UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
INSTITUTO DE GEOLOGIA
DIRECTOR: DR. JOSE C. GUERRERO

PALEONTOLOGIA MEXICANA NUMERO 46

THE UPPER BAJOCIAN AND LOWER BATHONIAN (JURASSIC) AMMONITE FAUNAS OF OAXACA, MEXICO AND WEST-TETHYAN AFFINITIES

BY
G.E.G. WESTERMANN
McMaster University, Hamilton, Ontario, Canada

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ABSTRACT

The Ammonitina of the Taberna Formation, partly known from the works of Burckhardt (1927) and Ochoterena (1963), is revised, based mostly on the collections of Erben (1956). The well known lower fauna, here named the *Parastrenoceras* ammonite association, includes abundant *Leptosphinctes* s. str., *Parastrenoceras* and *Oppelia* s. str.; some *Stephanoceras* s. str.; and rare *Sphaeroceratinae* and *?Lupherites*. This association is close to and partly conspecific with that of the European-North Chilean Subfurcatum Zone which is therefore extended to Mexico. *Leptosphinctes tabernai* n. sp. probably occurs in SW Germany; *Oppelia subradiata erbeni* n. subsp. is the first good evidence of this species outside Western Tethys; similarly, *Parastrenoceras* is known only from Europe and Mexico. Eastern Pacific elements are possibly minor associates, *i.e.* *?Stephanoceras* cf. *chilense* Hillebrandt and *?Lupherites*. The association is much more closely affiliated to the West Tethyan than to the circum-Pacific fauna and is good evidence for a "Central Atlantic" marine connection between the Pacific and Tethys.

The upper, mainly lower Bathonian ammonite fauna is known only from old collections without locality data. Arkell's assumption (1956; Arkell *et al.*, 1957) that the Duashnú "*Stephanoceras*" are in fact *Zigzagiceras*, is confirmed; "*S.*" *floresi* Burckhardt is type species of *Z.* (*Duashnoceras*) n. subgen. The apparently associated "*Stephanoceras* aff. *psilacanthum*" is classified as Zigzagiceratinae *gen. et sp. nov.* A; and most of the "*Dactylioceras* sp. indet." are tentatively placed in *Planisphinctes*. *Z. floresi* is the only known *Zigzagiceras* from outside Europe, again evidence for a marine connection between the eastern Pacific and western Tethys. This is also the first good indicator of the lower Bathonian in the circum-Pacific area.

Conservative palaeogeographic reconstruction of a Oaxaca embayment opening to the Pacific Ocean is difficult to reconcile with the biogeographic affinities of its Bajocian - early Bathonian ammonite faunas.

RESUMEN

Se revisa el Suborden Ammonitina de la Formación Taberna, parcialmente conocido por los trabajos de Burckhardt (1927) y Ochoterena (1963), principalmente con base en las colecciones de Erben (1956). La fauna inferior bien conocida, aquí denominada asociación de amonitas con *Parastrenoceras*, incluye abundantes *Leptosphinctes* s. str., *Parastrenoceras* y *Oppelia* s. str.; algunas *Stephanoceras* s. str.; y raras *Sphaeroceratinae* y *?Lupherites*. Esta asociación es cercana y parcialmente conespecífica con la de la Zona de Subfurcatum europea-norchilena la cual, por tanto, se extendió a México. *Leptosphinctes tabernai* n. sp. probablemente se encuentra en Alemania sud-occidental; *Oppelia subradiata erbeni* n. subsp. representa la primera evidencia buena de esta especie fuera del Tethys Occidental; de manera semejante, *Parastrenoceras* se conoce sólo de Europa y México. Los elementos Pacíficos orientales posiblemente constituyan asociaciones menores, *i.e.* *?Stephanoceras* cf. *chilense* Hillebrandt y *?Lupherites*. La asociación está más íntimamente relacionada con la fauna del Tethys Occidental que con la del circum-Pacífico y el Tethys.

La fauna de amonitas superior, principalmente del Batoniano inferior, se conoce solamente por colecciones antiguas, carentes de datos sobre su localización. La suposición de Arkell (1956; Arkell *et al.*, 1957) en cuanto a que los "*Stephanoceras*" de Duashnú fuesen de hecho *Zigzagiceras* se confirma; "*S.*" *floresi* Burckhardt es la especie tipo de *Z.* (*Duashnoceras*) n. subgen. "*Stephanoceras* aff. *psilacanthum*" aparentemente asociado se clasifica como Zigzagiceratinae *gen. et sp. nov.* A; y la mayor parte de "*Dactylioceras* sp. indet." se coloca tentativamente en *Planisphinctes*. *Z. floresi* es la única *Zigzagiceras* que se conoce fuera de Europa, y

también atestigua una conexión marina entre el Pacífico Oriental y el Tethys Occidental; además, se considera como el primer buen indicador del Batoniano inferior en el área circum-pacífica.

Es difícil reconciliar una reconstrucción paleogeográfica conservadora de una paleobahía en Oaxaca abierta al Océano Pacífico con las afinidades biogeográficas de sus faunas de amonitas del Bajociano y Batoniano temprano.

INTRODUCTION

The Middle Jurassic ammonoid fauna of Mexico has been the subject of only a very few taxonomic studies of any significance, *i.e.* the comprehensive classic work by Burckhardt (1927) and the thorough description of the new genera *Parastrenoceras* and "*Infrapatoceras*" =*Parapatoceras* by Ochoterena (1963, 1966). Unfortunately, these descriptions were largely based on older collections not made by these authors, and the collections may have been mixed. While Burckhardt relied on specimens collected, without much attention to stratigraphy, by Flores, Aguilera and Bonillas, Ochoterena's work was based on the excellent field work in the early fifties by H.K. Erben. Erben's large collections from sections described in detail, however, were not labelled or catalogued individually. Partial mixing is evident from the comparison of his listings with the distribution among the present lots of the taxa from the different localities (Table 1). A few of his specimens have apparently also been lost; *i.e.* the rare "*Sphaeroceras*" and some "*Stephanoceras*" recorded by him. His large ammonite collection from the neighbourhood of San Juan Diquiyú (locs. Ca 1-10), numbering in the hundreds of specimens, however, can be identified from their preservation; they all originated from a small stratigraphic interval bearing a well defined single ammonite association (here named the *Parastrenoceras* association); Erben's tentative taxa can be identified (see synonymies; "Perisphinctidae" = *Leptosphinctes*) so that mixing among the Diquiyú collections therefore did not destroy their usefulness.

It was Arkell (1957) who recognized that the Bajocian "*Stephanoceras* beds" of Duashnú in Oaxaca State were misidentified and contained instead *Zigzagiceras* and perisphinctids of the lower Bathonian. Although the collections had not been reexamined, most, but not all subsequent authors agreed with this conclusion or followed his authoritative opinion (Erben, 1956; Alencáster, 1963; Imlay, 1973; but *cf.* Sturani, 1971). I have come to support Arkell's view only after additional, better preserved specimens of *Zigzagiceras* became available. A thorough search of the old fossil collections in the Instituto de Geología revealed several almost complete body chambers with attached phragmocone impressions (external moulds) and fragments of larger body chambers which more clearly show the *Zigzagiceras* features than the previously known small fragments (including the holotype of *Z. floresi*). Unfortunately, again, the origin of these specimens is unknown and can only tentatively be traced to the type locality by the characteristic preservation.

Other parts of Burckhardts's (1927) monograph are also in urgent need of taxonomic revision, *i. e.* the many newly named "species" of *Reineckeia* from El Consuelo, Oaxaca, most of which I consider conspecific [=*R. latesellata* Burckh.]. Ochoterena's (1963) description of *Parastrenoceras* with three new species pointed

to the important faunal affinities with Europe, where Sturani (1971) was later able to tentatively identify one of the Mexican species. Ochoterena's (1966) "new" genus *Infrapatoceras* from the Callovian, however, is very close to and synonymous with *Parapatoceras* (Dietl, 1978).

The pelecypod fauna of Erben's collection from Oaxaca and Guerrero was described by Alencáster de Cserna (1963).

I visited some of the principal outcrops of the Taberna Formation in northwest Oaxaca and northeast Guerrero States, briefly in 1968 with H. Ochoterena and in 1975, together with A. C. Riccardi and C. González. We were, however, unable to reach the somewhat remote old fossil localities of Mixtepec and Duashnú.

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STRATIGRAPHY
(Figures 1-4)

UPPER BAJOCIAN-LOWER BATHONIAN TABERNA FORMATION

(1) *San Juan Diquiyú* (Diquiyú of Burckhardt, 1927). At the Barranca del Carrizo, near Tezoatlán, Oaxaca, is the type section of the Taberna Formation (Erben, 1956, p. 85). From here come also Erben's large ammonite collections (localities Cal-9) furnishing much of the material described herein, originating probably from about 5 m of calcareous shales with concretions (section below). The type section of the Taberna Formation, 1.5 km N.E. of Diquiyú, according to Erben (1956) is as follows (my generic revision; from top):

Simon Formation	c.250 m	Gray sandstone, medium to fine, and some shale with limonitic concretions, locally coal; unfossiliferous.
(transition beds, v-w)	35 m	Sandstone, fine, and brown shale with few concretions.; unfossiliferous.

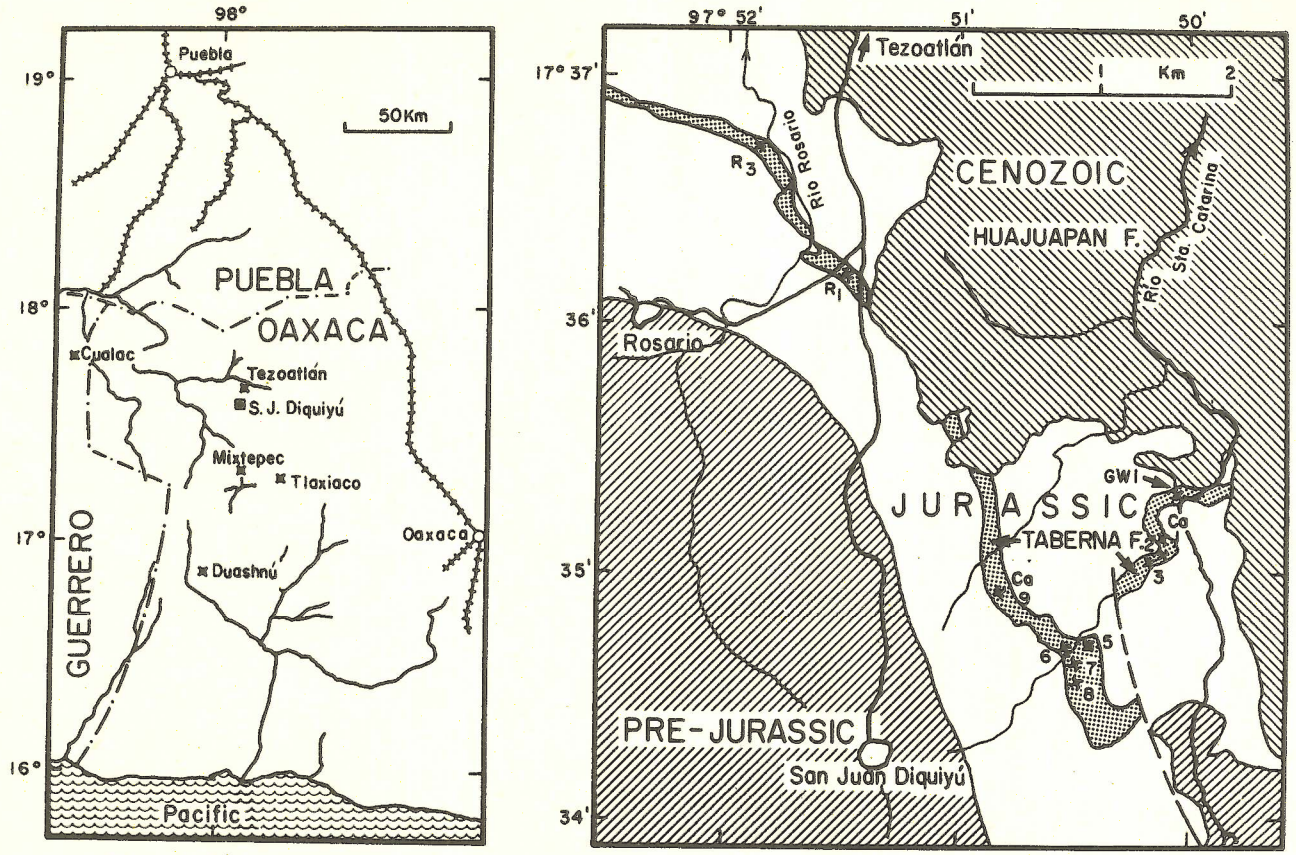

Figure 1.- Index maps for the principal fossil localities of the Taberna Formation in northwestern Oaxaca and Northwestern Oaxaca and northeastern Guerrero (see Figure 4). Left, after Burckhardt (1927); right, area of Rosario and San Juan Diquiyú south of Tezoatlán on simplified geologic map (after Alencáster, 1963).

Taberna Formation (94 m)	(j-u)	c. 77 m	Poorly exposed sequence of brown calcareous shales with red hematitic-calcareous concretions, and interbedded fine sandstone; unfossiliferous.
	(g-i) Ca9	4.8 m	Brown calcareous shales, greyish weathering, with hematitic-calcareous concretions, wine-red; containing abundant *Leptosphinctes* and also *Parastrenoceras, Oppelia,* "*Sphaeroceras*", "*Dactylioceras*?", and abundant pelecypods.
	(f)	0.5 m	Limestone bed with hematitic spherules; unfossiliferous.
	(e)	11.4 m	Yellow sandstone and ironstone, fine and very thin bedded, with hematitic concretions; some shale. Lower contact gradational; Ammonoidea indet. and Pelecypoda.
Zorrillo Formation	(d)	34 m	Sandstone and ironstone, brownish-yellowish, mostly fine and thin-bedded, with pockets of shale; unfossiliferous.

The *Leptosphinctes-Parastrenoceras-Oppelia* assemblage thus comes from a small interval at the base of the thick argillaceous sequence of the Taberna Formation, overlying beds transitional to the arenaceous, non-marine Zorrillo Formation. Since Erben's "*Sphaeroceras*" and "*Dactylioceras*?" could not be found in the Instituto de Geología collections, their true affinity cannot be determined.

This type sequence appears to be exceptionally thick since Erben's (1956, p. 26-30) estimates for the average thicknesses are 50-60 m for the Taberna and 80-100 m for the Simon Formation.

I visited this area in 1968 (with H. Ochoterena) and again in 1975 (with C. González and A. C. Riccardi) and identified the following assemblage from small stratigraphic intervals at loc. GW-1 (Río Sta. Catarina, 3 km NE of Diquiyú, Figure 1):

Leptosphinctes tabernai n. sp.
Parastrenoceras mixtecum Ochoterena
Oppelia cf. *subradiata* (Sow.)
Bivalvia indet.

Loc. GW-2 (Ca9 of Erben):

Leptosphinctes tabernai n. sp.
Parastrenoceras mixtecum Ochoterena
?*Stephanoceras* cf. *chilense* Hillebrandt

(2) *Rosario,* 1.5 km northeast of village, 4 km north of San Juan Diquiyú (Figure 1). Erben (1956, p. 78) described an incomplete section from his locality R3. The sequence of approximately 45 m consists of fine-bedded siltstone with vertical burrows, some interbedded limestone marl and shale, and calcareous, lim-

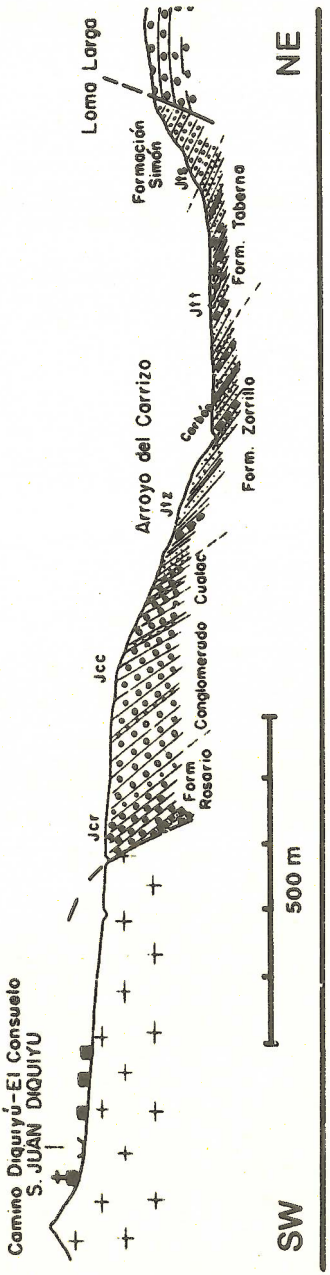

Figure 2.- Geologic structure and stratigraphic section northeast of San Juan Diquiyú (from Erben, 1956, pl. 3).

onitic and hematitic concretions. Fossiliferous intervals occur at about 18-20 m and 30-35 m above base; the lower one yielded *Oppelia* and *Leptosphinctes*, the upper one *Oppelia* and *Parastrenoceras*. Both assemblages are presumably from the *Leptosphinctes-Parastrenoceras-Oppelia* fauna.

(3) *San Andrés de Yutatio*, 3.5-5 km west of Rosario. The Taberna section investigated by Erben (1956, p. 91) is 150 m thick but still incomplete being bordered by faults. From top:

Taberna Formation	(a)	+ 50	m	Sandstone, siltstone and shale; plants.
	(b)	4	m	Siltstone, fine-bedded; plants and "*Stephanoceras*?".
	(c-d)	2	m	Calcareous siltstone, fine-bedded, and wine-red hematitic concretions, limestone bed; *Parabigotites*.
	A1,A2			*Leptosphinctes*, *Oppelia*, ?*Stephanoceras*, pelecypods.
	(several meters concealed)			
	(c)	1.4	m	Fine sandstone and yellow-brown siltstone, thin-bedded, with hematitic concretions; *Parastrenoceras*, *Leptosphinctes*.
	(f)	13.4	m	Calcareous shale and mudstone with abundant wine-red hematitic concretions; *Parastrenoceras*, *Leptosphinctes*, *Oppelia*, bivalves.
	(g-p)	80	m	Calcareous siltstones and fine sandstones with hematitic concretions; unfossiliferous.

The *Leptosphinctes-Parastrenoceras-Oppelia* fauna occurs throughout an interval of 20-25 m above the middle of the incomplete thick section. (For the Callovian section see also Avecilla, 1973).

(4) *Mixtepec*. Erben (1956, p. 110, enclosure 16) re-examined Burckhardt's section of the Bolita Hill and stream. The Taberna Formation is discordantly overlain by the basal conglomerate of the Cenozoic Huajuapan Formation so that varying, unknown parts of the Taberna are missing. The Taberna consists of brownish shales and marls with very abundant wine-red hematitic concretions and with interbedded thin-bedded sandstone and limonitic limestone. The highest beds are fine, thin-bedded, brown sandstone along the creek. The thicknesses, however, are unknown. From the concretions in the shale and marls (Locality M1) Erben lists:

" '*Stephanoceras*' aff. *paucicostatum* Felix & Lenk" [*nom.dub.*]
" '*Stephanoceras*' aff. *psilacanthum* Behrendsen -- frequent"
" '*Stephanoceras*' cf. *floresi* (Burckhardt)"
" '*Dactylioceras*' sp."
"Pelecypods indet.".

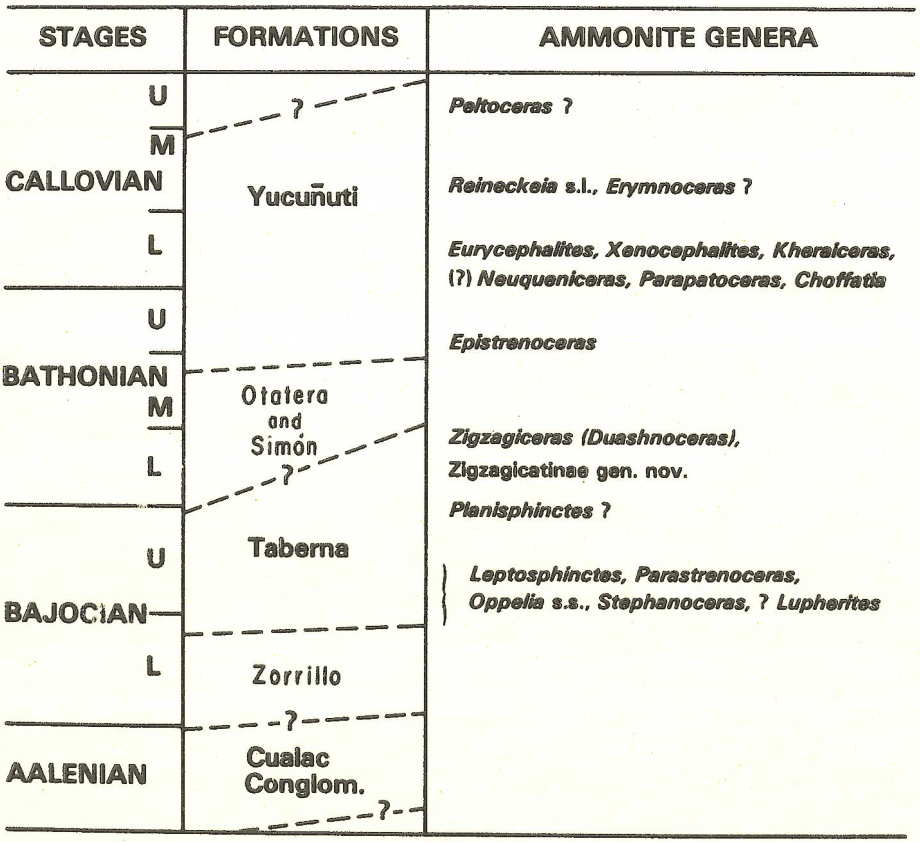

Figure 3.- The Middle Jurassic formations and ammonite genera of south-central Mexico.

From the "hill near Mixtepec" which, according to Erben (1956, p. 110) is the same locality as his Mi, Burckhardt (1927; 1930, p. 25, 30) described and listed an apparently mixed assemblage collected by Aguilera and Bonillas:

"*Dactylioceras* sp. ind."	= *Planisphinctes* (?) sp. nov. A
"*Stephanoceras* cf. *bigoti*"	= ?Leptosphinctinae (or ?Bigotitinae) gen. et sp. nov. A
"*S. undulatum*"	= *Stephanoceras* "*undulatum*" [nom.dub.]
"*S.* aff. *psilacanthum*"	= ?Zigzagiceratinae juv.

This collection may span the upper lower Bajocian to lower Bathonian, but it could also belong entirely to the upper Bajocian.

However, the only specimens (not catologued) in the collections of the Instituto de Geología labelled to come from Erben's Mixtepec locality, are two *Stephanoceras*? cf. *chilense* Hillebrandt indicating the middle/upper Bajocian boundary.

(5) *Duashnú.* This important locality, southwest of San Andrés Cabecera Nueva in Oaxaca, has not been re-examined (Erben, 1956, p. 122). The locality description and fossil collections, in fact, appear to go back to Flores (1909, *fide* Burckhardt, 1927, p. 3, 4, with quotations) who described the rocks as clayey slates with numerous hematitic concretions, local seams, micaceous slate and thick limestone beds, containing a *Stephanoceras* ex. gr. *humphriesianum* ["*S. paucicostatum*" Felix, *nom. dub.*]. Erben placed these rocks in the Taberna Formation. From these "*Stephanoceras* beds", Burckhardt (1927) described most of the fauna revised herein:

"*Dactylioceras* sp. ind. No. 1"	= *Planisphinctes* (?) sp. indet. A
"*Stephanoceras* aff. *psilacanthum*"	= Zigzagiceratinae sp. nov. A
"*S.* sp. ind. No. 1 (cfr. *triptolemus*)"	= ?*ibid.*
"*S. Floresi*"	= *Zigzagiceras* (*Duashnoceras*) *floresi* (Burckh.)
"*S.* aff. *Brodiaei*"	= *ibid.*

Following Arkell (1956), this assemblage is now dated as lower Bathonian (to uppermost Bajocian).

It is therefore apparent that the Taberna Formation is strongly diachronous, at least with respect to its upper boundary. In the Tezoatlán area, only the basal upper Bajocian is documented; while the presence of the lower Bathonian "*Zigzagiceras* fauna" has so far been established only for the Duashnú area further to the south; and both could be present around Mixtepec. As has been shown above, however, the fossiliferous beds yielding the lower ammonite fauna around Tezoatlán occur near the base of the formation, so that its upper parts could reach into the Bathonian, and the stratigraphy of the other areas is poorly known.

UPPER BATHONIAN-CALLOVIAN FORMATIONS

Regionally, the Simon Formation is overlain by the Otatera Formation (50-70 m), consisting of cross-bedded sandstone, quartz-sandstone and shales with hematitic concretions. The superjacent and highest Middle Jurassic unit is the Yucuñuti Formation (50-300 m) consisting of pelecypod and gastropod coquinas, limestones, marlstones, shales, calcareous and some limonitic concretions. The ammonite fauna consists of the rare *Epistrenoceras paracontrarium* Burckhardt (Cualac in northeastern Guerrero) clearly indicating the upper Bathonian; *Eurycephalites*, *Xenocephalites* and other Eurycephalitinae (*"Pleurocephalites"*), *Kheraiceras*, (?) *Neuqueniceras* and *Parapatoceras* (including *"Infrapatoceras"* Ochoterena, 1966, *cf.* Dietl, 1978), indicating the upper Bathonian and ?lower Callovian; coronate (?) *Reineckeia*, probably indicating the (upper lower to) middle Callovian; and of the long-ranging Perisphinctidae, *e.g. Choffatia* (incl. *Subgrossouvria*) and ?Peltoceratidae. The urgently needed stratigraphic and taxonomic revision is currently being carried out by the author.

The rich Middle Jurassic pelecypod fauna of northwestern Oaxaca and northeastern Guerrero was described by Alencáster de Cserna (1963; Table 1).

AGE AND AFFINITIES OF THE TABERNA AMMONITE FAUNAS

Two ammonite faunas can clearly be distinguished in the Taberna Formation. The lower one is the well established *Leptosphinctes-Parastrenoceras-Oppelia* fauna, here named the *Parastrenoceras* association; and the poorly known upper *Zigzagiceras* fauna.

PARASTRENOCERAS AMMONITE ASSOCIATION

This association is best developed in the lower part of the type Taberna Formation at San Juan Diquiyú (localities Ca. 1-10 and GW. 1 y 2). It includes, with the genera arranged in approximate order of abundance (asterisks marking other localities):

Leptosphinctes tabernai n. sp.
Parastrenoceras mixtecum Ochoterena
P. oaxacanum Ochoterena
P. tlaxiacense Ochoterena
Oppelia (*Oppelia*) *subradiata erbeni* n. subsp.
Stephanoceras "undulatum" Burckhardt [*nom. dub.*]*
S. cf. *orbignyi* (Buckman)*
?*S.* cf. *chilense* Hillebrandt [?*"S. paucicostatum"* Felix, *nom. dub.*]
?*Lupherites* cf. *chongi* (Hillebrandt)
"Sphaeroceras"

TABLE 1.- Fossil localities and collections.

Species	San Juan Diquiyú											Mixtepec			Duashnú	Other locs. (Unknown)
	A.1	Ca. 1	2	3	4	5	6	7	8	9	10	GW.1	2	Erben Mi	Burckhardt	
Leptosphinctes tabernai	0	0		0	+	+	x	+	+	0	x	x	x				
Parastrenoceras mixtecum	+	+	0		x	+	+	+	+	+		x	x				
Oppelia subradiata erbeni	0				x	0	0	+		+		?x					
Stephanoceras cf. *orbignyi*																	x
S. "undulatum"															x		
?S. cf. *chilense*	0					+	0				x		x	+			
?Lupherites cf. *chongi*						x											
Zigzagiceras (*Duashnoceras*) *floresi*														0		x	
Zigzagiceratinae *gen. et sp. nov.*														0	x	x	
Planisphinctes (?) sp.														0	x	x?	
?Bigotitinae *gen. et sp.* A.															x	?	

x in collections
0 inferred according to Erben, 1956
+ collection and description agree

The "*Sphaeroceras*" listed by Erben (1956, p. 86) could not be found in the collections. His identification may be correct, but this could also be a late *Chondroceras* or small *Megasphaeroceras.*

A possible additional member of this association is the enigmatic "*Stephanoceras* cf. *bigoti*" of Burckhardt which is here described under Bigotitinae? *gen. et sp. nov.* A. This could, however, be a latest Bajocian or even Bathonian-Oxfordian form.

This ammonite fauna can be dated clearly as Subfurcatum Chronozone and represents additional evidence for this zone in the east-central Pacific area (Westermann and Riccardi, 1980).

Leptosphinctes tabernai or a close relative occurs also in the Subfurcatum Zone of southwestern Germany (Dietl, 1980).

Parastrenoceras cf. *tlaxiacense* also occurs in the upper Subfurcatum Zone of the southern (Venetian) Alps, while the related species are there restricted to the basal Subfurcatum Zone, *i.e. P.* aff. *caumonti* (d'Orb.) and *P. lucretius* (d'Orb); no evidence exists in Mediterranean Europe for the occurrence of the genus outside of this zone (Sturani, 1971).

Oppelia (*Oppelia*) *subradiata* (Sow.) s. str. has hitherto been known unequivocally only from the Humphriesianum and Subfurcatum Zones of Europe; slightly earlier and later records are suspect (Sturani, 1971).

The true *Stephanoceras chilense* Hillebrandt occurs in the uppermost Humphriesianum Standard Zone and *S. chilense* Subzone of the basal upper Bajocian of northern Chile (Hillebrandt, 1977; Westermann and Riccardi, 1979). The Mexican form [?"*Stephanoceras paucicostata*" Felix, *nom. dub.*] also resembles somewhat the basal upper Bajocian *Lupherites* Imlay ["*Domeykoceras*" Hillebrandt] from Chile and the United States, and the rare north German *Alfeldites* Westermann ["*Germanites*"] from the middle Humphriesianum Zone. The true, poorly known *Lupherites chongi* (Hillebrandt) occurs in Chile together with *L. dehmi* (Hill.) in the basal upper Bajocian.

Sphaeroceras ranges from the Sauzei Chronozone of the lower Bajocian to well into the upper Bajocian (Westermann and Riccardi, 1979); while the much larger *Megasphaeroceras* marks the *M. rotundum* Zone in lower upper Bajocian of the United States, Alaska (Hall and Westermann, 1979), and possibly also in Chile (Hillebrandt, 1977; Westermann and Riccardi, 1979; Westermann, 1980).

Of other taxa described herein from unknown localities and/or stratigraphic levels, *Stephanoceras* (*Stephanoceras*) cf. *S. norbignyi* (Buckman) and *S.* "*undulatum*" Burckhardt [*nom. dub.*] are probably from the same fauna. *S. orbignyi* is common in Europe, particularly in the upper Humphriesianum Zone, and is known to range into the lower Subfurcatum Zone in the Basses-Alpes (Pavia, 1969). The record of *S. orbignyi* in Oregon (Imlay, 1973), however, is uncertain and with poor stratigraphic definition. The single body chamber of *Stephanoceras* (*Stephanoceras*) "*undulatum*" Burckhardt [*nom.dub.*], from an unknown horizon of the Mixtepec area, probably has its closest affiliates in southern Alaska and United States, where similar "*Itinsaites*" occur in the lower upper Bajocian (Imlay, 1962, 1967, 1973).

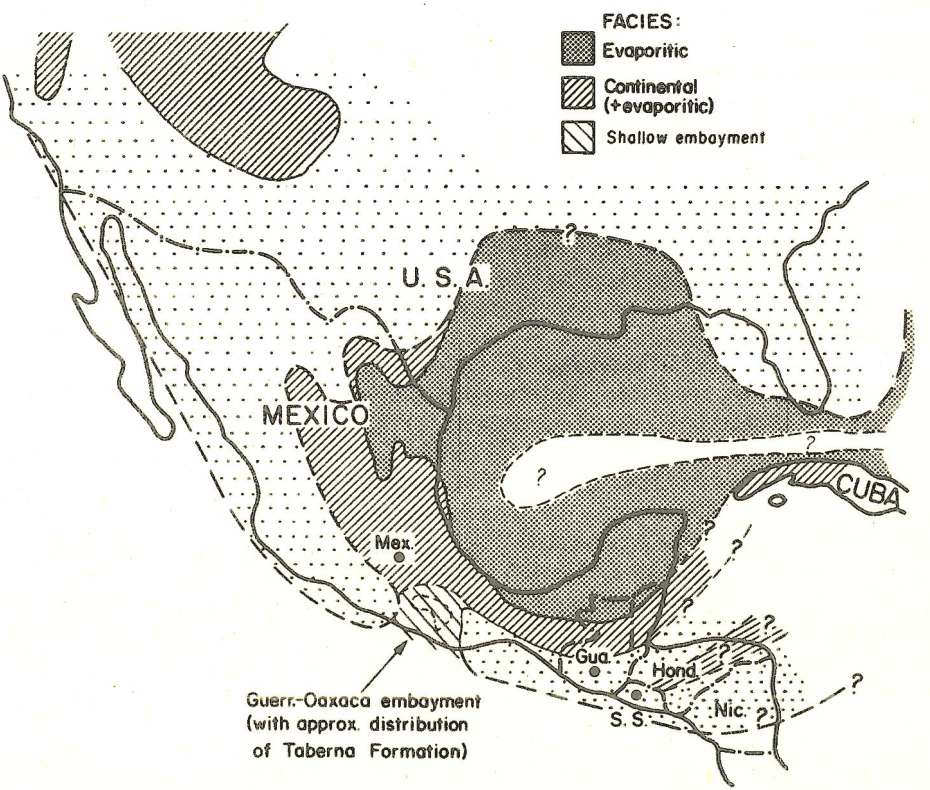

Figure 4.- Simplified lithofacies map for the Bajocian and Bathonian of Mexican Gulf region, with the Guerrero-Oaxaca embayment and the distribution area of the Taberna Formation (mainly after Cook and Bally, 1975).

The *Parastrenoceras* ammonite association can be placed securely into the Subfurcatum Standard Zone, thereby extending its range from N.W. Europe, western Tethys and N. Chile (Westermann and Riccardi, 1980) to Mexico.

The very abundant pelecypod fauna of the lower Taberna assemblage consisting mainly of Trigoniidae, has been described by Alencáster (1963):

Trigonia (*Trigonia*) *erbeni* Alencáster
T. (*Indotrigonia*) *impressa* Brodesip
Myophorella formosa (Lyett)
Vaugonia (*Vaugonia*) *kobayashii* Alencáster
V. (*V.*) *v-costata mexicana* Alencáster
Parallelodon (*Grammmatodon*) sp.
Mytilus (*Falcimytilus*) cf. *stricapillatus* Hayami
M. cf. *sublaevis* Sow.

ZIGZAGICERAS 'ASSEMBLAGE'(?)

The evidence for the association of *Zigzagiceras* (*Duashnoceras*) *floresi* (Burckhardt) and Zigzagiceratinae gen. et sp. nov. A is entirely "circumstantial"; the three or four specimens originally described under "*Stephanoceras*" *floresi*, "*S.* aff. *Brodiaei*" and "*S.* aff. *psilacanthum* forma 2 and ?1" all came from the "*Stephanoceras* beds" of a single collection made by Flores from Duashnú. The true *Zigzagiceras* (including the macroconch "*Procerozigzag*") is only known from the lower Bathonian of Europe and appears to be restricted to the middle Zigzag Standard Zone, Macrescens Subzone (Sturani, 1967; Hahn, 1969).

From the same Flores collections came a questionable *Planisphinctes* which Burckhardt called "*Dactylioceras* sp. ind. No. 1". *Planisphinctes* occurs just below the Bajocian/Bathonian boundary (Bomfordi Subzone of Parkinsoni Standard Zone) in England and the Alps (Sturani, 1967). Similar forms occur in the lower Bathonian. The two impressions of probable *Planisphinctes*, *i.e.* Burckhardt's "*Dactylioceras* sp. ind. No. 2, 3", however, are from the old Aguilera and Bonillas collections from "the neighbourhood of Mixtepec" (*cf.* Mixtepec above), without good locality or stratigraphic data. The Duashnú taxon Zigzagiceratinae *gen. et sp. nov.* A resembles most closely the aberrant supposed *Siemiradzkia* from the upper Zigzag Zone of the Basses-Alpes (Sturani, 1966). Its true affinity and age, however, remain obscure.

Only stratigraphically documented new collections can solve the problems of taxonomy and age of this enigmatic fauna.

PALAEOBIOGEOGRAPHY

PARASTRENOCERAS AMMONITE ASSOCIATION

The global affinities of this association are as follows (Figures 5, 6):

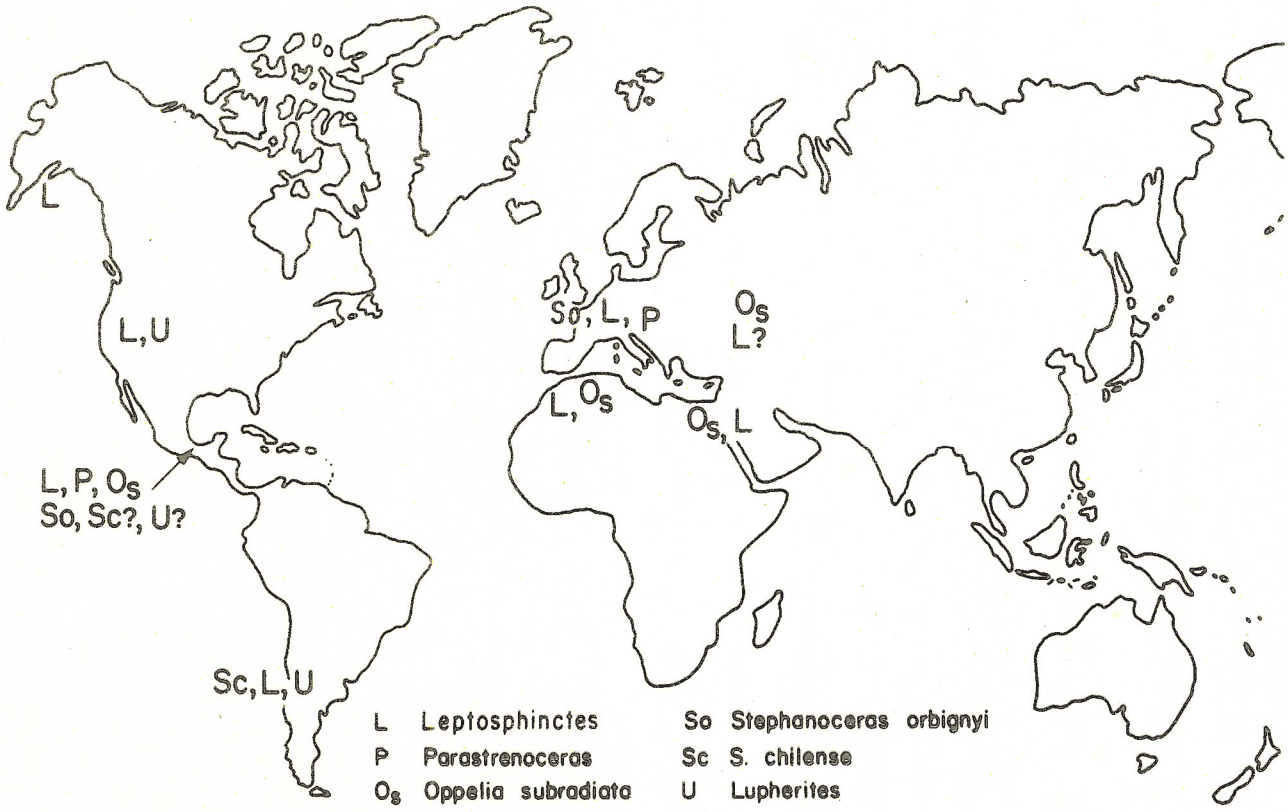

Figure 5.- Geographic distribution of the upper Bajocian ammonite genera of the Taberna Formation, plotted on the present-day globe.

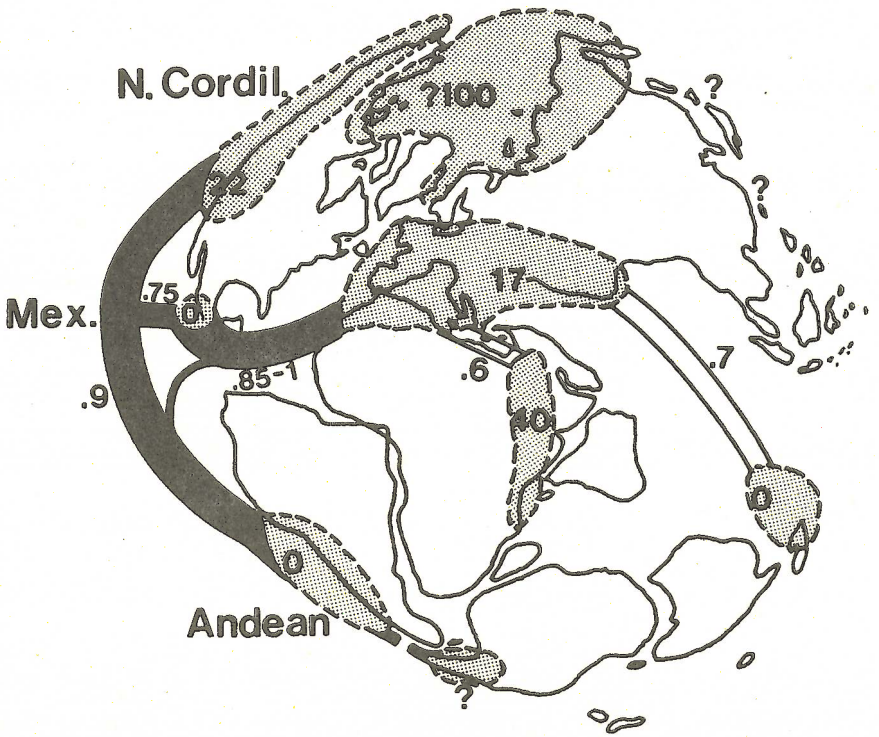

Figure 6.- Taxonomic resemblance of the upper Bajocian ammonite genera between the major areas of distribution (gray), with emphasis on the eastern Pacific areas. The Simpson Coefficients of Similarity between area pairs are indicated numerically and by the relative width of the bands connecting them. The numbers within the areas of distribution denote the degree of endemism (in percent).

The genus *Parastrenoceras* is known only from western Europe and southern Mexico, with *P. tlaxiacense* probably in common (Sturani, 1967).

The genus *Leptosphinctes* abounds in Europe and northern Africa (Morocco and Sinai), and it occurs usually as a minor element along the eastern Pacific borderlands (Westermann and Riccardi, 1976), from south Alaska to Neuquén, Argentina as well as in New Guinea (Westermann, 1980) and Japan? (Sato, 1962). The south Mexican occurrence, however, is not only most abundant but also closest in specific affinity to west-Mediterranean Europe (Dietl, 1980).

While the genus *Oppelia* is known throughout the Tethyan, Subtethyan and eastern Pacific areas, the known distribution of *O. subradiata* is restricted to western Tethys, northwest Europe and Mexico.

While the genus *Stephanoceras* is truly worldwide in distribution, the Mexican find of *S. orbignyi* (Buckman) would be the only one outside of Europe. The poorly known *S.* " *undulatum*" resembles the North American "microconch subgenus *Itinsaites*". *S. chilense* has so far been documented only from northern Chile (Hillebrandt, 1977), so that the possible Mexican find would point to a southern source. The alternate affinity of the poorly known Oaxaca form, however, would again be to western Europe, *i.e. Alfeldites* (for *Germanites* Westermann, 1954).

The questionable and rare presence of *Lupherites* in south Mexico would conform to the known east Pacific distribution of the genus from Oregon to northern Chile (Imlay, 1973; Hillebrandt, 1977; Hall and Westermann, 1979; Westermann and Riccardi, 1979).

The rare supposed "*Sphaeroceras*" of Erben is of some interest because it could be one of three genera, *i.e. Sphaeroceras* or *Chondroceras* which are from western Tethys and the eastern Pacific margin, or *Megasphaeroceras*, known from the western U.S.A., Peru and Chile only (Hillebrandt, 1970; Hall and Westermann, 1979; Westermann and Riccardi, 1979; Westerman *et al.*, 1980).

In conclusion, the *Parastrenoceras* ammonite association is closely linked to Eurafrica (Europe and North Africa) *i.e.* western Tethys. At the species level, one third to half of the taxa are in common between the two areas and, significantly, appear to be restricted to them; the Simpson Coefficient (SC; *cf.* Westermann and Riccardi, 1976) for species is therefore *ca.* 0.4. In contrast, specific affinity to the Andean fauna is highly questionable for two species and may not exist at all (SC = 0-0.25); while specific affinity to the North Cordilleran region (U.S.A., Canada, S. Alaska) is even lower, probably without species in common (SC = 0-0.1).

At the generic/subgeneric level, all Mexican taxa, with the exception of the questionable *Lupherites*, are also present in Eurafrica (SC = 0.85-1) and one is restricted to these two regions. Again, Mexico-Eurafrica affinity is higher than the affinity of the Mexican fauna to either the North Cordilleran (0.7-0.8) or Andean fauna (0.7-0.8); much higher than the Eurafrican affinities of the North Cordilleran fauna (0.6) and somewhat higher than that of the Andean fauna (0.8); and about as high as the North Cordilleran-Andean affinities (0.9; note that the Stephanoceratinae are included here, while they were included in the lower Bajocian in Westermann and Riccardi, 1976).

These biogeographic data have to be reconciled with the palaeogeographic reconstruction (Imlay, 1965; Cook and Bally, 1975): most of northeastern, east-central and southeast Mexico formed the marginal parts of the large basin of deposition of the Gulf of Mexico (Figure 4), which was surrounded by highlands in the north, west and south except for a narrow Pacific connection through the present States of Oaxaca and Guerrero. Most of the Middle Jurassic basin was filled with evaporites, covering the present Gulf, its eastern entrance, most of the Yucatán Peninsula and much of northeast Mexico. Much of the remainder of deposition in Mexico was non-marine with occasional saline basins, except for relatively small parts of south-central and central-eastern Mexico. The only known Bajocian-Bathonian

marine deposits in ammonite-bearing facies, however, are in western Oaxaca and northeast Guerrero States, *i.e.* in the southwestern extension of the Gulf basin. It thus appears that during this time, the Oaxaca depression was a marine embayment of the Pacific Ocean. The marine connection from the Pacific to western Tethys therefore passed further south; somewhere in the present Central America area (Figures 4, 6).

The palaeogeographic reconstructions for the Middle Jurassic of southern Mexico, however, are considered tentative because the "zero edge" (outcrop) is almost entirely due to Cenozoic erosion. For example, according to Cook and Bally (1975), a deep Middle Jurassic embayment existed in present El Salvador and western Honduras and its present erosional edge of uncertain position is only about 100 km distant from the southeastern, uncertain erosional edge of the Gulf basin. This is based on Mills and coworkers (1967), who however, for the Upper Triassic-Lower Jurassic, reconstruct a narrow trough opening to the northeast and filled with shallow-marine and flood plain deposits (El Plan Formation) bearing plant remains of uncertain age; the presence of Middle Jurassic deposits has not been demonstrated and this was an epoch of orogenic movements and volcanics.

The Andean and North Cordilleran contemporaneous ammonite assemblages of the *Megasphaeroceras rotundum* Zone differ markedly, not only in the absence of *Parastrenoceras* and, possibly *Oppelia* s. str., but in the abundant presence of *Megasphaeroceras, Teloceras* and *Spiroceras* (Hall and Westermann, 1979; Westermann and Riccardi, 1979; Westermann *et al.*, 1980). Perhaps, this is owing to the shallow, somewhat restricted facies of the Taberna Formation, which is also evident from the conspicuous absence of Lytoceratina and Phylloceratina. The first circum-Pacific find of the European *Strenoceras* in northern Chile is particularly interesting in this respect (Westermann and Riccardi, 1980).

ZIGZAGICERASS "ASSEMBLAGE" OF DUASHNU

The subgenus *Zigzagiceras* (including the macroconch "*Procerozigzag*") is restricted to a single subzone (Macrescens Subzone, Zigzag Standard Zone) of Europe (Sturani, 1967; Hahn, 1969). The endemic subgenus *Duashnoceras* of south-central Mexico is very probably closely related to the European forms and thus good evidence for a "Central Atlantic" connection between the Pacific and western Tethys. The other, presumably also early Bathonian (or latest Bajocian to middle Bathonian) fauna is supportive of such a connection. The Zigzagiceratinae *gen. et sp. nov.* A ("*Stephanoceras* aff. *psilacanthum*") resembles a form described from the upper Zigzag Zone of the Basses-Alpes (Sturani, 1967, pl. 24, fig. 7), while *Planisphinctes* is elsewhere known only from Europe.

The poorly known *Zigzagiceras* "assemblage", possibly belonging to different faunas and ages, is thus European and endemic in aspect, without known affinities to any circum-Pacific fauna. Phylloceratina and Lytoceratina are absent in the Bajocian-lower Bathonian cephalopod assemblage of the Taberna Formation (contrasting with the Callovian), indicating epeiric sea conditions at least 50-100 km from the open ocean (Westermann, 1975).

This confirms earlier conclusions reached by Riccardi and myself that a (sporadic) marine connection existed between the eastern Pacific and the western Tethys at least as early as the Bajocian (Westermann and Riccardi, 1976, 1979; Westermann, 1969, 1980). The conservative palaeogeographic reconstruction of a Oaxaca embayment after Cook and Bally (1975), however, is difficult to reconcile with the biogeographic affinities of the ammonite faunas in the Bajocian and early Bathonian. Several other possibilities will have to be considered, *e.g.* the Jurassic opening of the Mexican Gulf by ocean floor spreading and the different geographic position relative to autochthonous Mexico of the Oaxaca area belonging to an allochthonous microplate (Campa and Coney, 1981).

SYSTEMATIC DESCRIPTIONS

The fossil material is kept in the Instituto de Geología of the Universidad Nacional Autónoma de Mexico City (IGM) and in the Dept. of Geology of McMaster University (McM.).

Suborder Ammonitina Hyatt, 1899
Superfamily Haploceratacea Zittel, 1884
Family Oppeliidae Douville, 1890

Oppelia (*Oppelia*) *subradiata* (J. de C. Sowerby, 1823)

1823 *Ammonites subradiatus* J. de C. Sowerby, p. 23, pl. 421, fig. 2.
1845 *Ammonites subradiatus* -- D'Orbigny, pl. 118, fig. 3 (?non figs. 1, 2, 4 [*Oppelia subcostata* (J. Buckman, 1881)], non. pl. 129, fig. 3 [*Oecotrautes pulcher* (S. Buckman)] .
1869 *Oppelia subradiata* -- Waagen, p. 193, pl. 16, figs. 1a, b.
?1881 *Oppelia subcostata* J. Buckman, p. 63 [for *Am. subradiatus* of d'Orbigny, pl. 118, figs. 1, 2, 4 only], -- Subsp.?
?1924 *Oppelia Waageni* S. Buckman, pl. 704 [for *O. subradiata* of Waagen].
?1925 *Oppelia lectotypa* S. Buckman, pl. 704* [for *O. waageni* Buckman, non Zittel, 1870].
1952 *Oppelia subradiata* -- Arkell, text-fig. 11, figs. la-b [holotype refigured], ?fig. 2.
1956 *Oppelia* aff. *subradiata* -- Erben, p. 29, 79, 83-88.
?1971 *Oppelia subradiata* -- Sturani, p. 112, pl. 7, figs. 2-3 [juv.].

Oppelia (*O.*) *subradiata erbeni* n. subsp.
(Plate 1, figures 1-5)

Diagnosis: A subspecies of *O. subradiata* with smooth inner flank and rather prominent ribbing on outer flank of mature phragmocone, with widely spaced bifurcate secondaries.

Holotype: The completely septate internal mould illustrated on Plate 1, figure 1 (IGM 2793).

Type locality and horizon: Locality Ca 4, 1.5 km to the northeast of San Juan Diquiyú, Oaxaca State, Mexico; Taberna Formation, *Parastrenoceras* beds, upper Bajocian.

Name: Honoring Prof. H. K. Erben, Bonn, who collected this assemblage in 1954.

Material: 13-16 specimens from Taberna Formation of San Juan Diquiyú, Oaxaca: The holotype and three (four?) septate fragments from locality Ca 4; one incomplete phragmocone and two fragments from Ca 7; one large phragmocone and two fragments from Ca 7; one large phragmocone from Ca 10 ("Capas con *Cosmoceras*" = *Parastrenoceras*); five-eight septate fragments from Ca 9. (For locations see Introduction.)

Description: The phragmocone whorls beyond 20 mm diameter are highly compressed and involute, *i.e.*, more than twice higher than wide, and with an umbilical width of only 8-12 percent of the diameter. The vertical umbilical wall rounds narrowly into the subparallel inner flank; somewhat above the middle of whorl height, the flanks start to converge slightly toward the ventro-lateral shoulders; the venter is moderately broad and fastigate to slightly keeled, comprising an angle of approximately 90-110° (right to somewhat obtuse). The adult phragmocone diameter of the macroconch is about 80 mm.

The ornamentation is restricted to the outer half of the whorls at all growth stages and changes quite drastically at about 45-50 mm diameter. The inner whorls have dense subequal ribs on the ventral one-third only. They lean slightly forward and project briefly on the ventral shoulder, leaving a narrow smooth band beside the keel or fastigation. There are about 40 riblets per half-whorl. The ultimate phragmocone whorl has more prominent and more widely spaced ribbing. It is differentiated into slightly crescented, long secondaries beginning at mid-flank, and fasciculate short tertiaries, one or two for each secondary, totalling only about 30 per half-whorl. Primaries and spiralic groove, again, are missing; however, very faint prorsiradiate swellings are present above mid-flank on the holotype.

Toward the end of the phragmocone, the ribbing becomes obsolete, so that the body chamber was probably entirely smooth. The septal suture closely resembles that of *O. subradiata* s.s. (*cf.* Arkell, 1951, text-fig. 11), consisting of two large subequal saddles divided by a large lateral lobe, and several much smaller umbilical elements, with rather low degree of complexity.

Discussion: The holotype of the type species, *O. subradiata,* was re-figured by Arkell (1951, text-fig. 11); it is a fully septate internal mould of only 48 mm diameter, with involute and strongly compressed subrectangular whorls bearing 50-55 somewhat differentiated riblets on the ultimate half-whorl. It came from the Inferior Oolite, probably Sauzei Zone, of England. At similar size, the Mexican form closely resembles the *O. subradiata* holotype, except for the slightly less dense and undifferentiated ribbing at this stage, being a good match to Arkell's hypotype (1951, text-fig. 11-2). The outer whorls of *O. subradiata* appear to be unknown, but may be identical to the much larger, still entirely septate type specimens of *O. lectotypa* Buckman (1924-25, pl. 524), probably from the lower "Oolite ferrugineux de Bayeux" of the condensed Humphriesianum-Subfurcatum Zones; or with the large *O. subcostata* Buckman (1881, pl. 63; for *Am. subradiatus* of d'Orbigny, pl. 118, figs. 1, 2, 4 only) from the same formation. Compared to the small holo-

type of *O. subradiata*, the outer whorl of *O. lectotypa* is distinguished only in the somewhat greater inflation and that of *O. subcostata* in the slightly larger umbilicus with wider ribbing. Sturani (1971) and Pavia (1971) have distinguished three species, but this appears to be extreme; all may well be variants (formas) of a single species or, at most, subspecies. The outer phragmocone whorl of these larger "species" differs from those of the Mexican form only in the reduction, rather than strengthening of ribbing. In this, our form comes closer to *O. flexa* (Buckman, 1924, pl. 525a, b), probably from the upper part of the "Oolite ferrugineux de Bayeux" and late Bajocian in age. *O. flexa*, according to its author, occurs also in the Subfurcatum Zone of England, and perhaps in the Venetian Alps (Sturani, 1964, p. 114). It has stouter and more evolute whorls; more prominent and longer, more distant ribbing on the penultimate phragmocone whorl; and strongly rursiradiate, blunt secondaries with fasciculate and intercalated short tertiaries on the ultimate whorl of the phragmocone. Obsolescent prorsiradiate primaries and a faint mid-lateral groove are also developed on *O. flexa*, giving the ornament a falcate appearance. The ornament becomes obsolete toward the end of the large (108 mm) phragmocone of the holotype of *O. flexa* and, according to Sturani (1964), is absent on the inner flank of the nucleus. *O. flexa* therefore is quite distinct from the three species discussed above and here included *O. subradiata* s.l.

The Oaxaca form clearly agrees with *O. subradiata* s.s. in the whorl section, coiling and ornament of the inner whorls; while its ultimate phragmocone whorl develops the ornament of *O. flexa*, although less extremely. Preferring a conservative classification, I include the new form as a subspecies in *O. subradiata.*

Significantly, *O. subradiata* s.l. has not been documented from elsewhere in the Americas, with the possible exception of the small fragment from the lower upper Bajocian of Oregon described by Imlay (1973, p. 78); the presence of dense short riblets on the ventral shoulder without secondaries is like in the Oaxaca form, but incompleteness prevents specific determination.

Measurement (in mm):

	D	H	W	U
Holotype, phragm.	72	39.8	16.7	7.8
	c.37	18.5	9.0	–
Plate 1, figure 5, phragm.	46.5	24.4	11.2	5.7
	27	13.9	6.9	c.4.3
Plate 1, figure 4, beg. body ch.	85.5	48.5	19.3	8.2
	c.46	24.5	11.3	–

Superfamily Stephanocerataceae Neumayr
Family Stephanoceratidae Neumayr
Subfamily Stephanoceratinae Neumayr
Genus *Stephanoceras* Waagen, 1869
Type species: *Am. humphriesianum* J. de C. Sowerby

?*Stephanoceras* cf. *S. chilense* Hillebrandt, 1977, ♂ & ?♀
(Plate 2, figures 1a-6c)

??1891 *Stephanoceras paucicostatus* Felix, p. 180, pl. 27, figs. 17, 17a. [*nom. dub.*]

Material: One complete microconch and one damaged ?macroconch from Erben's loc. Mi, near Mixtepec; two-three incomplete specimens from Erben's locs. Ca 10 and Ca 5, and two incomplete fragmentary specimens from loc. GW 2, near San Juan Diquiyú (*Parastrenoceras* beds). All Taberna Formation.

Description: The whorls are subcircular and almost serpenticonic throughout. They bear very sharp and dense ribbing, with furcation occurring at mid-flank in minute, sharp spines or tubercles (internal mould). The primaries are projected while the secondaries, about three per primary, pass straight over the venter, without reduction in height. The ribbing of the nucleus consists of dense to moderately spaced, slightly to strongly prosiradiate primaries which divide at about 3/5 whorl height into two and three secondaries. One specimen is complete with lateral lappets at 40 mm diameter. The largest specimen (Plate 2, figure 1) is septate to the end at 60 mm diameter, and thus probably a macroconch. The septum is planulate with strongly retracted umbilical elements. U_2 is minute and, internally, the oblique U_n separates the small U_n/U_3 from the much larger I/U_n saddle.

Discussion: There is good resemblance in coiling and whorl sections to *Stephanoceras chilense* Hillebrandt and *Lupherites* spp. ["*Domeykoceras*"], respectively from the topmost lower and basal upper Bajocian of northern Chile (Hillebrandt, 1977) and, the latter, also from western U.S.A. (Imlay, 1973). *S. chilense* differs from our form in the somewhat longer and more strongly curved primaries also on the intermediate whorls, while *Lupherites* has also longer primaries and consistently projected and or fasciculate secondaries.

Affinities also exist to the extremely rare *Alfeldites* ["Germanites"] hitherto known only from its type locality near Alfeld in northwest Germany (Westermann, 1954) where it occurs in the middle Humphriesianum Zone. While the type species *A. bicostatus* (West.) has biplicate ribbing which is obsolete on the nucleus, other species have denser secondaries and bear minute mid-lateral tubercles (Westermann, 1954, pl. 30, fig. 9).

"*Stephanoceras paucicostatum*" Felix (1891) from Tlaxiaco, the first Middle Jurassic ammonite described from Mexico, was based on the impression of the umbilicus attached to a small whorl fragment (original illustrations reproduced here, Plate 3, figure 1). If the original illustration is natural size and correct, the whorl fragment was subcircular (W $\sim$ 15, H $\sim$ 14 mm), with dense sharp ribbing including forward curved primaries and mid-lateral fine tubercles. The inner whorls had similar primaries. There is reasonable resemblance with *S. chilense*. The single fragment, however, does not suffice as a holotype characterizing a new species. "*S. paucicostatum*" is therefore considered a *nomen dubium*.

Stephanoceras cf. *S. orbignyi* (Buckman, 1908, 1927) ♂ or ♀ juv.
(Plate 4, figures 2a-c)

?1846 *Ammonites Braikenridgii* Sowerby -- d'Orbigny, p. 400, pl. 35, figs. 3, 4, ?5.
cf. 1908 *Normannites orbignyi* nov. -- S. Buckman, p. 146.
cf. 1927 *Normannites orbignyi*, S. Buckman, pl. 734.
cf. 1954 *Normannites (Normannites) orbignyi* [with subspp.], Westermann, p. 135, pls. 5-8 [additional synonymu].
?1954 *Normannites (Normannites) masckei* Westermann, p. 155, pl. 8, figs. 2-4.
cf. 1954 *Normannites (Normannites) crassispinatus* Westermann, p. 158, pl. 8, figs. 5-6; pl.9, figs. 8-9.
?1973 *Normannites (Normannites) orbignyi*, Imlay, p. 82, pl. 42, figs. 9, 10, 18, 20.

Material: Single specimen "No. 13" from unknown locality in typical preservation of Taberna Formation: full whorl body chamber as internal mould and phragmocone as impression in ferruginous nodule.

Description: The phragmocone and body chamber whorls are widely umbilicate and almost serpenticonic, with the umbilical width increasing from 43 to 48 percent of the diameter. The whorl section is ellipsoidal and moderately depressed (W/H 1.55) with width slightly increasing, from 43.5 to 48 percent of the diameter. The increasing depression of the whorls and the exceptional length of the body chamber suggest that the specimen at 50 mm diameter may not be fully grown. This could therefore be a juvenile macroconch (♀) rather than an almost complete microconch (♂). The coarse ornament consists of 21 to 22 rectiradiate primaries per whorl which terminate in mid-lateral prominent tubercles (possibly spines on the body chamber). The straight and continuous secondaries arise by regular bifurcation with very rare additional intercalatories. Primaries and secondaries are prominent on the external mould of the phragmocone, but blunt on the internal mould of the body chamber. The preserved latest septum and suture display the planulate structure with retracted (suspensive) umbilical lobes typical of Stephanoceratinae.

Comparison: This microconch is abundant in the Humphriesianum Zone of Europe, particularly in its upper part (Westermann, 1954). Several specimens were also described under that name from the Snowshoe Formation of Oregon (Imlay, 1973), but are too poorly preserved for definite specific identification; in particular, it is unclear if biplication is developed regularly on the inner whorls. No other American records of this species exist. In the Mediterranean Europe, this species is known to range into the Subfurcatum Zone (Pavia, 1969).

Nomenclature: The confusion concerning the type specimen was reviewed earlier (Westermann, 1954, p. 136). Buckman (1908) had erected his species on d'Orbigny's "*Am. Humphriesianus* Sowerby" and later (1927) figured a complete microconch from Dorset under the same name. In his application to the International Commission on Zoological Nomenclature for type species designation, Arkell (1951, p. 223), however, used the 1927 date, thus designating Buckman's specimen

as the type, *i.e.* the neotype. Since d'Orbigny's figures may be synthesograms and no specimen (holotype) matching the figures appears to exist in the d'Orbigny collections, the neotype is fully valid.

Even if this should be a macroconch (♀), rather than an almost complete microconch (♂) as appears to be the case, the close morphologic affinities with "*Normannites*" *orbignyi* (type species) warrant tentative specific identification with this species known with certainty only in the microconch. There is little doubt, furthermore, that the macroconch dimorph of "*N.*" *orbignyi* is a typical *Stephanoceras* and not *Teloceras*, so that *Normannites* becomes a junior subjective synonym of *Stephanoceras* (Westermann, 1969).

Measurements (in mm):

Plate 4, figure 2	D	H	W	U	W/H	P/S
body ch.	50	13.9 (28)	24 (48)	23.8 (48)	1.7	21
body ch.	38	11.2 (31.5)	17.4 (46)	16.9 (44.5)	1.55	22/50
(begin.)	33	9.2 (28)	14.4 (43.5)	14.3 (43)	1.55	

Stephanoceras (*Stephanoceras*) "*undulatum*" Burckhardt, 1927 ♂ [*nom. dub.*]
(Plate 4, figures 1a-b)

1927 *Stephanoceras undulatum* Burckhardt, p. 22, pl. 12, figs. 1-4.

Description: The holotype which is the only known specimen, consists of the complete 3/4 whorl body chamber only and is therefore insufficient. It is damaged on the left side but bears incomplete lappets on both sides indicating that this is a stephanoceratid microconch of somewhat more than average diameter (62 mm). The specimen came from an old collection (Aguilera and Bonillas) from the "*Stephanoceras* beds" of the Mixtepec area, Oaxaca. This collection included the two small impressions (lost) of "*S.* aff. *psilacanthus* forma 3" which can only tentatively be identified with *Stephanoceras* s.l., *i.e.* "*S.* cfr. *Bigoti*", a new genus and species of either the ?Leptosphinctinae or ?Bigotitinae; and "*Dactylioceras* spp. ind. No. 2 and 3, here placed in *Planisphinctes* (?).

The body chamber of the small microconch has subcircular, only slightly depressed (W/H = 1.1-1.2) whorl sections throughout. It bears prominent, sharp and forward-curved primaries which end at the middle of the whorl height in high round nodes (internal mould). There are about three prominent secondaries per primary which pass over the venter with slight projection and aperturad convexity. The secondaries become coarser toward the aperture which bears simple "spatulate" lateral lappets.

Discussion: This is clearly a narrow-whorled "*Normannites* (*Itinsaites*)", *i.e.* the microconch to *Stephanoceras* s.s. (Hall and Westermann, 1979), but it differs from all others by the subcircular whorl section already at the beginning of the body chamber and possibly in the projected ribbing (*cf.* Westermann, 1954) as al-

ready pointed out by Burckhardt. All South American species with similar whorl section have finer secondaries. Curved ribbing is common in North and South American species.

Significantly "*Normannites* (*Itinsaites*)" McLearn [as "*Dettermannites*" Imlay] is well known from the lower upper Bajocian of South Alaska and U.S.A. (Imlay, 1962, 1967, 1973).

Genus *Lupherites* Imlay, 1973
[Synonym: *Domeykoceras* Hillebrandt, 1977]
Type species: *L. senecaensis* Imlay, 1973

?*Lupherites* cf. *L. chongi* (Hillebrandt, 1977)
(Plate 2, figures 7a-c)

A single specimen from the *Parastrenoceras* beds of San Juan Diquiyú, Oaxaca (loc. Ca 5a of Erben, 1956), has 1/3 whorl of the phragmocone and a small fragment of the terminal body chamber. The phragmocone ornament consists of moderately dense, forward curved to somewhat prorsiradiate primaries (about 12-15 per half-whorl), mid-lateral modes, and dense convexly forward-curved secondaries. The septal suture has small, almost straight umbilical lobes and a subradial saddle envelope. The body chamber is subquadratic in section, and has flexed, fasciculate dense ribbing with curved irregular primaries.

This specimen closely resembles *L. chongi*, except for the septal suture which is strongly retracted in the Chilean forms. According to material of *L. senecaensis* collected by Paul Smith, the Oregon species also has strongly oblique sutural elements (missing in Imlay, 1973, pl. 47, fig. 15).

Superfamily Perisphinctaceae Steinmann, 1890
Family Perisphinctidae Steinmann, 1890
Subfamily Leptosphinctinae Arkell, 1950
Genus *Leptosphinctes* Buckman, 1920
Type species: *L. leptus* Buckman, 1920

Leptosphinctes tabernai n. sp.
(Plates 5-8)

1956 "Perisphinctidos" (Leptosphinctinae?) -- Erben, p. 29 etc.

Holotype: The phragmocone on Plate 5, figures 1a-d (IGM 2798).

Locus typicus and stratum typicum: Locality Ca-6 of Erben (1956, p. 83) at San Juan Diquiyú in Oaxaca State; lower part of the Taberna Formation (see below).

Derivatio nominis: Referring to the Taberna Formation.

Diagnosis: A species of *Leptosphinctes* with prominent ribbing; primaries

short and secondaries subcontinuous without marked mid-ventral reduction on all but outer 1-2 whorls.

Material: Numerous specimens, mostly incomplete internal moulds, from the Taberna Formation of San Juan Diquiyú, Oaxaca State: Erben's localities Ca 4, 5, 6, 7, 8, 10. (The specimens were not catalogued individually and may therefore have been mixed; the matrix of the Taberna Formation, however, is highly distinct); one large specimen with complete body chamber and damaged phragmocone from locality GW 2 (McM. J 2024a).

Description: The shell is evolute planulate with compressed whorls and has relatively prominent ribbing for the genus.

The nucleus has subcircular to somewhat depressed whorls, with more or less distinct lateral shoulder, and bears prorsiradiate, moderately prominent, sharp primaries. These are long and divide high on the flank into two or three forward-curved, subcontinuous secondaries. Small lateral tubercles were probably present on the shell in most cases. The intermediate and outer whorls are compressed-ovate, with shallow umbilical slopes grading into the weakly convex flanks. The venter is evenly curved to slightly arched, becoming more narrowly curved as the whorls grow more compressed toward the end of the phragmocone. The ribbing is only slightly more dense and usually less prominent than on the nucleus. Bifurcation and trifurcation occur high on the flank. The secondaries are subcontinuous and convex up to the ultimate phragmocone whorl where they become blunt and obsolescent at mid-venter. Deep, strongly prorsiradiate constrictions are present throughout.

The phragmocone diameter is between about 55 and 100 mm. The smaller specimens, however, may be immature or incomplete since septal approximation is evident only in the specimens with 70 mm diameter. At least the great majority of the specimens therefore appears to be macroconchs.

Only a single complete body chamber is available (Plate 6) which measures 151 mm in diameter. It is almost a full whorl in length, commences at 102 mm and terminates in a gently curved peristome with broad, somewhat flared (internal mould) ventral lappet. The ribbing is somewhat blunt with smooth venter on the first 1/3 whorl and subsequently becomes obsolete. At least one deep constriction is developed on this internal mould. Although this specimen has most of the phragmocone destroyed, the rather prominent ribbing is visible on the intermediate whorls.

Remarks: This species appears to be highly variable in the spacing and prominence of the ribbing, particularly of the inner whorls. Alternatively, the presence of several closely affiliated species has to be assumed. The mode of variation cannot be resolved without detailed stratigraphy. The finer ribbed forms somewhat resemble *L. cliffensis* Imlay (1964) from the upper Bajocian of south Alaska, but differ in the shorter primaries, greater involution and the less developed mature lateral shoulder. Imlay's species, however, was based on a single incomplete specimen, *i.e.* the holotype (plastotype available) from the lower part of the "Bowser Member of the Tuxedni Formation" (= Twist Creek Siltstone of Tuxedni Group at Cook Inlet). The association with *Megasphaeroceras rotundum* Imlay and *Oppelia (Liroxyites)*

kellumi Imlay clearly marks the *M. rotundum* Zone of the lower upper Bajocian (Hall and Westermann, 1979).

This species probably occurs also in the Subfurcatum Zone of southwest Germany (Dietl, 1980).

Leptosphinctes is also known from the lower upper Bajocian of the United States (Imlay, 1973), Chile (Hillebrandt, 1977; Covacevich and Piracés, 1976) and Argentina (Westermann and Riccardi, 1979).

Measurements (in mm):

	D	H	W	U
Holotype, phrag.	68.2	19.2	17.4	22.5
Plate 7, figure 1, phrag.	59.7	19.4	18.6	19.7
Figure 2, phrag.	89.7	25.2	19.2	28.7
Figure 3, phrag.	91.5	26.3	20.3	31.1

Subfamily ?Leptosphinctinae (or ?Bigotitinae Westermann, 1956)
gen. et sp. nov. A
(Plate 4, figure 3)

1927 *Stephanoceras* cfr. *Bigoti* Munier-Chalmas -- Burckhardt, p. 21, pl. 11, fig. 11.
?1927 *Stephanoceras* sp. ind. No. 2 Burckhardt, p. 27, pl. 11, No. 12.

Material: Burckhardt's original paraffin moulds from natural impressions: "*St.* cfr. *Bigoti*", right side and venter of probably complete specimen, somewhat distorted, from the "*Stephanoceras* beds" of Mixtepec area, Oaxaca (coll. Aguilera and Bonillas; IGM A-II-10-49, No. 1915); ?"*St.* sp. ind. No. 2", left side of inner whorls only, from "*Stephanoceras beds*" of Duashnú, southwest of San Andrés Cabecera Nueva, Oaxaca (coll. Flores, IGM A-II-11-3).

Description: To judge from the coiling, the small shell of 58 mm diameter was probably complete. The shell is planulate serpenticonic, with the subcircular whorls becoming advolute toward the end. The umbilicus is extremely shallow and the inner flanks slope gently to the umbilical seam. The ornament consists of slightly forward-curved, moderately prominent and spaced, somewhat blunt primaries which reach from the umbilical seam to the middle of the side. Here they bear obsolete bullae (radially extended nodes) and bifurcate consistently but somewhat unevenly into broad, blunt, straight and continuous secondaries. On the ultimate half-whorl, presumably part of the body chamber, the primaries become blunt and withdraw from the umbilical seam, while the bullae become more prominent and extend asymmetrically into one of the secondaries.

The septal suture is partially preserved on the cast, particularly towards the end of the penultimate whorl, where marginal parts of the septa remained attached to the mould. Although many details are obscure, it is clearly not markedly retracted.

Discussion: The cast from the further developed natural external mould supports Arkell's view (1956, p. 565) that this specimen and perhaps also Burckhardt's poorly preserved "*Stephanoceras* sp. ind. No. 2" could belong to the upper Bajocian Leptosphinctinae. The best resemblance appears to be to coarsely ribbed forms of the subgenus *Cleistosphinctes*, e.g. "*Pseudobigotella*" *otiophora* Buckman (1920, pl. 191) from the Subfurcatum Zone of England, microconchs which also miss constrictions. Other somewhat similar forms were described from the Subfurcatum Zone of the Basses-Alpes (Pavia, 1971), but none is quite as coarsely ribbed and all seem to have somewhat projected secondaries and a strongly retracted suture.

The Alaskan Leptosphinctinae (Imlay, 1962) have much longer primaries and marked constrictions, while the poorly preserved specimens from Oregon (Imlay, 1973) have longer and/or much denser primaries.

In consideration of the weakly retracted suture, "*Stephanoceras* cf. *bigoti*" also resembles *Bigotites*, e.q. *B. dimensis* Sturani (1967) from the basal Bathonian of the Basses-Alpes (except for the missing constrictions and more retracted suture) and, especially, *Parabigotites*. Some of the most serpenticonic species of the European *Bigotites*, mostly from the Garantiana Zone, differ by the less prominent, curved and partially interrupted ventral ribbing (*cf.* Bentz, 1924, pl. 8, figs. 7, 8). The North American *Parabigotites crassicostatus* Imlay, from the Crassicostatus (*ca.* Sauzei) Zone of south Alaska, Oregon and the Western Interior United States, is distinguished in the slightly broader whorls and the projected ribbing crossing convexly over the venter (Imlay, 1964, 1973). Constriction and "segmental growth" are not always obvious in these genera and are missing in many specimens. In contrast to Imlay's statement in the original descriptions of *Parabigotites* (1964,p. B54), the septal suture is only weakly retracted at maturity and essentially straight with radial saddle envelope on the immature whorls (*cf.* Imlay, 1964, pl. 29, figs. 8, 9).

Bigotites and *Parabigotites* (and ??*Patrulia* Sturani, 1971) are thus clearly distinct from *Leptosphinctes* and allied genera which have strongly retracted (and more complicated) sutures. The subfamily *Bigotitinae* Westermann (1956) may perhaps be retained (excluding the leptosphinctid "genera" originally listed).

Measurements (in mm):

	D	H	W	U	P	S
Plate 4, figure 3	58	--	--	29.8	15-16	c.30
?body ch.	45	13.0	13.5	21.8	14	27
?end phrag.	33	9.8	c.10	16.3	14	c.28

?Subfamily Parkinsoniinae Buckman, 1920

Genus *Parastrenoceras* Ochoterena, 1963

[= ?*Subcollina* Spath, 1925; cf. Sturani, 1971, p. 164]

Type species: *Parastrenoceras mixtecum* Ochoterena, 1963

Discussion: This genus, with the three supposed species *P. mixtecum*, *P. oaxacanum* and *P. tlaxiacense* Ochoterena spp., is the only ammonite genus from the fossiliferous Taberna Formation previously described in detail and illustrated profusely (Ochoterena, 1963). All specimens came from Erben's collections made in the area of San Juan Diquiyú, Oaxaca State, and were described apparently without attention to stratigraphic distribution. The type species ♀ is by far the most common, while the two other species (?♂) were based respectively on three and two fragmentary specimens only. The original figures of the holotypes are here reproduced (Plate 9).

The whorls are subcircular to subquadratic and evolute. The long recti- or prorsiradiate primaries end in ventro-lateral tubercles or clavi. The subradial secondaries occur in singles, pairs and/or triplets and tend to become obsolete. There are ventral tubercles beside a smooth mid-ventral band. The tubercles of the internal mould indicate spines on the shell. The septal suture is simple and straight (without retraction).

The closest relative is *Strenoceras* which is distinguished in the shorter primaries ending in lateral nodes or spines, and in the more prominent, less numerous and longer secondaries with less marked, fewer ventral tubercles.

Significantly, the other species in the genus are all from western Europe, *i.e. P. caumontii* and *P. lucretius* d'Orbigny spp., from the lower Subfurcatum Zone (Banksi Subzone), basal upper Bajocian (Sturani, 1971). Sturani also described *P.* cf. *tlaxiacense* Ochoterena from the upper Subfurcatum Zone (Baculatum Subzone) of the Venetian Alps. Significantly, in the European sequence *P. lucretius* and *P. caumonti* appear slightly before *Strenoceras*, *i.e.* in the Polygyralis Subzone of the middle Subfurcatum Zone, and *Parastrenoceras* spans the Subfurcatum Zone to which it is restricted (Sturani, 1971).

(?) Subfamily Zigzagiceratinae Schindewolf, 1925

Sturani (1967) has demonstrated that the mainly lower Bathonian genus *Siemiradzkia* Hyatt, placed by Arkell (1957) in the Pseudoperisphinctinae, is rather closely affiliated to the lower Bathonian genus *Zigzagiceras* Buckman (s.str.). In typical *Zigzagiceras* microconchs the "zigzag ornament" with distant, thin, long and curved primaries bearing parabolic nodes occurs up to the beginning of the mature body chamber, where thinner primaries are intercalated between those bearing the nodes until all become similar under loss of the nodes. In the *Siemiradzkia* microconch, finer primaries are present between the node-bearing, more prominent ones on the inner whorls also and all become similar on the outer whorl. Morphologic intermediaries are known, *e.g. Zigzagiceras*? *torrensi* Sturani. Sturani (1967) derives the Zigzagiceratinae from *Bigotites* (of the Leptosphinctinae/Bigotitinae) by loss of the constrictions and modification of the ornament.

Mangold (1970) includes in this subfamily *Zigzagiceras* (microconch, including macroconch *Procerozigzag*), *Planisphinctes* (m., incl. M. *Lobosphinctes*, ?*Fran-*

chia), *Procerites* (M., incl. m. *Siemiradkzkia*), *Wagnericeras* (M.), *Homeoplanulites* (m., incl. M. *Parachoffatia*, syn. "*Pseudoperisphinctes*"), and *Indosphinctes* (M., m. *Elatmites*). The total range is from the Parkinsoni Zone of the upper Bajocian to the Patina Zone of the lower Callovian.

The searching of the fossil collections in the Instituto de Geología yielded a number of unlabelled specimens (unknown localities) identical with "*Stephanoceras*" *floresi* Burckhardt, "*S.* aff. *brodiaei*" and "*Stephanoceras* aff. *psilacanthum*" of Burckhardt in identical but more complete preservation. This includes body chambers, several of which are attached to the complete external mould of the phragmocone. By casting the phragmocone in dental latex, several complete specimens were reconstructed. This material, especially the body chambers, tentatively confirms not only Arkell's (1956, 1958) view that the supposed "*Stephanoceras*" from Duashnú are *Zigzagiceras*, but also that the supposed "*S.* aff. *psilacanthus*" belongs to a related, unnamed genus on the strength of its almost identical adult stage. In contrast to other Zigzagiceratinae, however, the Mexican forms have prominent spines, rather than parabolic nodes, and undifferentiated primary ribbing on the nucleus. In *Z. floresi*, the primaries are also shorter with the spines near midflank so that the inner whorls resemble coronate *Stephanoceras* or *Teloceras* as well as the newly described *Lupherites chongi* (Hillebrandt, 1977). In fact, I had believed Arkell to be wrong in assigning this species to *Zigzagiceras*, following Sturani (1971), until the discovery of the complete specimens and of additional body chambers in the old collections. In the absence of information on rock succession and fossil associations, however, even the subfamily assignment remains somewhat uncertain. The other species, the former "*Stephanoceras* aff. *psilacanthus*", has undifferentiated, rather dense primaries on the immature whorls, again contrasting with the immature ornament of fine-ribbed Zigzagiceratinae, *e.g. Siemiradzkia*; yet the body chamber whorl resembles *Zigzagiceras* particularly closely. This species belongs to a new genus which, again, can only tentatively be placed in the Zigzagiceratinae, pending additional specimens and stratigraphic information.

Another taxon characterized by similar whorl shape and adult ribbing is the upper Bajocian to lower Callovian *Cadomites*. The subfamily Cadomitinae Westermann, however, is clearly distinct in the bullate septum with paired internal lateral saddles. The Mexican forms have the planulate septum and suture of Stephanoceratinae and Perisphinctidae.

The principal collecting site is the "*Stephanoceras* beds" of Duashnú in Oaxaca, a remote locality which apprently was visited only by Flores at the turn of the century. Neither Erben (1956) nor I, together with C. González and A. C. Riccardi, were able to reexamine it. The local geology and rock sequence of Duashnú thus remain unknown, and no new material is available (Erben's relevant material from Mixtepec appears to be lost).

(?) Genus *Zigzagiceras* Buckman, 1920
Type species: *Ammonites zigzag* d'Orbigny, 1846

Subgenus *Duashnoceras* n. subgen.
Type species: *Stephanoceras floresi* Burckhardt, 1927

Derivatio nominis: From the type locality of *S. floresi*, near Duashnú in Oaxaca province.

Diagnosis: Juvenile ornament with regular ribbing; subsequent ornament coronate, *Zigzagiceras*-style, with prominent spines (instead of parabolic nodes), placed near mid-whorl, retained to aperture of microconch.

Zigzagiceras (*Duashnoceras*) *floresi* (Burckhardt, 1927) ♂ & ??
(Plate 10, figures 1-5; Plate 11, figures 1-2)

1927 *Stephanoceras floresi* Burckhardt, p. 25, pl. 12, figs. 14-16, 18-20.
1927 *Stephanoceras* aff. *Brodiaei* -- Burckhardt, p. 25, pl. 12, figs. 10-11.

Material: The holotype (IGM 1920-21) and the original natural impressions of "*Stephanoceras* aff. *brodiaei*" (IGM 1919) from "*Stephanoceras* beds" of Duashnú (coll. Flores); two microconchs (IGM 2817), two macroconchs (?) (IGM 2816) and one crushed specimen, all internal moulds of body chambers with attached external moulds of phragmocone which has been dissolved away, in matrix of brownish weathering (hematitic?) calcareous concretions resembling those of the Duashnú "*Stephanoceras* beds", from old collections of unknown origin.

Description: The planulate shell has rather evolute and somewhat depressed-elliptical, coronate whorls throughout. The umbilicus is rather shallow and subconical due to the gentle umbilical slope. As usual, the body chamber, a good 3/4 whorl long in the complete microconch, becomes more rounded by negative allometry of whorl width.

The nucleus to about 10 mm diameter has moderately dense, recti- to prorsiradiate and blunt primaries terminating in small nodes. The ornament of the outer phragmocone whorls consists of very widely spaced thin and curved primaries which may become obsolete leaving an almost smooth umbilical slope (and inner flank); high mid-whorl spines, only six to eight per half-whorl placed backward from the primaries in the position of parabolic nodes; and moderately to very dense, rounded, continuous and orad convex secondaries, five to six per spine and primary.

The body chamber ornament resembles that of the phragmocone, except for the slight reduction of the spines and the increased prominence and spacing of the secondaries on some specimens.

Only the ultimate septum and suture are known because the phragmocone is preserved as external mould. The fluting structure is typically planulate with single principal saddle axis as in Stephanoceratinae and Perisphinctidae. The umbilical.

elements are, however, only slightly to moderately retracted and oblique, perhaps owing to adult modification.

One specimen (Plate 10, figure 3) is a complete microconch with 52 mm diameter. It bears short lateral lappets and displays marked coarsening of the secondaries. Two other specimens (Plate 10, figure 2; Plate 11, figure 2) range in inferred complete diameter from 45 to 65 mm but have no peristomes; the smaller one may also be immature.

Holotype: The species was based on two small body chamber fragments said to have come from a single specimen, the holotype (Plate 20, figures 1a-d). Approximately 1/4 whorl is missing between the fragments and the aperture is missing. The last septum, almost perfectly preserved, is planulate, with a single large internal lateral saddle; a small, slightly oblique lobe (which is either U_n or the dorsal branch of U_1) and similar saddle; a weakly retracted external suture with radial saddle envelope, small U_2, subequal L/U_2 and U_2/U_3 saddles, and a broad U_3 which is barely as deep as E and L. It is ponted out, however, that terminal sutures are commonly less retracted than the adolescent sutures of the same specimen.

The whorl section between ribs is subcircular throughout, with rather shallow sloping inner flanks and highly curved venter. The body chamber ornament on the internal mould consists of widely spaced curved primaries, only six to seven per half-whorl; prominent round tubercles which probably bear spines at mid-whorl and in the retarded position of parabolic nodes; and of dense, sharp and orad convex secondaries, five or six per primary. The aperture is unknown.

The holotype was collected by T. Flores in the "*Stephanoceras* beds" of Duashnú, southwest of San Andrés Cabecera Nueva, Oaxaca. From the same locality, Burckhardt (1927) also described "*Stephanoceras* aff. *Brodiaei*", here placed in the same species, "*S.* aff. *psilacanthum* forma 1 & 2" [Zigzagiceratinae *gen. et sp. nov.* A, part.], "*Stephanoceras* sp. ind. No. 1 & 2" (1 same, 2?) and "*Dactylioceras* sp. ind. No. 1" [?*Planisphinctes*].

Discussion: S. floresi is of appreciable chronologic significance. Arkell (1956, p. 564; 1957, p. L315; 1958, p. 180) identified *S. floresi* and Burckhardt's "*S.* aff. *Brodiaei*" with the lower Bathonian *Zigzagiceras* comparing them with *Z.* [*Procerozigzag*] *crassizigzag* (Buckman)♀. (Since *Z. crassizigzag* is based on a macroconch with stout perisphinctoid outer whorls (referred to the "dimorphsubgenus" *Procerozigzag*), the better comparison is with the microconchiate *Zigzagiceras* [s.str.] ex gr. *euryodus* (Schmidt) ♂ (Plate 3). Arkell found support for this younger age of part of the "*Stephanoceras*" fauna in Burckhardt's "*Dactylioceras* sp. ind. No. 2" which he placed in *Planisphinctes* and/or *Siemiradzkia.*

The true *Zigzagiceras* has parabolic nodes at 2/3 to 3/4 whorl height, a feature which Arkell (1958, pl. 170) himself considered as highly diagnostic (*cf.* d'Orbigny, 1846, pl. 129, figs. 9-11; Buckman, 1920, pl. 153; Hahn, 1969, pl. 2, figs. 3, 4 and pl. 9, fig. 3). *Z. floresi* differs by the hypertrophy of the parabolic nodes into prominent conical spines which are positioned near mid-whorl, so that the venter is more strongly arched; the presence of a "normally" ribbed nucleus; the persistent

coronate stage to the adult aperture in the microconch; and perhaps in a less retracted septal suture. The *Zigzagiceras* suture resembles that of the closely related *Procerites* with its high complexity and narrow lobes, but seems to be somewhat less retracted (Buckman, 1922, pl. 335; Sturani, 1967, pl. 17).

According to Hahn (1969) and Sturani (1967) the genus *Zigzagiceras* is restricted to the Macrescens Subzone of the middle Zigzag Standard Zone of Europe.

Except for the *Zigzagiceras*-like primaries, there is some resemblance to the microconchiate *Stephanoceras* (*Skirroceras*?) aff. *nodosum* (Quenstedt) from the lower/upper Bajocian boundary beds of Caracoles, Chile (Westermann and Riccardi, 1979) and to macroconchiate "*S.* aff. *nodosum*" from the upper Bajocian of the Western Interior U.S.A. (Imlay, 1967, pl. 7, fig. 4), which is said to have six or seven secondaries per primary on the phragmocone. In the basal upper Bajocian of northern Chile occurs *Lupherites* ["*Domeykoceras*"] *chongi* (Hillebrandt, 1977, pl. 5, figs. 1-3), which has similar inner whorls but differs again in the ornament with normal primaries, here becoming much finer and subfasciculate on the outer whorls.

The only possible *Cadomites* with similar whorl section is *C.*? *humphriesiformis* Roché (1939, pl. 2, fig. 3) from the Subfurcatum Zone of France. The primaries of the French species are longer, less curved and continuous with the nodes. The septal suture and, hence, the generic affinity of the French species, however, are uncertain. The Cadomitinae differ in the bullate septum with paired internal lateral saddles divided by a large U_n (Westermann, 1956).

In conclusion, the ornament differs significantly from that of the Stephanoceratidae and resembles more strongly that of the Zigzagiceratinae, with the tall spines substituting for parabolic nodes. The Zigzagiceratinae affinity appears to be even stronger in the body chamber whorl of "*Stephanoceras* aff. *psilacanthum* forma 2" [Zigzagiceratinae *gen. et sp. nov.* A] described below. A lower Bathonian age, thus, seems highly probable for these taxa.

Measurements (in mm):

	D	W	H	U	P/	S/ whorl
Holotype, end body ch.	45-50	28	26.5	–	6-7	c.40
Plate 10, figure 5, aperture	52	19.5	16.5	22.5	8	33
beg. body ch.	31.6	16	10.5	14.7	6	39

(?) Zigzagiceratinae *gen. et sp. nov.* A, ♂ (& ♀)
(Plate 11, figures 3-7)

1927 *Stephanoceras* aff. *psilacanthum* Behrendsen (forma 2) -- Burckhardt, p. 23, pl. 12, figs. 6, 7.

?1927 *Stephanoceras* aff. *psilacanthum* Behrendsen (forma 1) -- Burckhardt, p. 23, pl. 12, figs. 5, 8, 9.

?1927 *Stephanoceras* sp. ind. No. 1 -- Burckhardt, p. 27, pl. 11, fig. 10; pl. 12, fig. 21.

Material: The original impressions to Burckhardt's illustrations in the above synonymy from Duashnú (coll. Flores): three body chamber fragments in single lot from old collections in the Instituto de Geología, from unknown locality, but in same matrix and preservation (body chambers in ferruginous siltstone) as *Zigzagiceras floresi* (IGM 1918, 1922).

Description: The small shell is thin-planulate with wide and very shallow umbilicus and subcircular whorl section. The ornament of the almost serpenticonic inner whorls to 20-25 mm diameter consists of moderately dense, long and prorsiradiate primaries which arise some distance from the umbilical seam. They end above the middle of the flank at about 3/5 whorl height in small nodes. The secondaries are dense, three to four per primary, and cross the venter with orad convexity. The outer one or two whorls become subquadratic with coronate ornament resembling that of *Zigzagiceras*. The long thin distant primaries curve strongly and tend to end slightly beside the pointed tubercles or low spines. The body chamber of the microconch, one of which is almost complete (Plate 11, figure 3), has distant primaries and rather large rounded, somewhat parabolic nodes up to the aperture. Since these are internal moulds, the shell may have had modest spines. The dense secondaries are strongly convex to almost crescentic throughout.

The microconchiate body chamber terminates at about 58 mm with lateral lappets, of which the bases are preserved (Plate 11, figure 3). Two otherwise identical body chamber fragments are much larger (respectively c.100 and c.120 mm D) while still incomplete, suggesting that they are macroconchs (Plate 11, figures 4-5).

The septal suture is unknown.

Discussion: In all *Zigzagiceras* microconchs ["*Zigzagiceras* s.s."] and macroconchs ["*Procerozigzag*"], the coronate stage with distant, curved primaries and parabolic (or clavate?) nodes is followed by the perisphinctoid stage which coincides approximately with the body chamber in the microconch and with several outer whorls in the macroconch (*cf.* Arkell, 1958). In this rare Mexican form, an extended 'perisphinctoid' stage is followed by the coronate stage. Yet, the close resemblance of its outer whorl to the European *Zigzagiceras zigzag* (d'Orbigny) ♂ and *Z. euryodus* (Schmidt) ♂ cannot be denied (*cf.* Arkell, 1958; Sturani, 1967; Hahn, 1969).

The best resemblance and closest affinity may be to the variants of supposed *Siemiradzkia* described by Sturani (1967, pl. 24, figs. 4, 5, 7) from the upper Zigzag Standard Zone of the Basses-Alpes. These fragmentary European specimens display marked ontogenetic coarsening of ornament, with a modified perisphinctoid stage followed by the coronate stage. This ornament is reminiscent of the Bathonian-Callovian *Neuqueniceras* as well as the upper Callovian *Pseudopeltoceras*, but both differ in the straight primaries bearing the nodes directly.

The true *Cadomites psilacanthus* (Wermbter), reexamined by Westermann and Rioult (1975), is unrelated to this form.

Measurements (in mm):

	D	H	W	U	P	S
Plate 11, figure 3, aperture (lappets)	59	17.1	21.1	25.6	11-12	46
body ch.	43	14.8	14.9	--	--	--
Plate 11, figure 4, body ch.	(c.120)	32.2	30.1	--	--	--

?Subfamily Pseudoperisphinctinae Schindewolf, 1925

[The nominate genus *Pseudoperisphinctes* is now considered to be a junior subjective synonym of *Choffatia, e.g.* Schindewolf (1966); Hahn (1969); or of *Homeoplanulites, e.g.* Mangold (1970) who includes this subfamily in the Zigzagiceratinae.]

Genus *Planisphinctes* Buckman, 1922
Type species: *P. planilobus* Buckman, 1922

Planisphinctes (?) sp. nov. A
(Plate 4, figures 4-5b)

?1927 *Dactylioceras* sp. ind. No. 1 -- Burckhardt, p. 19, pl. 11, fig. 5.
1927 *Dactylioceras* sp. ind. No. 2 -- Burckhardt, p. 19, pl. 11, figs. 6, 7.
1927 *Dactylioceras* sp. ind. No. 3 -- Burckhardt, p. 20, pl. 11, figs. 8, 8a, 9.

Material: Burckhardt's external moulds and wax impressions of "*Dactylioceras*" as in the synonymy from the "beds with *Stephanoceras*" at (?) Duashnú ("No. 1") and Mixtepec ("No. 2, 3"), Oaxaca.

Description: The shell is small and flat-planulate. The whorls are serpenticonic and subquadratic to slightly compressed subrectangular with narrowly curved umbilical slope arising vertically from the seam, and weakly convex venter which is somewhat separated from the flat flanks. The umbilicus is extremely shallow but stepped. Since the specimens are either natural moulds or wax impressions from incomplete moulds, the adult size and state of completeness are unknown. The larger one of the Mixtepec specimens, "*Dactylioceras* sp. ind. No. 2", after slight development of the natural mould, has a diameter of 39 mm.

The juvenile whorls to 6-8 mm diameter appear to be smooth, even on the shell, and the ornament arises gradually with very fine and dense, prorsiradiate primaries slowly becoming more prominent and more widely spaced. The primaries reach from the umbilical shoulder to the ventral shoulder at about 3/4 whorl height or slightly below, where they attain their greatest prominence; while some continue simple, the majority of primaries divides indistinctly into two slightly projected secondaries of similar prominence. At 20-25 m diameter, the ribs cross straight over the venter ("*Dactylioceras* sp. ind. No. 3" with complete venter), but are probably somewhat convex at larger diameter. On the ultimate half-whorl of the incom-

plete larger specimen, the primaries become more prominent, sharp and wider spaced, terminating in minute bullate tubercles.

Discussion: The probably correct generic identification of this form is owing to Arkell (1956, p. 5611; 1957, pl. 317), who dated most of Burckhardt's fauna from the "*Stephanoceras* beds" as Zigzag Zone. The genus is very rare in England, where the holotype was said to have come from the Zigzag Zone (Buckman, 1922, pl. 327; Arkell, 1958, p. 230). According to Sturani (1967, p. 40), however, the stratum typicum as well as the main distribution of this and other species in the Basses-Alpes, France is in the upper Parkinsoni Zone (Bomfordi Subzone) of the topmost Bajocian. The genus also occurs in the probably condensed uppermost Bajocian- lower Bathonian of the Caucasus and Iran (*op. cit.*).

This new species which remains unnamed because of the poor material, differs from *P. planiforme* in the finer ornament of the inner whorls, the absence of a ventral rib interruption (*cf.* Sturani, 1967) and the more compressed whorl section. *P. tenuissimus* (Siemiradzki) has more densely ribbed outer whorls. Another similar form, particularly in the fine ribbing of the immature stage, is "*Procerites*? (*Gracilisphinctes*?) sp. indet. juv." of Sturani (1967, pl. 10, fig. 3) from the lower Bathonian of the Basses-Alpes.

Burckhardt's distorted "*Dactylioceras* sp. ind. No. 1" (here Plate 11, figure 7) from Duashnú differs in the much more prominent ribbing of the outer whorl, while it agrees in the inner whorls. Arkell (1956) may have been correct to include it also in *Planisphinctes.*

Neither the "*Dactylioceras*?" listed by Erben (1956, p. 86) from the fossiliferous sections at San Juan Diquiyú, nor the "*Dactylioceras* sp." listed from the Mixtepec section (p. 110) could be found in his collections stored at the Instituto de Geología in Mexico City.

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PLATES 1-11

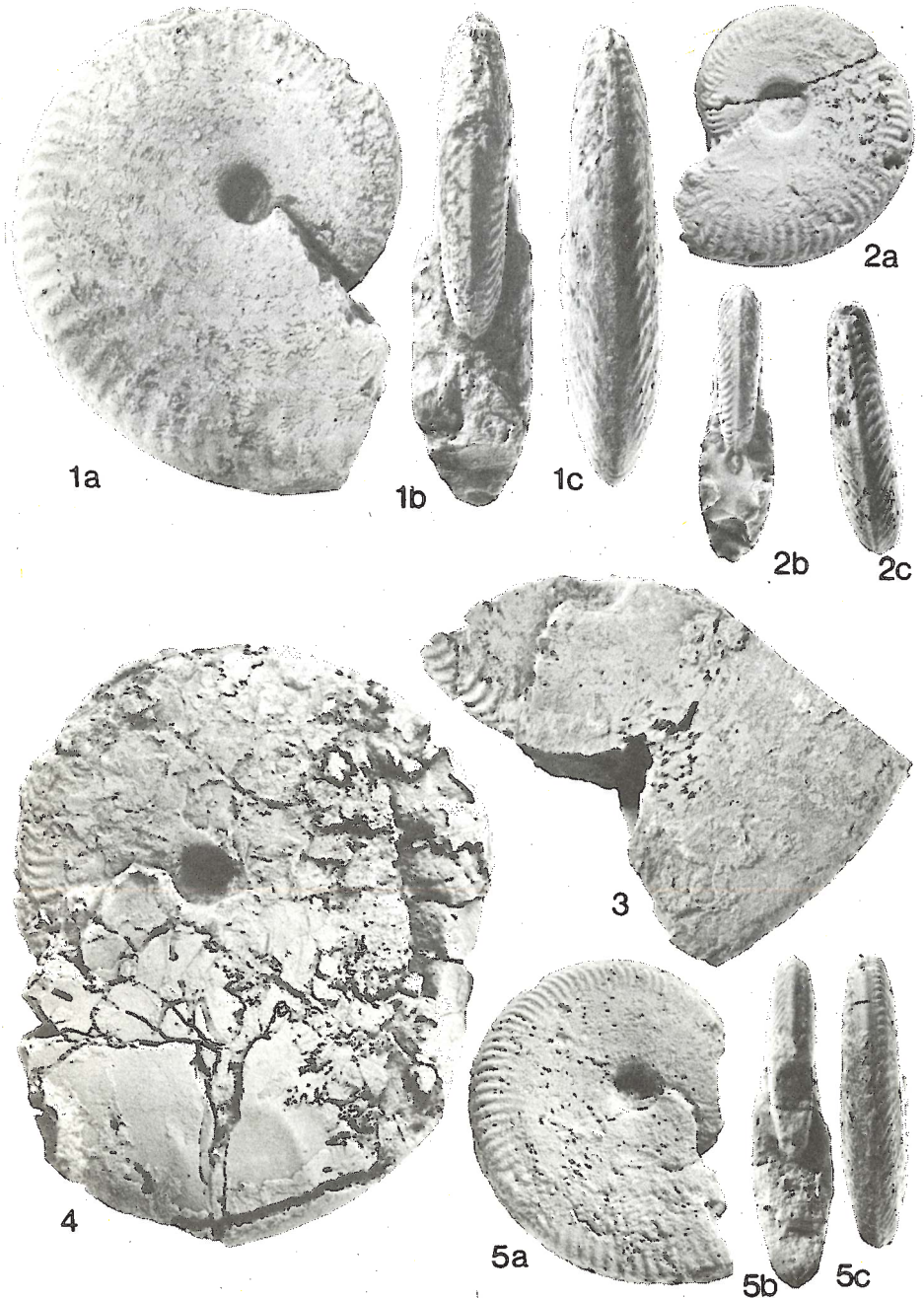
PLATE 1

OPPELIA (OPPELIA) SUBRADIATA ERBENI

(All figures natural size)

Figures 1-5.- *Oppelia* (*Oppelia*) *subradiata erbeni* n. subsp. from the *Parastrenoceras* association of the Taberna Formation, near San Juan Diquiyú.

1a-c: Holotype (IGM 2793) completely septate internal mould from locality Ca-4.
2a-c: Septate internal mould from locality Ca-7/9 (IGM 2794).
3: Fragment of large adult phragmocone from locality Ca-4 (IGM 2795).
4: Damaged adult specimen with beginning of body chamber, from locality Ca-11 (?) (IGM 2796).
5a-c: Septate internal mould from locality Ca-7 (IGM 2797).



OPPELIA (OPPELIA) SUBRADIATA ERBENI

PLATE 2

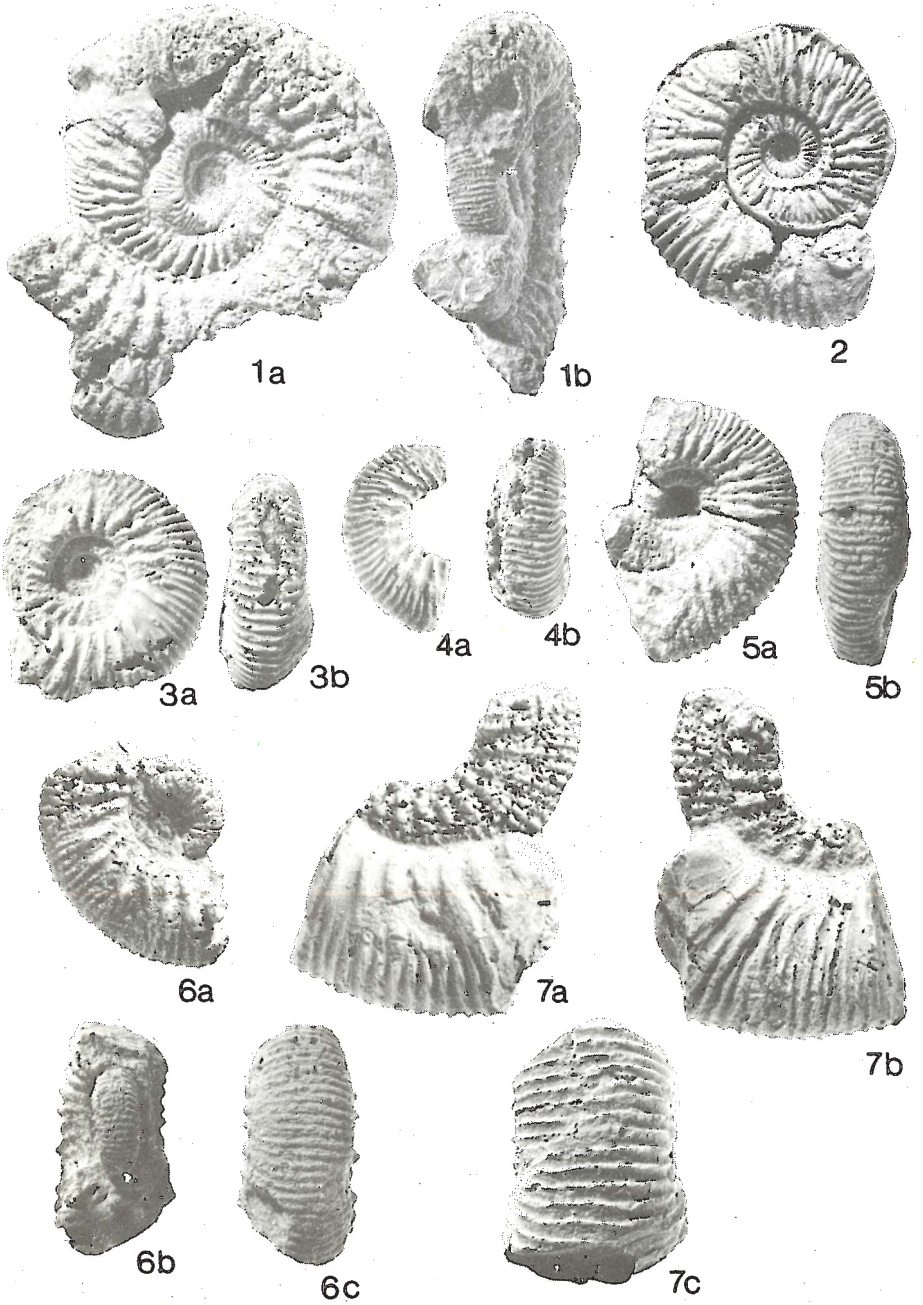
?*STEPHANOCERAS* AND ?*LUPHERITES*

(All figures natural size)

Figures 1-6.- ?*Stephanoceras* cf. *S. chilense* Hillebrandt from the *Parastrenoceras* association of the Taberna Formation.

1a-b: Somewhat distorted and damaged phragmocone of a macroconch (?) from locality M-1, Mixtepec (IGM 2807).
2: Complete microconch with lappets, from locality M-1, Mixtepec (IGM 2808).
3a-b: Phragmocone with beginning of body chamber (?), from locality Ca-5, San Juan Diquiyú (IGM 2809).
4a-b: Whorl fragment from locality Ca-10, San Juan Diquiyú (IGM 2810).
5a-6c: Septate, damaged specimens from locality GW-2, San Juan Diquiyú (McM. J 2042b, c).

Figures 7a-c.- ?*Lupherites* cf. *L. chongi* Hillebrandt from locality Ca-5, San Juan Diquiyú (IGM 2811).



?STEPHANOCERAS AND *?LUPHERITES*

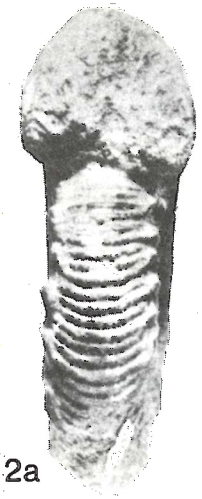
PLATE 3

STEPHANOCERAS AND EUROPEAN *ZIGZAGICERAS*

Figures 1a-b.- Holotype of "*Stephanoceras paucicostatum*" Felix, from Tlaxiaco area.

Figures 2-4.- Typical European *Zigzagiceras*.

2a-c: Z. *euryodus* (Schmidt) ♂.
3-4: Z. *crassizigzag* Buckman ♀ to which Arkell (1956, 1958) compared "*Stephanoceras*" *floresi* Burckhardt. All are from the Zigzag Zone of England (from Arkell, 1958, pl. 20, figs. 7-8 and pl. 21, fig. 1).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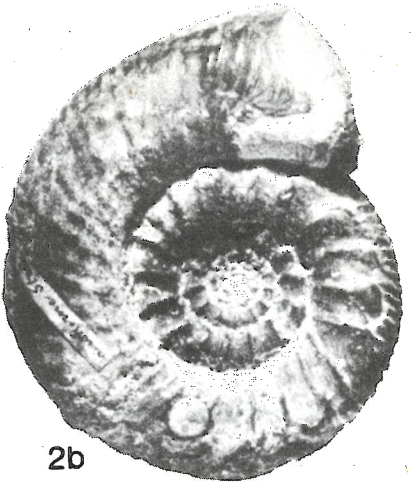
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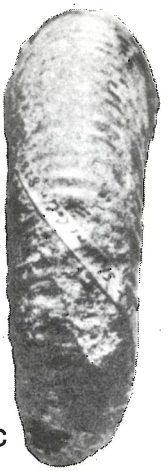
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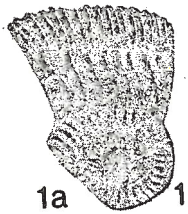
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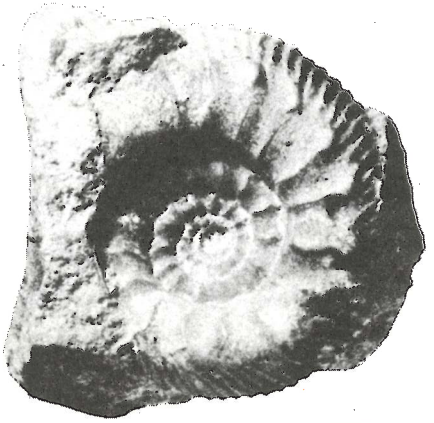
1b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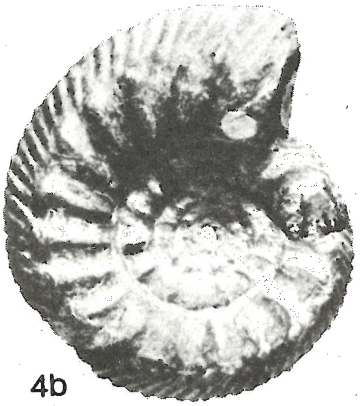
4a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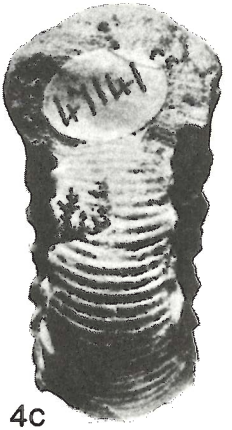


4c

STEPHANOCERAS AND EUROPEAN *ZIGZAGICERAS*

PLATE 4

STEPHANOCERAS AND PERISPHINCTIDAE

(All figures natural size)

Figures 1a-b.- *Stephanoceras* (*Stephanoceras*) "*undulatum*" Burckhardt [*nom. dub.*] holotype, complete body chamber from "*Stephanoceras* beds"? near Mixtepec (IGM 1916).

Figures 2a-c.- *Stephanoceras* cf. *orbignyi* (Buckman), phragmocone (latex cast) and full whorl body chamber; 2b, ultimate half-whorl of phragmocone in same orientation; from unknown locality in matrix of Taberna Formation (IGM 2812).

Figure 3.- ?*Leptosphinctinae* (or ?*Bigotitinae*) gen. et. sp. nov. A, "*Stephanoceras* cf. *Bigoti*" of Burckhardt; latex cast of developed natural external mould, possibly complete, from "*Stephanoceras* beds" near Mixtepec (IGM 1915).

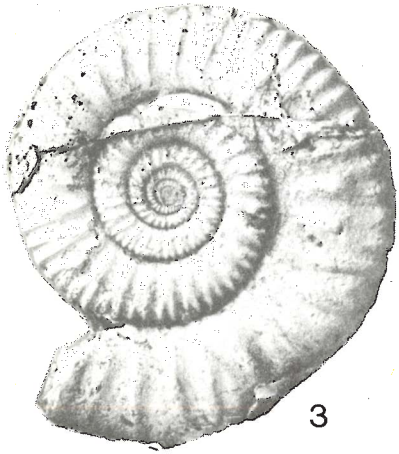
Figures 4-5b.- *Planisphinctes* (?) sp. nov. A.
"*Dactylioceras* sp. ind. Nos. 2, 3" of Burckhardt; casts of natural moulds, from "*Stephanoceras* beds" near Mixtepec (IGM 1914, 2121); latex cast from further developed mould.

Figure 6.- Perisphinctidae indet.
"*Stephanoceras* sp. ind. No. 2" latex cast of natural impression, from "*Stephanoceras* beds" *cf.* Duashnú (IGM 1923).

1a

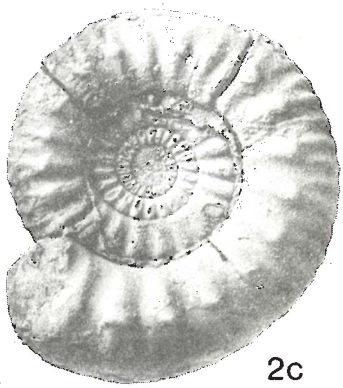
1b

2a



3

2b



2c

4

5a

5b

6

STEPHANOCERAS AND PERISPHINCTIDAE

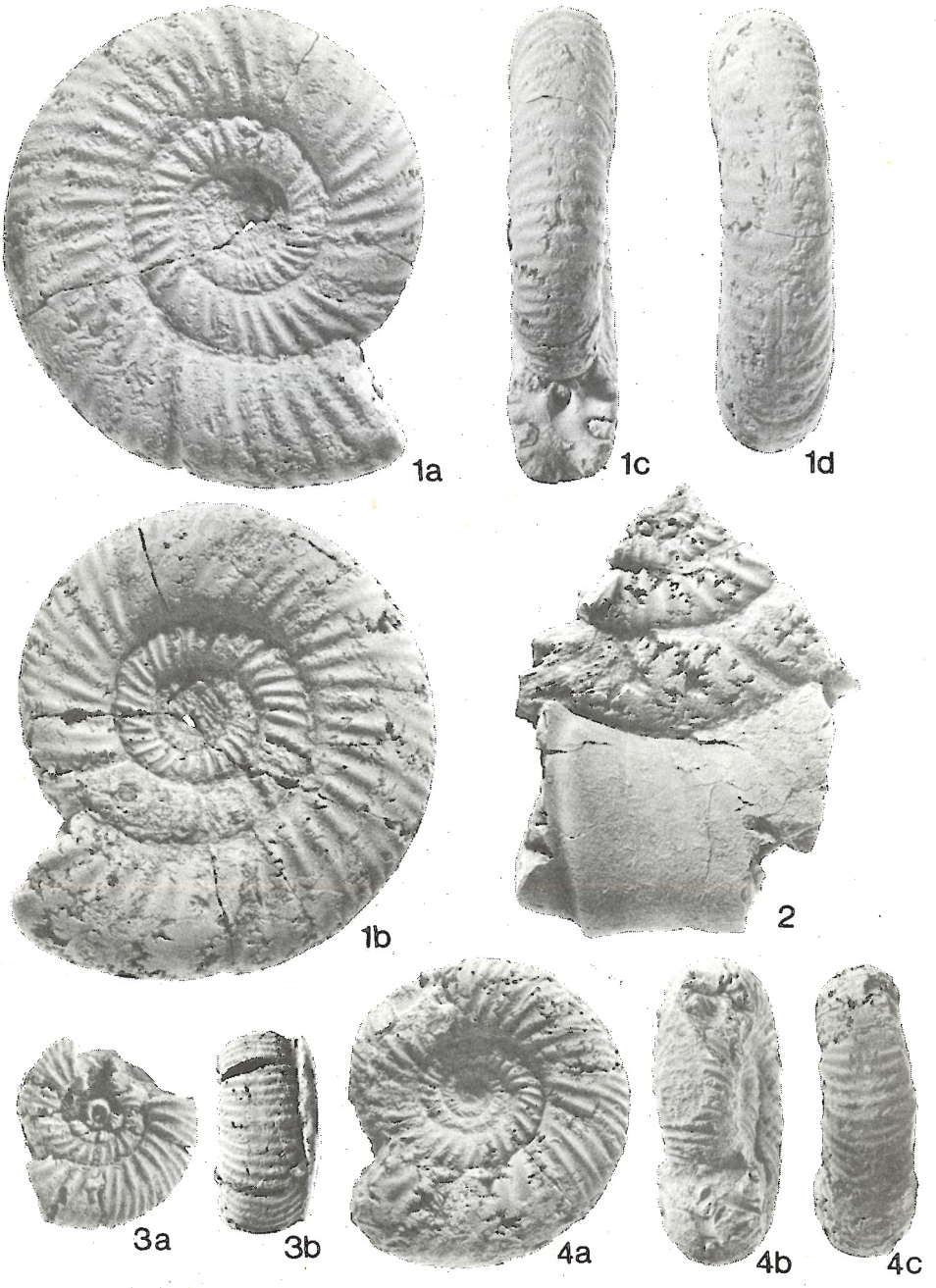
PLATE 5

LEPTOSPHINCTES

(All figures natural size)

Figures 1-4.- *Leptosphinctes tabernai* n. sp. from the *Parastrenoceras* association of the Taberna Formation near San Juan Diquiyú.

1a-d: Holotype (IGM 2798) fully septate internal mould from locality Ca-6.
2: Fragment of phragmocone and body chamber from locality Ca-7 (IGM 2799).
3a-b: Juvenile whorls from locality Ca-7 (IGM
4a-c: Fully septate internal mould from locality Ca-5 (IGM 2800).



LEPTOSPHINCTES

PLATE 6

LEPTOSPHINCTES

Leptosphinctes tabernai n. sp.

Complete specimen with damaged inner whorls, from the *Parastrenoceras* association of the Taberna Formation of locality GW-2, near San Juan Diquiyú (MeM. j 2042a), x 0.8.

LEPTOSPHINCTES

PLATE 7

LEPTOSPHINCTES

(All figures natural size)

Figures 1-3.- *Leptosphinctes tabernai* n. sp.
From the *Parastrenoceras* assemblage of the Taberna Formation near San Juan Diquiyú.

1a-b: Fully septate internal mould, from locality Ca-7 (IGM 2801).
2: Complete adult phragmocone, from locality Ca-4 (IGM 2802).
3a-b: Fully septate internal mould, from locality Ca-8 (IGM 2803).

1a

2

3a

3b

1b

LEPTOSPHINCTES

PLATE 8

LEPTOSPHINCTES

(All figures natural size)

Figures 1-4.- *Leptosphinctes tabernai* n. sp.
From the *Parastrenoceras* assemblage of the Taberna Formation near San Juan Diquiyú.

1a-b: Large adult phragmocone, from the locality Ca-10 (IGM 2804).

2a-4: Incomplete phragmocones, from locality Ca-4 (IGM 2805-06).

1a

1b

2a

2b

3a

3b

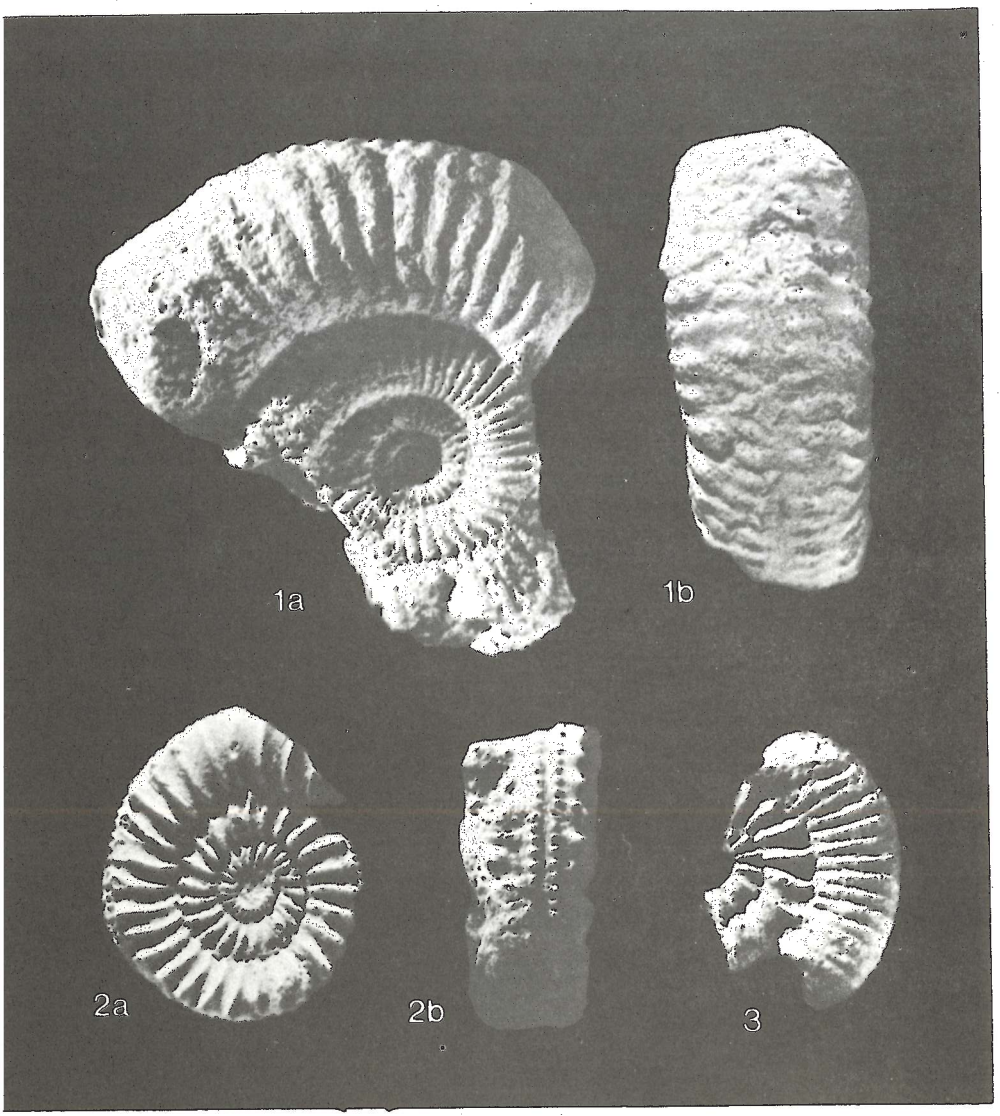
4

LEPTOSPHINCTES

PLATE 9

PARASTRENOCERAS

The holotypes of (1a, b) ***Parastrenoceras mixtecum***, (2a,b) ***P. tlaxiacense***, and (3) ***P. oaxacanum*** Ochoterena spp. (reproduced from Ochoterena, 1963).



PARASTRENOCERAS

PLATE 10

(?) *ZIGZAGICERAS*

(All figures natural size unless otherwise indicated)

Figures 1-5.- *Zigzagiceras* (*Duashnoceras*) *floresi* (Burckhardt), 0 & ♀

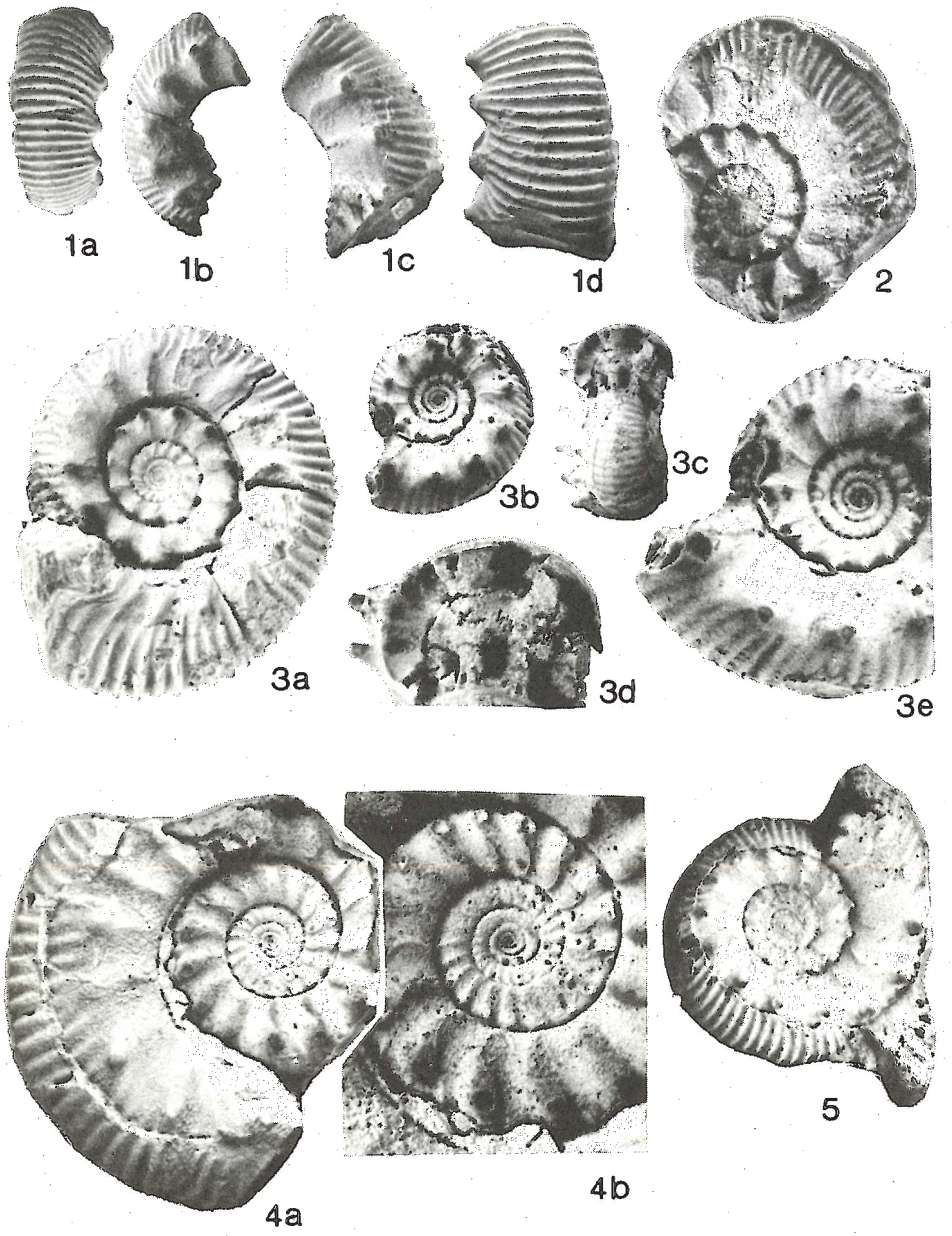
1a-d: Holotype (IGM 1920-21), two body chamber fragments said to come from single specimen, from "*Stephanoceras* beds" of Duashnú;

2: Original to "*Stephanoceras* aff. *Brodiaei* J. Sow." of Burckhardt (IGM 1919), plasticine cast of developed natural external mould, from "*Stephanoceras* beds" of Duashnú.

3a-e: Complete adult microconch, body chamber with latex impression of phragmocone external mould, from unknown locality but same preservation as specimens of Figures 1,2 (IGM 2813)b-c latex cast of phragmocone with (planulate) ultimate septum; d-e, part of same, x 2.

4a-b: Almost complete body chamber with latex impression of phragmocone natural external mould, from unknown locality like Figure 3 (IGM 2814); b, x 2.

5: Phragmocone latex impression of natural external mould, with fragment of body chamber from unknown locality like Figure 3 (IGM 2815).



(?) *ZIGZAGICERAS*

PLATE 11

(?) ZIGZAGICERATINAE

(All figures natural size)

Figures 1-2.- *Zigzagiceras* (*Duashnoceras*) *floresi* (Burckhardt), unknown locality, but in same preservation as Duashnú specimens.

1: Damaged body chamber with latex cast of phragmocone external natural mould, probable macroconch (IGM 2816).
2: First quarter whorl of body chamber with latex impression of phragmocone external mould, probable microconch (IGM 2817).

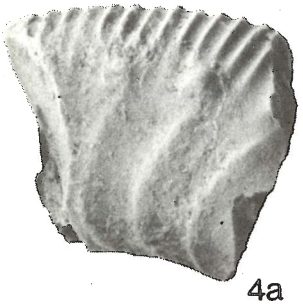
Figures 3a-(?7). Zigzagiceratinae *gen. et. sp. nov.* A.

3a-b: Incomplete internal mould of body chamber, from unknown locality like Figure 1 (IGM 2818).
4a-5: Fragment of body chamber, possibly macroconch, from unknown locality like Figure 1 (IGM 2819-20).
6: Original to "*Stephanoceras* aff. *psilacanthum* Behrendsen forma 2" of Burckhardt, wax impression of incomplete natural external mould, from "*Stephanoceras* beds" of Duashnú (IGM 2918).
7: Original to "*Dactylioceras* sp. indet No. 1" (IGM 1922) of Burckhardt, damaged wax impressions of incomplete natural external mould, from "*Stephanoceras* beds" of Duashnú.

1

3a

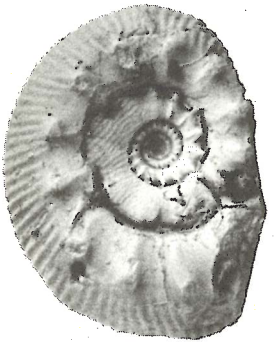
3b



4a

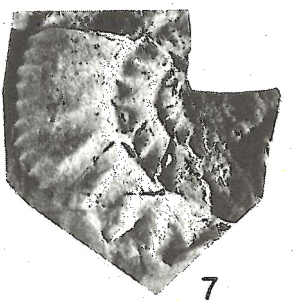
4b

5



2

6



7

(?) ZIGZAGICERATINAE

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