwini* Zone in the subdivision of the Tithonian stage as proposed by Enay & Geyssant (1975). The genus

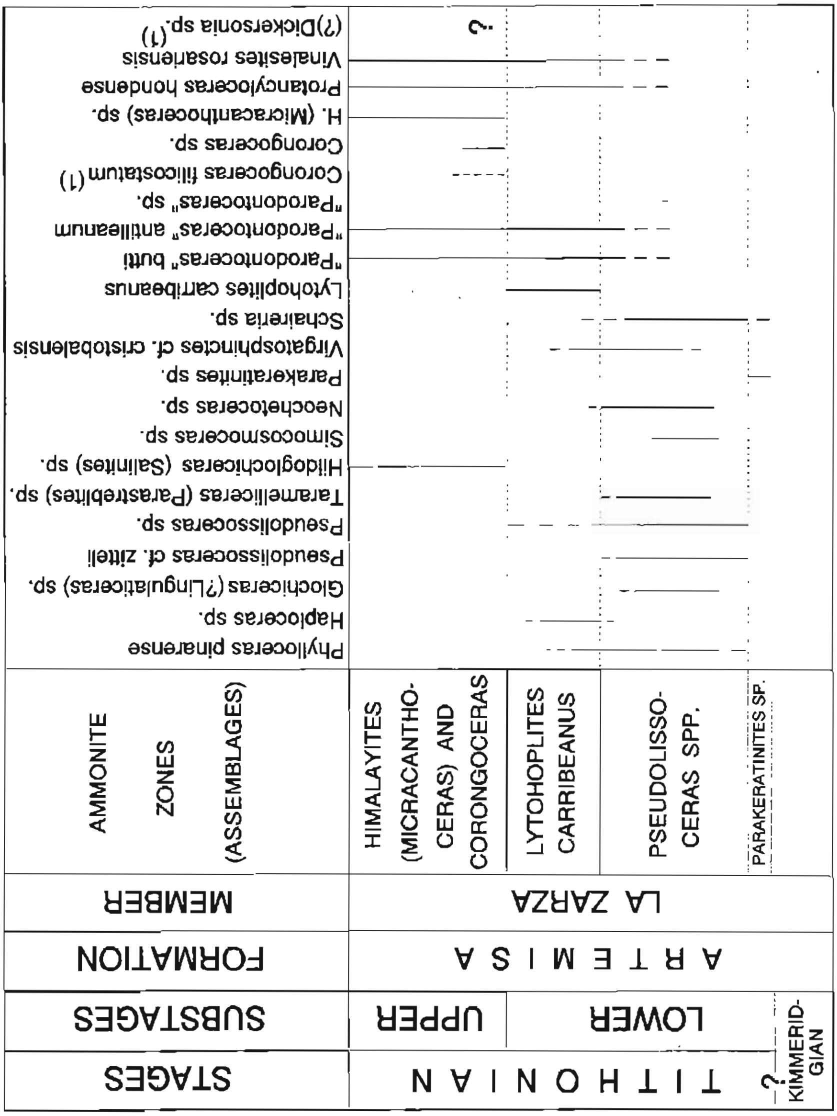


Fig. 8 Stratigraphic range of ammonite taxa collected in the Tithonian deposits of Sierra del Rosario during this study and previous works (Imlay, 1942; Myczyński, 1989, 1990). The range of taxa reported by Imlay (1942) and marked here with (1) is uncertain; the Kimmeridgian-Tithonian boundary is indicated tentatively because of lack of index fauna below the *Parakeratinites* sp. horizon

Parakeratinites Zeiss, 1968, was derived by Olóriz (1978) from the genus *Franconites* Zeiss (Zeiss, 1968). According to the scheme elaborated by Zeiss (1984) for the Lower Tithonian of Franconia, the genus *Franconites* Zeiss, 1968 occurs below the *Pseudolissoceras bavaricum* Zone. On the basis of the aforementioned data, the age of the horizon containing *Parakeratinites* sp. is Early Tithonian. This horizon may correspond to the *Albertinum* Zone or to the *Darwini* Zone according to the earlier subdivision of the Tithonian (Enay & Geyssant, 1975). The horizon containing *Parakeratinites* sp. may correspond to the lowermost part of the *Verruciferum* Zone in the scheme of Olóriz (1978).

Pseudolissoceras spp. Zone

The *Pseudolissoceras* spp. Zone is the oldest ammonite zone occurring in the Sierra del Rosario (Fig. 8). This zone is established here as an equivalent of the earlier distinguished *Virgatosphicntes*, *Pseudolissoceras* and *Simocosmoceras* Zone (Myczyński, 1989, fig. 15). The name change of this zone was found useful because of the scarcity of the ammonites *Simocosmoceras* and *Virgatosphinctes* in the Sierra del Rosario. The stratigraphic range of these genera is not well known in this area. On the contrary, the ammonites belonging to the genus *Pseudolissoceras* are relatively frequent in the Lower Tithonian limestones of the southern sequence of the Sierra del Rosario. The lower boundary of the *Pseudolissoceras* spp. Zone is accepted at the first occurrence of the index genus. The upper boundary is defined by the first appearance of *Lytohoplites carribeanus* Imlay. The thickness of the deposits of the *Pseudolissoceras* spp. Zone is about 10 m.

The ammonites of the genus *Pseudolissoceras* Spath, 1925, collected from the upper part of the La Zarza Member, resemble the species *Pseudolissoceras zitteli* (Burckhardt), as suggested by Imlay (1942). Simultaneously, the presence of the genus *Neochetoceras* Spath, 1925 may indicate that this assemblage corresponds partly to the Early Tithonian *Mazapilites* spp. Zone in the Sierra de los Organos. However, ammonites belonging to the genus *Mazapilites* have not been found in the Sierra del Rosario.

The early occurrence of the heteromorph ammonites *Protancyloceras hondense* (Imlay) and *Vinalesites rosariensis* (Imlay) is very characteristic for the Tithonian ammonite assemblages of the southern sequence of the Sierra del Rosario. They occur together with representatives of the genera *Pseudolissoceras*, *Virgatosphinctes* and *"Parodontoceras"* (Fig. 9). In the Sierra de los Organos, the heteromorphs are known only in the Upper Tithonian limestones being the most abundant in the uppermost part of this substage (Myczyński, 1989).

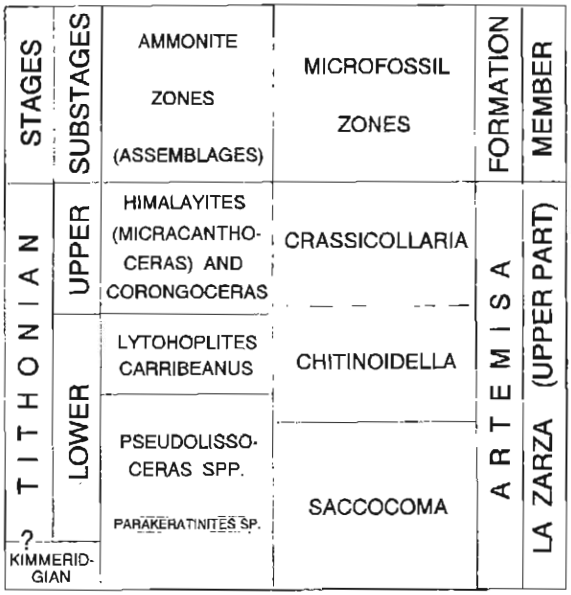


Fig. 9 Correlation of the ammonite and microfossil zones distinguished in the Tithonian deposits of the southern sequence of Sierra del Rosario

Another characteristic feature of the Early Tithonian ammonite assemblages of Sierra del Rosario is the presence of forms identified as *Glochiceras (?Lingulaticeras)* sp. Previously, these ammonites were not reported in Cuba. They have two shallow lateral grooves, which normally are not observed in the genus *Glochiceras*. Moreover, the shell outline and details of ornamentation of the specimens from the Sierra del Rosario are very similar to such features of ammonites belonging to the genus *Hildoglochiceras* in the Lower Tithonian of Madagascar (Collignon, 1960). The Cuban specimens differ from those known from Madagascar by the presence of two lateral grooves and a more evolute coiling of the shell.

Lytohoplites carribeanus Zone

The *Lytohoplites carribeanus* Range Zone (Myczyński, 1989) is the second ammonite zone in the Early Tithonian of the Sierra del Rosario (Fig. 8). In the sections studied, the *L. carribeanus* Zone comprises limestones up to 16 m thick. The ammonites of the genus *Lytohoplites* may occur together with *"Parodontoceras" antilleanum* Imlay, *"Parodontoceras" butti* Imlay, *Virgatosphinctes* sp., *Protancyloceras hondense* (Imlay), *Phylloceras pinarense* Imlay, *Vinalesites rosariensis* (Imlay), *Glochiceras (?Lingulaticeras)* sp., *Taramelliceras (Parastreblites)* sp., *Pseudolissoceras* sp. and *Neochetoceras* sp.

The ammonites of the genus *"Parodontoceras"* Spath, 1923 = *Butticeras* Houša, 1975 (Houša & Nuez, 1975) have been recorded in the Sierra del Rosario in the Lower

and Upper Tithonian limestones (Fig. 8, 9). In the Lower Tithonian, *"Parodontoceras" butti* Imlay and *"Parodontoceras" antilleanum* Imlay occur together with the representatives of the genera *Pseudolissoceras* and *Virgatosphinctes*. In the present paper, the species *"P". butti* and *"P". antilleanum* are included (with reservation) to the genus *"Parodontoceras" sensu* Verma & Westermann (1973). The Cuban ammonites do not belong to the genus *Parodontoceras* (Houša, 1974).

Another characteristic feature of the Early Tithonian fauna of the Sierra del Rosario is frequent occurrence of the ammonites belonging to the genus *Phylloceras*, represented only by one species – *Phylloceras pinarense* Imlay, and absence of Lytoceratina.

Himalayites (Micracanthoceras) and *Corongoceras* Zone

The third ammonite zone, the *Himalayites (Micracanthoceras) - Corongoceras* Assemblage Range Zone, represents Late Tithonian (Fig. 8). The limestones included within this zone are 6 m thick in the La Piedra de Genaro section, and about 4 m thick in the Cinco Pesos section. The lower boundary of the *H. (Micracanthoceras) - Corongoceras* Zone is determined by the first occurrence of the index taxa. Its upper boundary is undefined due to the absence of identifiable ammonites in the youngest limestones of the Upper Tithonian.

In the studied sections, the Late Tithonian ammonites are less frequent than the Early Tithonian ones. The Late Tithonian ammonites belong to the following genera: *Himalayites (Micracanthoceras)*, *Hildoglochiceras*, *"Parodontoceras"*, *Corongoceras*, *Dickersonia*, *Protancyloceras* and *Vinalesites*. The ammonites from the genera *Kossmatia*, *Proniceras*, *Durangites*, and *Phanerostephanus*, characteristic for the Sierra de los Organos (Myczyński, 1989), were not recorded in the Sierra del Rosario. The Late Tithonian ammonites are infrequent in the Sierra del Rosario, being sometimes represented only by the heteromorphs and *"Parodontoceras"* spp.

The ammonites belonging to the genus *"Parodontoceras"* occur throughout the whole Late Tithonian (Fig. 9), while those of the genus *Hildoglochiceras (Salinites)* Cantu Chapa, 1968 (Myczyński, 1989) are infrequent in the Sierra del Rosario sections. In Berriasian deposits, the ammonites are rare. The calpionellids are less frequent and rather poorly preserved in the uppermost Tithonian and Lower Berriasian limestones. This does not allow the authors to establish the Tithonian/Berriasian boundary in the Sierra del Rosario. Only in the Seboruco-Linares section were Berriasian calpionellids recorded in the pinkish limestones directly overlying the dark-grey limestones containing *Protancyloceras hondense* (Imlay) and *Vinalesites rosariensis* (Imlay) (Myczyński, 1977).

MICROFOSSIL ZONES

Saccocoma Partial Range Zone

In Cuba, the *Saccocoma* Partial Range Zone has been established in the Sierra de los Organos (Myczyński & Pszczółkowski, 1990). In the present study this zone is distinguished in two sections (Figs 3, 6). In the remaining sections, the *Saccocoma* Zone cannot be distinguished because of the poorly defined boundary with the *Chitinoidella* Zone. The thickness of limestones belonging to the *Saccocoma* Zone is over 20 m in the southern sequence of the Sierra del Rosario.

The lower boundary of the *Saccocoma* Zone occurs in the limestones of the La Zarza Member below the ammonite-bearing strata. The upper boundary is defined by the first occurrence of the genus *Chitinoidella* (Myczyński & Pszczółkowski, 1990). This boundary does not correspond to the upper boundary of the *Saccocoma* Zone as established in France (Dromart & Atrops, 1988).

Besides the index taxon, the limestones belonging to the *Saccocoma* Zone contain *Globochaete alpina* Lombard, spicules of Didemnidae, calcispheres and Radiolaria. The following microfossils are considered as spicules of Didemnidae: *Didemnoides moreti* (Durand Delga, 1957) - Pl. III, 4, *Didemnum* sp. (Pl. III, 5) and *Didemnum carpaticum* Mišík et Borza, 1978 (Pl. III, 8). Microfossils *incertae sedis*: *Colomisphaera carpathica* (Borza) (Pl. IV, 2), *Colomisphaera cieszynica* Nowak, *C. minutissima* (Colom), *C.* cf. *pulla* (Borza), *Cadosina parvula* Nagy and *Cadosina fusca* Wanner are included here within calcispheres.

Chitinoidella Zone

In the Sierra del Rosario, the presence of the *Chitinoidella* Zone has been established by Kreisel & Furrazola-Bermúdez (1971), but only in one outcrop of the Artemisa Formation limestones, corresponding to the Cinco Pesos section (Fig. 3). In the present paper, the *Chitinoidella* Zone is also distinguished in the La Piedra de Genaro section (Fig. 4), and in the La Villa - La Revuelta section (Fig. 6). In this zone, the following microfossils have been identified: *Chitinoidella boneti* Doben (Pl. IV, 4-6), *Ch. cristobalensis* (Furrazola-Bermúdez) - Pl. IV, 7, *Chitinoidella* sp. (Pl. IV, 8), *Saccocoma* sp. (Pl. III, 2), *Didemnoides moreti*, *Didemnum carpaticum* Mišík et Borza, *Didemnum* sp., *Colomisphaera minutissima* (Colom), *C. carpathica* (Borza), *C. cieszynica* Nowak, *Cadosina parvula* Nagy, *Cadosina fusca* Wanner, *Globochaete alpina* Lombard, and Radiolaria.

The thickness of the limestones belonging to the *Chitinoidella* Zone does not exceed 8 m. The lower boundary of this zone is indicated by the first occurrence of the index taxon (*Chitinoidella* sp.). The

upper boundary cannot be defined, because of a break in the outcrop (Fig. 3). No specimens of *Chitinoidella* spp. were recorded in samples taken from the El Toro section (Fig. 5).

Crassicollaria Zone

The Late Tithonian *Crassicollaria* Standard Zone is distinguished in the Cinco Pesos section (Fig. 3) and the La Piedra de Genaro section (Fig. 4). It is documented by calpionellids: *Crassicollaria intermedia* Durand Delga, *Cr.* cf. *brevis* Remane, *Crassicollaria* sp., *Calpionella alpina* Lorenz, *C.* cf. *alpina* and *Tintinnopsella carpathica* (Murgeanu et Filipescu). The following microfossils are also present in the *Crassicollaria* Zone: *Saccocoma* sp., *Didemnoides moreti* Durand Delga, *Didemnum* sp., calcispheres, and abundant Radiolaria.

MICROFACIES

Saccocoma-Didemnidae microfacies

This microfacies consists mainly of calcareous spicules of Tunicata (Ascidiacea) belonging to the family Didemnidae, and of segments of planktonic crinoids (*Saccocoma* sp.). These microfossils occur in biocalcisiltites, biomicrites, biomicrosparites and ammonite coquinas. In fine-grained detrital limestones spicules of Didemnidae prevail, but locally *Saccocoma* segments may also be abundant.

Usually, the spicules are circular in cross-section (Pl. III, 3, 4), sometimes oval (Pl. III, 7). The spicules composed of 12 - 20 radially arranged calcitic elements have been described as *Didemnoides rosetta* Bonet et Benveniste-Velasquez in the Kimmeridgian(?) - Hauterivian deposits of Mexico (Bonet & Benveniste-Velasquez, 1971). Later, Mišík & Borza (1978) recognized the priority of the name *Stomiosphaera moreti* (Durand Delga, 1957), and renamed these spicules *Didemnoides moreti* (Durand Delga). In the Lower Tithonian limestones of Sierra del Rosario, spicules of the *D. moreti* type are very frequent (Pl. III, 4, 6).

Borza & Mišík (1975) distinguished microfossils similar to *D. moreti*, but consisting only of 6 - 9 calcitic elements, as a new taxon named *Gemeridella minuta* Borza et Mišík. The spicules similar to the specimens described by Borza & Mišík (1975), and especially to those illustrated by Mišík & Borza (1978), are common in the Tithonian limestones of the Sierra del Rosario. However, the Cuban spicules do not have the characteristic appendices as observed on the holotype of *Gemeridella minuta*, and also on some other Triassic specimens (Borza & Mišík, 1975, Taf. I, 1, 2, 5, 6; Mišík & Borza, 1978, Taf. I, 1-3). On the other hand, the Cuban spicules are very similar to some Holocene and Recent spicules of Ascidiacea belonging to the species *Didemnum candidum* Savigny, 1816, and illustrated by Bonet & Benveniste-Velasquez (1971, Lám. IV, 1, 6, 7; Lám. V, 3; Lám. VIII, 5, 6). On this basis, some forms occurring in the Tithonian limestones of Sierra del Rosario may be identified as spicules of fossil

Ascidiacea from the genus *Didemnum* Savigny, 1816. Lancet-shaped calcitic elements, forming the spicules of *D. candidum*, were infrequently observed in the Sierra del Rosario spicules (Pl. III, 4). Usually, these delicate elements are broken and are not preserved in their original form. Other calcareous spicules recorded in the Tithonian limestones of Sierra del Rosario, belong to *Didemnum carpaticum* Mišík & Borza (1978, Taf. III, 8).

The *Saccocoma*-Didemnidae microfacies is characteristic for the Lower Tithonian limestones of the southern sequence of Sierra del Rosario (Fig. 10). It is frequent in biocalcisiltites composed of fine-grained detritus (Pl. III, 1). This microfacies is also common in the Lower Tithonian of Sierra de los Organos. Spicules of Didemnidae occurring there in limestones of the El Americano Member (Guasasa Formation) have been preliminary named "*Globochaete*-like microfossils" (Myczyński & Pszczółkowski, 1990). The similarity of these microfossils to calcareous spicules abundantly represented in the Tithonian of Sierra del Rosario, as well as to those described in the Jurassic deposits of Mexico (Bonet & Benveniste-Velasquez, 1971) make it possible to identify them as spicules of Didemnidae.

The *Saccocoma*-Didemnidae microfacies is far less frequent in the Upper Tithonian deposits of Cordillera de Guaniguanico. In the northern sequence of Sierra del Rosario this microfacies is rarely observed in the limestones of the Lower and Upper Tithonian.

Calcisphere-bearing microfacies

The microfacies dominated by calcispheres (Calcisphaerulidae, Stomiosphaeridae and Cadosinidae Wanner, 1940 – see and Borza, 1969; "microproblematics" of Cecca &Řehánek, 1991) is infrequent in the Lower Tithonian limestones of Sierra del Rosario. It was observed in some thin sections from the Lower Tithonian limestones exposed on the El Toro hill (Fig. 5). Besides calcispheres (*Cadosina fusca* Wanner – Pl. III, 9; *Colomisphaera* spp. – Pl. IV, 1-3), spicules of Didemnidae, fragments of *Saccocoma*, and sometimes, Radiolaria and *Globochaete*, occur in this microfacies. Phosphatized remains of fishes (scales and vertebrae), and shells of juvenile ammonites are also present.

The planktonic microfossils *incertae sedis*, once included within the genus *Colomisphaera* Nowak, 1968, have been assigned to the family Stomiosphaeridae Wanner, 1940 (Nowak, 1968). To his genus *Colomisphaera*, Nowak (1968) included fossil microorganisms described earlier as *Fibrosphaera minutissima* Colom, and some representatives of *Cadosina* (*sensu* Nagy, 1966 and Borza, 1969). Later, Aubry *et al.* (1988) concluded that „the genus *Colomisphaera* is based on a misconception of its type-species *Stomiosphaera minutissima* (Colom)". According to Aubry *et al.* (1988) the taxon *Fibrosphaera minutissima* Colom, represents, in fact, Jurassic microorganisms belonging to *Schizosphaerella punctulata* Deflandre et Dangeard, known from the Hettangian to the Lower Kimmeridgian. Nevertheless, Aubry *et al.* (1988) do not regard the genus *Colomisphaera* as a junior synonym of the *Schizosphaerella* Deflan-

dre et Dangeard. They concluded, that the taxonomy of the Tithonian and Early Cretaceous microfossils assigned to the genus *Colomisphaera* needs revision.

Until that revision has been done, the discussed microfossils may provisionally remain in the genus *Colomisphaera*. Because of the secondary (diagenetic) origin of a fringe of thin radiating calcitic fibers around the two valves of *Schizosphaerella punctulata* Deflandre et Dangeard (Källin, 1980), some (or all) species of the genus *Colomisphaera* Nowak, 1968 may be artificial taxa. For example, co-occurrence of calcispheres referred to as *Colomisphaera cieszynica* Nowak (Pl. IV, 1) and *C. carpathica* (Borza) (Pl. IV, 2) in the Lower Tithonian limestones of the Sierra del Rosario suggests that both taxa are, in fact, two forms of the same microorganism, differing in the thickness of the calcitic fringe of diagenetic origin. Sometimes, a similar secondary fringe formed also around other microorganisms, such as *Chitinoidella* (Pl. IV, 9). The microfossils assigned here to *Colomisphaera* spp. may belong to Schizosphaerellidae Deflandre, 1959, or to another group of microorganisms, such as *Pithonella* Lorenz, 1901 (see Bolli, 1974, 1978; Keupp, 1978).

Globochaete-bearing microfacies

The microfacies containing *Globochaete alpina* Lombard as the most abundant microfossil is rarely observed in the studied Tithonian deposits. As usual, other microorganisms (spicules of Didemnidae, *Saccocoma* sp., calcispheres) are also present in this microfacies. In the Upper Tithonian limestones, calpionellids and radiolarians occur together with *Globochaete alpina*.

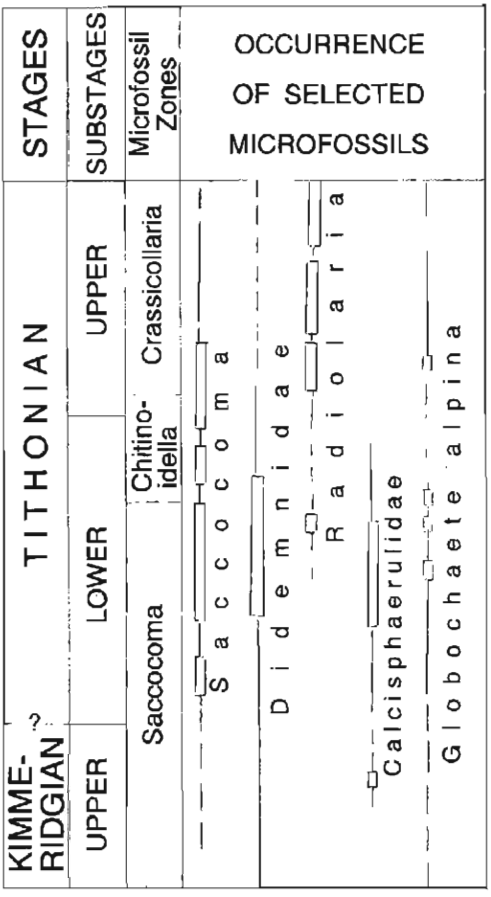
Chitinoidella-bearing microfacies

The microfacies frequently containing *Chitinoidella* spp. (Pl. III, 3) occurs in black limestones of late Early Tithonian age. Sometimes, as the specimens of *Chitinoidella* are poorly preserved, their presence in microsparitic matrix may be overlooked. The remains of *Saccocoma*, spicules of Didemnidae, calcispheres and radiolarians are also observed in this microfacies.

Radiolarian microfacies

In the Tithonian limestones of Sierra del Rosario, voids left after dissolved tests of Radiolaria are, as usual, filled with sparitic calcite (Pl. III, 2), making impossible or difficult identification of taxa in thin sections. In some cases, better preserved calcitic molds may be found belonging to the following genera: *Acaeniotyle*, *Alievium*, *?Archaeodictyomitra*, *Mirifusus* and *Sethocapsa*. The radiolarian microfacies occurs in biomicrites and biomicrosparites, which are often laminated. The darker laminae contain abundant Radiolaria, while the lighter ones are poorer in these microfossils.

Spicules of Didemnidae, *Globochaete alpina* Lombard, *Saccocoma*, *Chitinoidella* spp. or Calpionellidae are also present in the radiolarian microfacies. In addition, detritus of ammonite shells and phosphatic fish debris occur in the Lower Tithonian limestones.



In the southern sequence of Sierra del Rosario, Radiolaria appear in the upper part of the *Saccocoma* Zone, but are subordinate with respect to other microorganisms (Fig. 10). In the Upper Tithonian, the radiolarian microfacies is dominant in the limestones of the uppermost part of the La Zarza Member. In the northern sequence, (Rancho Manete section – Fig. 7), the radiolarian microfacies is the most important in the entire column of the upper part of the La Zarza Member, that is, also in the Lower Tithonian limestones. In the radiolarian limestones, ammonites are infrequent or missing, calpionellids are infrequent and/or poorly preserved.

Fig. 10 Occurrence of selected microfossils in the studied Tithonian sections of the southern sequence of Sierra del Rosario

CORRELATION OF AMMONITE AND MICROFOSSIL ZONES

Three ammonite zones and three microfossil zones are distinguished in the Tithonian of the southern sequence of Sierra del Rosario (Fig. 9). In the Early Tithonian, the *Pseudolissoceras* spp. Zone corresponds to the upper part of the *Saccocoma* Zone and probably to the lowermost part of the *Chitinoidella* Zone.

The *Lytohoplites carribeanus* Zone correlates with a major part of the *Chitinoidella* spp. Zone (Fig. 9), as in the Sierra de los Organos (Myczyński & Pszczółkowski, 1990). More precise correlation of the boundaries of the *Chitinoidella* Zone with the ammonite assemblages requires further study.

The Late Tithonian *H. (Micracanthoceras) - Corongoceras* Zone corresponds to the *Crassicollaria* Zone and, probably, to the upper-

most part of the *Chitinoidella* Zone (Fig. 9). The index ammonites of the *H. (Micracanthoceras) - Corongoceras* Zone are less numerous in the Sierra del Rosario than in the Sierra de los Organos. In the former area, the upper boundary of this zone is poorly defined due to the scarcity of ammonites. In the upper part of the discussed ammonite zone calpionellids are less frequent and usually poorly preserved; thus, it is rather difficult to determine the Tithonian/Berriasian boundary.

COMPARISON OF TITHONIAN AMMONITE ASSEMBLAGES IN CUBA WITH THOSE FROM OTHER AREAS OF THE CARIBBEAN PROVINCE

The ammonites found in the Tithonian deposits of the northern sequence do also occur in the southern sequence of Sierra del Rosario. Besides the taxa recorded in the Rancho Manete section (Fig. 7), some specimens of *"Parodontoceras"* spp. have been collected but not yet described from other outcrops of the Tithonian limestones belonging to the northern sequence. Bivalves of the genus *Buchia* occur in the Tithonian deposits of both sequences of Sierra del Rosario. These are dark-grey to black limestones with analogous microfacies. Some minor differences, namely earlier appearance of the radiolarian microfacies and scarcity of ammonites in the northern sequence, reflect diversified paleobathymetry in the northern part of the the northern part of the Proto-Caribbean basin. The Tithonian deposits of both sequences were, however, laid down in adjacent areas of this sedimentary basin.

The Tithonian ammonite assemblages of Western Cuba are similar to those known in central Cuba (Shopov in: Kantchev *et al.*, 1978; Myczyński, 1989). Most of the taxa, such as *Protancyloceras hondense* (Imlay), *Vinalesites rosariensis* (Imlay), *"Parodontoceras" butti* Imlay, *"Parodontoceras" antilleanum* Imlay, *Pseudolissoceras*, *Hildoglochiceras (Salinites)*, *Lytohoplites*, *Corongoceras* (Imlay, 1942; Shopov in: Kantchev *et al.*, 1978), probably also ammonites of the genus *Mazapilites* (Shopov in: Kantchev *et al.*, 1978) are common in the compared parts of Cuba. The Tithonian limestones of the Camajuaní sequence belong to the La Trocha Formation. The Constancia and Veloz formations of the Placetas sequence, yielded only a few ammonites (Shopov in: Kantchev *et al.*, 1978; Myczyński & Triff, 1986).

According to Olóriz *et al.* (1990), in the Tithonian and Berriasian endemic genera of ammonites inhabited the entire southern margin of the North American plate (Mexico, Cuba and southern part of the United States). According to them, this could indicate a biogeographic uniformity of this area. At the end of the Jurassic, a marked regres-

sive trend has been recorded in the nothernmost areas of the Mexican platforms (*op. cit.*).

In the authors' opinion, in the Caribbean Province (*sensu* Westermann, 1984, and Myczyński, 1989), some differences between the Tithonian ammonite assemblages of Cuba and Mexico may be stated:

1. the Cuban endemic taxa: *Vinalesites rosariensis* (Imlay) and *Protancyloceras hondense* (Imlay) are not known in Mexico;

2. Some taxa characteristic for western Cuba (*"Parodontoceras" butti* Imlay, *"P". antilleanum* Imlay and *Lytohoplites carribeanus* Imlay) are absent or infrequently recorded in Mexico;

3. Some endemic Mexican ammonites (genera *Suarites*, *Acevedites*) are absent in western Cuba;

4. The genus *Substeueroceras* (latest Tithonian?-Early Berriasian) is not known from Cuba.

Towards the boundary of the Early and Late Tithonian, there was a marked change in the character of the ammonite assemblages in the West Cuban part of the Proto-Caribbean basin (Myczyński, 1989). During the Late Tithonian, endemic and Indo-Pacific taxa became the dominant components of ammonite fauna, while the Tethyan ammonites almost disappeared. Apparently, at this time, the Proto-Atlantic seaway was restricted, thus being of limited significance for migration of the western Tethyan ammonites into the Caribbean Province. It seems that migration of ammonites from the Indo-Pacific area (across the Andean Province) was easier at that time. In Western Cuba, the succession of microfacies indicate a consequently transgressive trend from the Late Kimmeridgian to the Berriasian.

TITHONIAN RADIOLARIA-BEARING DEPOSITS IN CUBA AS COMPARED WITH OTHER AREAS OF THE CARIBBEAN REGION

In the Sierra del Rosario, radiolarian microfacies first appears in the limestones of the lowermost Tithonian belonging to the northern stratigraphic sequence. In the southern sequence, the first occurrence of this microfacies is observed in the upper part of the Lower Tithonian, while in the Sierra de los Organos it is not known in the deposits older than the Late Tithonian (Myczyński & Pszczółkowski, 1990). During the Late Tithonian, the radiolarian microfacies developed in all three sequences of Cordillera de Guaniguanico replacing the *Saccocoma*-Didemnidae and the calcisphaere-bearing microfacies. The radiolarian microfacies is dominant in the Upper Tithonian deposits also in the Camajuaní sequence of central Cuba (unpublished data of the second author, A. P.). A similar phenomenon was observed in the Upper Tithonian of the Camagüey Province. Therefore, during the

Late Tithonian, conditions favourable for radiolarian development were established in the Cuban part of the Proto-Caribbean basin. The radiolarian microfacies also prevails in the Berriasian of Cordillera de Guaniguanico (Pszczółkowski, 1978), the ammonites being very infrequent in the deposits of this age. During the Berriasian the basin floor in Western Cuba probably descended below the ACD.

The above data indicate differentiated bathymetry of the northern (Cuban) part of the Proto-Caribbean basin. At the end of the Jurassic, changes in bathymetry were caused by subsidence of the Florida-Bahamas and Yucatan platform margins. During the Tithonian, the Proto-Caribbean basin widened significantly (Ross & Scotese, 1988, fig. 5; Stephan *et al.*, 1990, pl. 4) allowing for improvement in its connection with the Pacific Ocean. In the Camagüey Province of Cuba, Upper Tithonian ammonite-bearing radiolarian limestones directly overlie basalts interbedded with sedimentary rocks containing *Saccocoma* and Radiolaria (Iturralde-Vinent & Marí Morales, 1988). However, true radiolarites are absent in the Jurassic of Cuba.

In the Caribbean region the Tithonian radiolarites (or radiolarian cherts) are only known in Puerto Rico (Mattson, 1984; Donnelly, 1985) and on the La Désirade in the Lesser Antilles (Montgomery *et al.*, 1992). The radiolarian cherts from La Désirade may have been deposited in the Pacific rather than in the Proto-Caribbean basin (*op. cit.*). The connection of that basin with the Pacific during the Tithonian was probably also through a strait which separated Yucatan from Florida (Pszczółkowski, 1987; Fourcade *et al.*, 1991). At the end of the Jurassic, and during the Early Cretaceous, deep sea sediments were deposited in the central part of the seaway located between the Yucatan and Florida blocks (Marton & Buffler, 1992).

The radiolarian microfacies, during the Late Tithonian-Berriasian, developed not only in Cuba but also in the western part of the Proto-Atlantic (Ogg *et al.*, 1983). However, in the Jurassic of Cuba, neither brown and red marls of the Atlantic Cat Gap Formation, nor nodular limestones (*Rosso Ammonitico*), are known. In the Tithonian of Western Cuba, limestones of Maiolica facies are also unknown contrary to suggestions of Fourcade *et al.* (1991). In the Cordillera de Guaniguanico, the Tithonian limestones are dark-grey to black in colour and do not contain chert intercalations. The presence of Maiolica-type limestones is more probable in the Lower Cretaceous of Cuba (Wieczorek, 1988). The Late Jurassic deposits of Cordillera de Guaniguanico belonged to the Gulf of Mexico-Caribbean domain. This domain differed from the Mediterranean Tethys and the Central Atlantic (or Proto-Atlantic) domains in its sedimentary facies, and also because of its biogeographic connections with the Pacific Ocean during the Late Tithonian.

REFERENCES

AUBRY, M. P., F. DEPECHE & T. DUFOUR, 1988. *Stomiosphaera minutissima* (Colom, 1935) from the Lias of Mallorca (Balearic Islands) and Umbria (Italy), and *Schizosphaerella punctulata* Deflandre & Dangeard, 1938: taxonomic revision. *Geobios*, 21 (6): 709 – 727.

BOLLI, H. M., 1974. Jurassic and Cretaceous Calcisphaerulidae from DSDP Leg 27, Eastern Indian Ocean. In: J. J. Veevers, J. R. Heirtzler, *et al.*, *Init. Repts D.S.D.P., Leg 27*, Washington D.C.: 843 – 907.

BOLLI, H. M., 1978. Upper Jurassic Calcisphaerulidae from DSDP Leg 44, Hole 391C, Blake-Bahama Basin, western North Atlantic. In: W. E. Benson, R. E. Sheridan *et al.*, *Init. Repts D.S.D.P., Leg 44*, Washington D.C.: 911 – 919.

BONET, F. & N. BENVENISTE-VELASQUEZ, 1971. Espículas de ascidias fósiles y actuales. *Rev. Inst. Mexic. Petrol.*, 3 (4): 8 – 35.

BORZA, K., 1969. *Die Mikrofazies und Mikrofossilien des Oberjuras und der Unterkreide der Klippenzone der Westkarpaten*. Vyd. Slov. Akad. Vied., Bratislava: 1 – 301.

BORZA, K. & M. MIŠÍK, 1975. *Gemeridella minuta* n. gen., n.sp. aus der oberen Trias der Westkarpaten. *Geol. Zborn. (Geol. Carpath.)*, 26 (1): 77 – 84.

CECCA, F. & J. ŘEHÁNEK, 1991. First correlation between Late Jurassic ammonite and "microproblematic" biostratigraphic scales. Results from Marches Apennines (Central Italy). *C. R. Acad. Sci. Paris*, 313 (II): 1441 – 1446.

COLLIGNON, M., 1960. *Atlas de fossiles caractéristiques de Madagascar*. V, Kimmeridgian, pp. 96-133; VI, Tithonique, pp. 134-175. Minist. Min. l'Energ. Rep. Malgache.

DONNELLY, T. W., 1985. Mesozoic and Cenozoic plate evolution of the Caribbean region. In: F. G. Stehli & S. D. Webb (eds), *The Great American Biotic Interchange*, pp. 89 – 121, Plenum Press, New York & London.

DROMART, G. & F. ATROPS, 1988. Valeur stratigraphique des biomicrofaciès pélagiques dans le jurassique supérieur de la Téthys occidentale. *C. R. Acad. Sci. Paris*, 306 (II): 1365 – 1371.

DURAND DELGA, M., 1957. Quelques remarques sur les Fibrosphères. *Publ. Serv. Carte Géol. Algérie*, 13: 153 – 164.

ENAY, R. & J. R. GEYSSANT, 1975. Faunes d'ammonites du Tithonique des châines bétiques (Espagne méridionale). *Colloq. Limite Jurass.-Crét., Lyon-Neuchâtel, Sept. 1973. Mém. BRGM*, 86: 39 – 55.

FOURCADE, E., J. AZEMA, F. CECCA, M. BONNEAU, B. PEYBERNES & J. DERCOURT, 1991. Essai de reconstitution cartographique de la paléogéographie et des paléoenvironnements de la Tethys au Tithonique supérieur (138 à 135 Ma). *Bull. Soc. Géol. Fr.*, 162 (6): 1197 – 1208.

FURRAZOLA-BERMUDEZ, G., 1965. *Tres nuevas especies de Tintínidos del Jurásico Superior de Cuba*. Inst. Cubano Rec. Min., Publ. Esp. 2: 1 – 29, La Habana.

FURRAZOLA-BERMUDEZ, G. & K. KREISEL, 1973. Los Tintínidos de Cuba. *Rev. Tecnologica*, 11 (1): 27 – 45. La Habana.

HERRERA, N. M., 1961. Contribución a la estratigrafía de la provincia de Pinar del Río. *Rev. Soc. Geol. Cubana Ing.*, 61 (1-2): 2 – 21. La Habana.

HOUŠA, 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.), La Habana.

HOUŠA, V. & M. NUEZ, DE LA, 1975. Ammonite fauna of the Tithonian and lowermost Cretaceous of Cuba. *Mem. BRGM*, 86, p. 57. Lyon - Neuchâtel.

IMLAY, R., 1942. Late Jurassic fossils from Cuba and their economic significance. *Geol. Soc. Amer. Bull.*, 53: 1417 – 1478.

ITURRALDE VINENT, M. A., & T. MARI MORALES, 1988. Toleitas del Tithoniano en la Sierra de Camaján, Camagüey. Posible datación de la corteza oceanica. *Rev. Tecnologica*, 18 (1): 25 – 32. La Habana.

JUDOLEY, K. & G. FURRAZOLA-BERMUDEZ, 1968. *Estratigrafía y fauna del Jurásico de Cuba.* Publ. Esp. ICRM, pp. 1 – 126. La Habana.

KANCHEV, J., J. BOYANOV, N. POPOV, R. CABRERA, A. GORANOV, N. IOLKICEV, M. KANAZIRSKI & M. STANCHEVA, 1978. *Geología de la provincia de Las Villas (resultados de las investigaciones geológicas y levantamiento geológico a escala 1:250 000 realizados durante el período 1969-1975* (unpublished). Inst. Geol. Paleont. Acad. Cien. Cuba, La Habana.

KÄLIN, O., 1980. *Schizosphaerella punctulata* Deflandre & Dangeard: wall ultrastructure and preservation in deeper-water carbonate sediments of the Tethyan Jurassic. *Eclogae Geol. Helv.*, 73 (3): 983 – 1008.

KEUPP, H., 1978. Calcisphaeren des Untertithon der südlichen Frankenalb und die systematische Stellung von *Pithonella* Lorenz 1901. *N. Jb. Geol. Palaont., Mh.*, H. 2: 87 – 98.

KREISEL, K. & G. FURRAZOLA-BERMUDEZ, 1971. *Notas preliminares sobre la distribución de Tintínidos en Cuba.* Publ. Esp. 5: 1 – 24, La Habana.

LEWIS, J. W., 1932. Geology of Cuba. *Amer. Assoc. Petrol. Geol. Bull.*, 16 (6): 533 – 555.

MARTON, Gy. & R. T. BUFFLER, 1992. Evolution of a Mesozoic seaway, southeastern Gulf of Mexico. *Progr. Abstr. 13th Caribb. Geol. Conf., Pinar del Río, Cuba*, p. 51.

MATTSON, P. H., 1984. Caribbean structural breaks and plate movements. In: W. E. Bonini, R. B. Hargraves & R. Shagam (eds), *The Caribbean-South American Plate Boundary and Regional Tectonics*, p. 131 – 152. *Geol. Soc. Amer. Mem.*, 162. Boulder, Colorado.

MIŠÍK, M. & K. BORZA, 1978. *Gemeridella, Didemnoides, Didemnum* und körperchen ähnlicher Gestalt aus dem Mesozoikum der Westkarpaten. *Geol. Zborn. (Geol. Carpath.)*, 29 (2): 307 – 326.

MONTGOMERY, H., E. A. PESSAGNO, Jr., & I. M. MUÑOZ, 1992. Jurassic (Tithonian) Radiolaria from La Désirade (Lesser Antilles): preliminary paleontological and tectonic implications. *Tectonics*, 11 (6): 1426 – 1432.

MYCZYŃSKI, R., 1977. Lower Cretaceous ammonites from Sierra del Rosario (western Cuba). *Acta Palaeont. Pol.*, 22 (2): 139 – 173.

MYCZYŃSKI, R. 1989. Ammonite biostratigraphy of the Tithonian of western Cuba. *Ann. Soc. Geol. Pol.*, 59: 43 – 125.

MYCZYŃSKI, R. 1990. *Simocosmoceras* Spath (Perisphinctidae, Ammonitina) in the Lower Tithonian of Sierra del Rosario (western Cuba). *Atti II Conv. Int. F.E.A. Pergola (1987)*: 401 – 403.

MYCZYŃSKI, R. & J. TRIFF, 1986. Los ammonites del Cretácico Inferior de las provincias de Pinar del Río y Matanzas. *Bull. Pol. Acad. Sci., Earth Sci.*, 34, (1): 113 – 137.

MYCZYŃSKI, R. & A. PSZCZÓŁKOWSKI, 1990. Tithonian stratigraphy in the Sierra de los Organos, western Cuba: correlation of the ammonite and microfossil zones. *Atti II Conv. Int. F.E.A. Pergola (1987)*: 405 – 415.

NAGY, I., 1966. Sur le rôle stratigraphique des genres *Stomiosphaera* et *Cadosina* dans le Jurassique supérieur de la Montagne Mecsek. *Földt. Közl.*, 96 (1): 86 – 104.

NOWAK, W., 1968. Stomiosferidy warstw cieszyńskich (kimeryd-hoteryw) polskiego Śląska Cieszyńskiego i ich znaczenie stratygraficzne (Stomiosphaerids of the Cieszyn beds, Kimmeridgian-Hauterivian, in the Polish Cieszyn Silesia and their stratigraphical value). *Ann. Soc. Geol. Pol.*, 38 (2-3): 275 – 334.

OGG, J. G., A. H. F. ROBERTSON & L. F. JANSA, 1983. Jurassic sedimentation history of Site 534 (Western North Atlantic) and of the Atlantic-Tethys Seaway. In: F. M. Gradstein *et al.*, *Init. Repts D.S.D.P. Leg 76*, Washington D.C.: 829 – 884.

OLORIZ, F., 1978. Kimmeridgiense-Tithonico Inferior en el sector Central de las Cordilleras Beticas (Zona Subbetica), paleontología, bioestratigrafía. *Tesis Doctor. Univ. Granada*, 184: 1 – 785.

OLORIZ, F., A. B. VILLASEÑOR, C. GONZALEZ & G. E. G. WESTERMANN, 1990. Las plataformas mexicanas durante el Jurásico Superior. Un ejemplo de áreas de recepción en biogeografía. In: J. Civis Llovera & J. A. Flores Villarejo (eds), *Actas Paleont. (Actas IV Jorn. de Paleont.), Salamanca, 13-15 Oct. 1988*: 277 – 287.

PSZCZÓŁKOWSKI, A., 1971. Jurassic, Cretaceous and Paleogene deposits of Sierra del Rosario (Cuba). *Bull. Acad. Polon. Sci. Sér. Sci. Terre*, 19 (4): 249 – 259.

PSZCZÓŁKOWSKI, A., 1978. Geosynclinal sequences of the Cordillera de Guaniguanico in western Cuba; their lithostratigraphy, facies development and paleogeography. *Acta Geol. Pol.*, 28: 1 – 96.

PSZCZÓŁKOWSKI, A., 1987. Paleogeography and paleotectonic evolution of Cuba and adjoining areas during the Jurassic-Early Cretaceous. *Ann. Soc. Geol. Pol.*, 57: 127 – 142.

PSZCZÓŁKOWSKI, A., 1988. Secuencias miogeosinclinales de la cordillera de Guaniguanico; su litoestratigrafía, desarrollo de facies y paleogeografía. In: *Contrib. geol. provin. Pinar del Río*, Edit. Cient.-Técn., p. 5 – 84. La Habana.

ROSS, M. I. & C. R. SCOTESE, 1988. A hierarchical tectonic model of the Gulf of Mexico and Caribbean region. *Tectonophysics*, 155: 139 – 168.

STEPHAN, J.-F., B. MERCIER DE LEPINAY, E. CALAIS, M. TARDY, C. BECK, J.-C. CARFANTAN, J.-L. OLIVET, J.-M. VILA, P. BOUYSSE, A. MAUFFRET, J. BOURGOIS, J.-M. THERY, J. TOURNON, R. BLANCHET & J. DERCOURT, 1990. Paleogeodynamic maps of the Caribbean: 14 steps from Lias to Present. *Bull. Soc. Géol. Fr.*, (8), 6: 915 – 919 + Supplément (Atlas).

VERMA, H. M. & G. E. G. WESTERMANN, 1973. The Tithonian (Jurassic) ammonite fauna and stratigraphy of Sierra Catorce, San Luis Potosí, Mexico. *Bull. Am. Paleont.*, 63: 107 – 314.

WESTERMANN, G., 1984. The Middle Jurassic Proto-Atlantic and Atlantic. *Circum-Pacific Jurassic Res. Gr. Proj. No. 171, Rept. 2.* Hamilton, Ontario: 107.

WIECZOREK, J., 1988. Maiolica - a unique facies of the Western Tethys. *Ann. Soc. Geol. Pol.*, 58: 255 – 276.

ZEISS, A., 1968. Unterschungen zur Paläontologie der Cephalopoden des Unter-Tithon der Südlischen Frankenalb. *Abh. Bayer. Akad. Wiss., Math. Naturw.* KL., N. F., 132: 1 – 190.

ZEISS, A., 1984. In: *Guide Book to Excursions (Upper Jurassic). Int. Sympos. Jurass. Stratigr., Erlangen (1984)*: 68 – 90.

Ryszard Myczyński i Andrzej Pszczółkowski

STRATYGRAFIA I MIKROFACJE TYTONU W SIERRA DEL ROSARIO, W ZACHODNIEJ CZĘŚCI KUBY

Streszczenie

W zbadanych profilach osadów tytonu Sierra del Rosario w zachodniej części Kuby wyróżniono horyzont z *Parakeratinites* sp. oraz poziomy: *Pseudolissoceras* spp., *Lytohoplites carribeanus* i *Himalayites (Micracanthoceras)* - *Corongoceras*. Wymie-

nione poziomy amonitowe zostały skorelowane z poziomami *Saccocoma*, *Chitinoidella* i *Crassicollaria* wydzielonymi na podstawie mikroskamieniałości.

W osadach dolnego tytonu Sierra del Rosario jest rozpowszechniona mikrofacja sakkokomowo-didemnidowa, natomiast w wapieniach górnego tytonu przeważa mikrofacja radiolariowa. W górnym tytonie mikrofacja radiolariowa rozwinęła się we wszystkich sukcesjach kordyliery Guaniguanico. Następstwo mikrofacji wskazuje na stopniowe zmiany w paleobatymetrii (pogłębienie) w północnej części basenu protokaraibskiego między najniższym tytonem i beriasem. Taksony endemiczne i indo-pacyficzne przeważają w zespole amonitów górnego tytonu w sukcesjach kordyliery Guaniguanico. Fakt ten autorzy wiążą z poprawą połączeń basenu protokaraibskiego z Pacyfikiem.

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EXPLANATIONS OF PLATES

Plate I

1a — *"Parodontoceras" butti* Imlay
b — *Vinalesites rosariensis* (Imlay); La Zarza Member, Lower Tithonian, El Toro section, Sierra del Rosario, × 1
2 — *Hildoglochiceras (Salinites) grossicostatum* Imlay; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, Sierra del Rosario, × 1.5
3 — *Protancyloceras hondense* (Imlay); La Zarza Member, Lower Tithonian, El Toro section, × 1.5
4 — *Lytohoplites carribeanus* Imlay; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.5
5a — *Lytohoplites* sp.
b — *Protancyloceras* sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.5

Plate II

1 — *Taramelliceras (Parastreblites)* sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.2
2 — *Glochiceras (?Lingulaticeras)* sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.2
3 — *Taramelliceras (Parastreblites)* sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1
4 — *Glochiceras (?Lingulaticeras)* sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 2
5 — *Pseudolissoceras zitteli* (Burckhardt); La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.2
6 — *Glochiceras (?Lingulaticeras)* sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.5
7 — *Parakeratinites* sp.; La Zarza Member, Lower Tithonian, Rancho Manete section, × 1.5
8a — *Haploceras* sp.;
b — *Glochiceras (?Lingulaticeras)* sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.5
9 —

Taramelliceras (Parastreblites) sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.5

10 — *Glochiceras (?Lingulaticeras)* sp.; La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 1.5

11 — *Himalayites (Micracanthoceras)* cf. *alamense* (Imlay); La Zarza Member, Upper Tithonian, La Piedra de Genaro section, × 1.5

Plate III

1 — *Saccocoma*-Didemnidae microfacies; limestones of the La Zarza Member, Lower Tithonian, La Piedra de Genaro section, Sierra del Rosario, × 60

2 — Radiolarian microfacies with *Saccocoma* skeletal debris; La Zarza Member, *Chitinoidella* Zone, Cinco Pesos section, × 40

3 — *Chitinoidella*-bearing microfacies; La Zarza Member, *Chitinoidella* Zone, Cinco Pesos section, × 170

4 — *Didemnoides moreti* (Durand Delga, 1957); the fragment of lancet-shaped calcitic element is visible in the upper (right) part of the spicule; La Villa - La Revuelta section, Lower Tithonian limestone; thin section, × 420

5 — *Didemnum* sp.; La Zarza Member, Lower Tithonian, El Toro section, × 385

6 — *Didemnoides moreti* (Durand Delga); Lower Tithonian limestone of the La Zarza Member, La Piedra de Genaro section, SEM micrograph, × 1000

7 — Elongated spicule of Didemnidae; La Zarza Member, Lower Tithonian, Cinco Pesos section, × 320

8 — *Didemnum carpaticum* Mišík et Borza, 1978; La Zarza Member, Lower Tithonian, La Villa - La Revuelta section, × 190

9 — *Cadosina fusca* Wanner; Artemisa Formation, Tithonian, Rancho Manete section, × 300

Plate IV

1 — *Colomisphaera cieszynica* Nowak; Artemisa Formation, Lower Tithonian, Rancho Manete section, × 300

2 — *Colomisphaera carpathica* (Borza); La Zarza Member, Lower Tithonian, La Piedra de Genaro section, × 415

3 — *Colomisphaera minutissima* (Colom); La Zarza Member, Lower Tithonian, El Toro section, × 400

4 — *Chitinoidella boneti* Doben; La Zarza Member, *Chitinoidella* Zone, La Villa - La Revuelta section, × 330

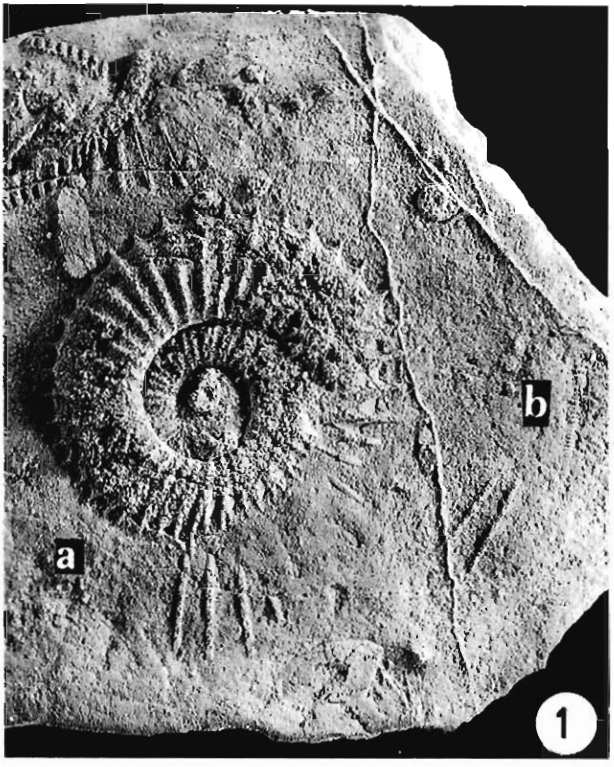
5 — *Chitinoidella boneti* Doben; La Zarza Member, *Chitinoidella* Zone, La Villa - La Revuelta section, × 400

6 — *Chitinoidella boneti* Doben; La Zarza Member, *Chitinoidella* Zone, La Villa - La Revuelta section, × 415

7 — *Chitinoidella cristobalensis* (Furrazola-Bermúdez); La Zarza Member, *Chitinoidella* Zone, La Villa - La Revuelta section, × 400

8 — *Chitinoidella* sp.; La Zarza Member, *Chitinoidella* Zone, Cinco Pesos section, × 560

9 — Specimen of *Chitinoidella boneti* Doben with a calcitic fringe of diagenetic origin; La Zarza Member, *Chitinoidella* Zone, La Villa-La Revuelta section, × 160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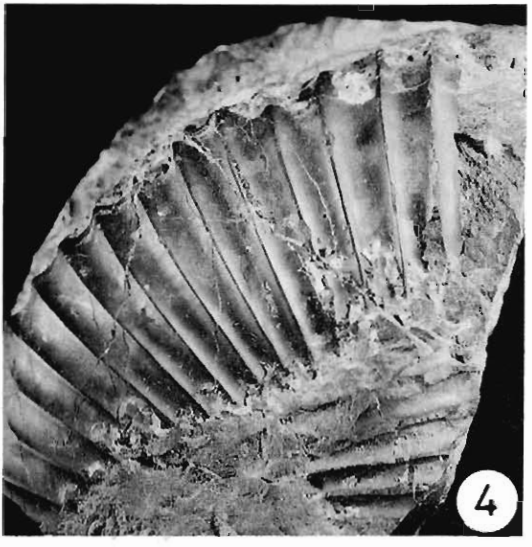
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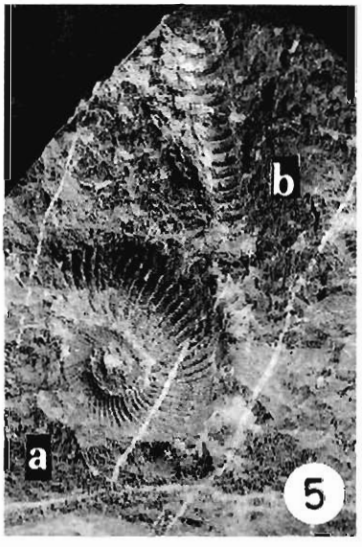
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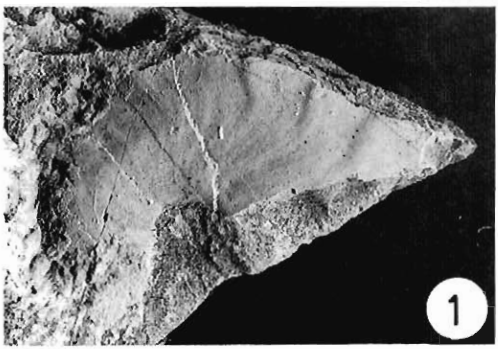
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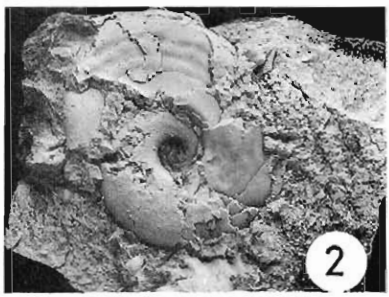
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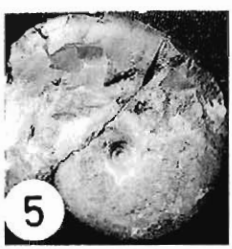
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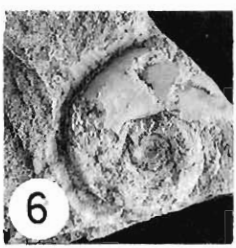
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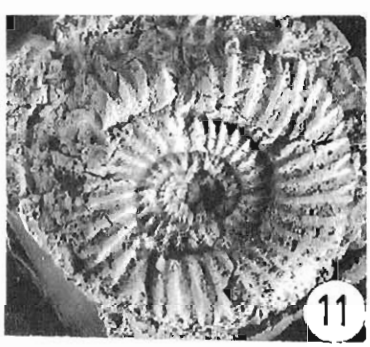
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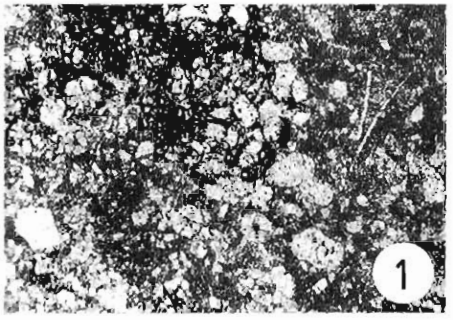
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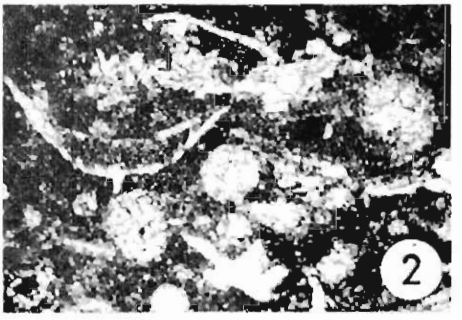
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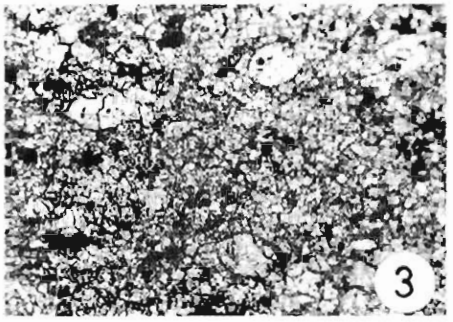
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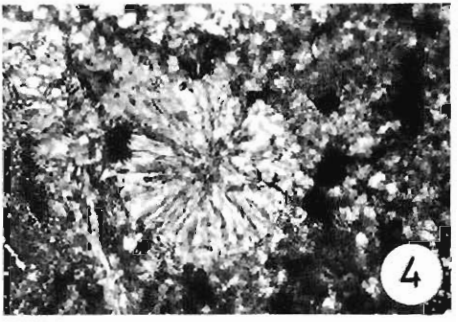
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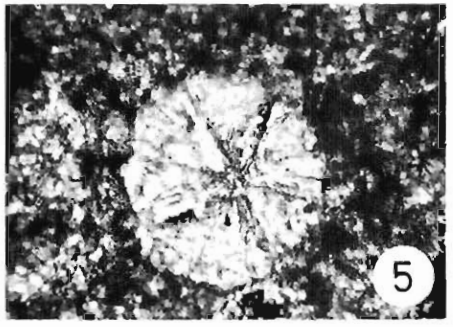
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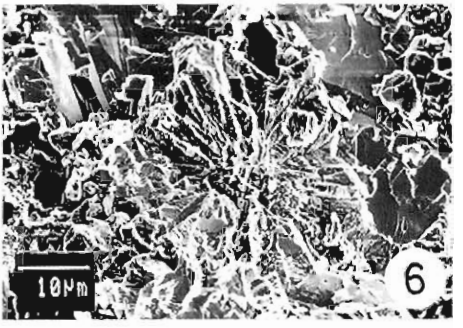
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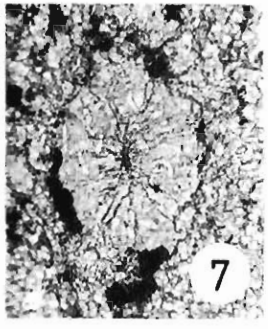
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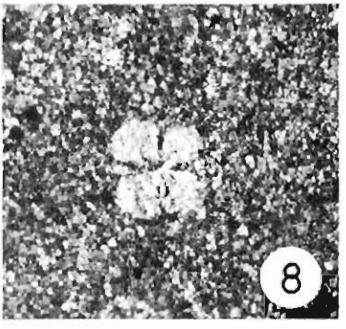
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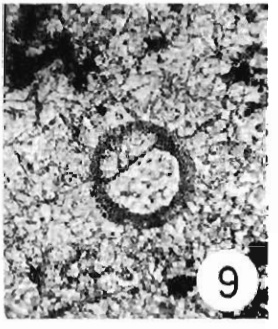
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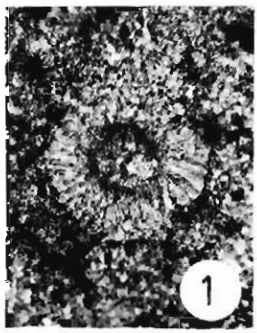
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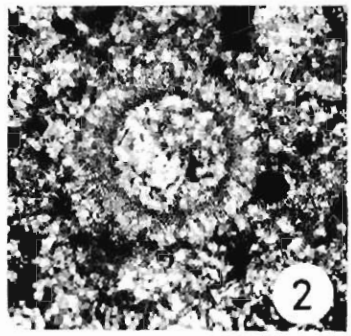
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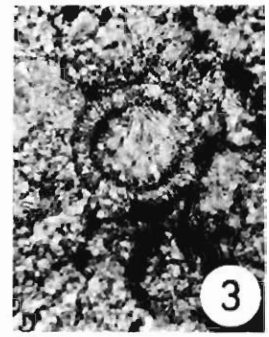
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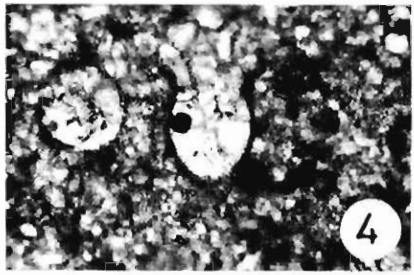
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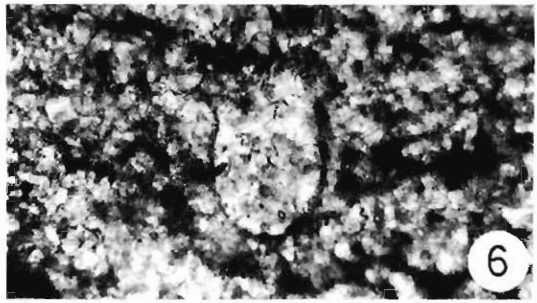
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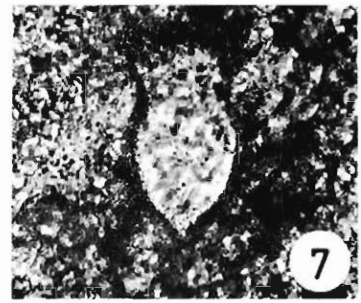
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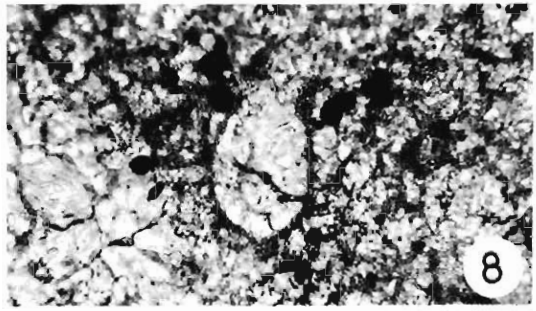
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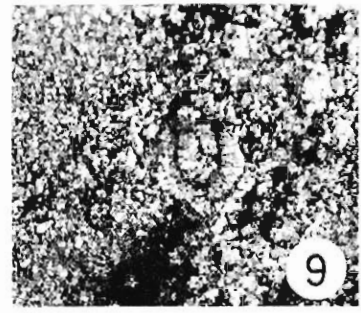
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