

FEDERICO OLÓRIZ, LILIANA LARA, ALEJANDRA DE LA MORA,
ANA B. VILLASEÑOR & CELESTINA GONZÁLEZ-ARREOLA

The Kimmeridgian/Tithonian boundary in the "Barranquito del Alacrán" section at Cuencamé (Durango, Mexico); its biostratigraphy and ecos- tratigraphic interpretation

ABSTRACT: The data obtained from a new section of the Upper Jurassic in the Mexican Altiplano, studied bed-by-bed, reveal the presence of a fauna of *Hybonoticeras*, the absence of *Mazapilites*, and the recorded FAD of *Subplanitoides siliceum* (QUENSTEDT), which together show that the Kimmeridgian/Tithonian boundary in this part of Mexico is not related to the FAD of *Mazapilites*. The taphonomic analysis, sedimentological observations and the control of macroinvertebrate assemblages permit the interpretation of the eco-sedimentary evolution in a low-energy, moderately shallow, and relatively proximal environment, which was confined at least to the lower waters. In this monotonous succession of siltstones, the ecostratigraphic analysis reveals difficulties for the recognition of a sequence boundary coinciding with the Kimmeridgian/Tithonian boundary, as considered in recent proposals of the sequence stratigraphy.

INTRODUCTION

One of the most remarkable characteristics of the copious paleontological information available on the Upper Jurassic in Mexico is the imprecise boundaries between the recognized biostratigraphic units. This situation is due to the almost total lack of data from sections studied bed-by-bed. This has, moreover, impeded progress in research on ammonites, improvement of correlations and, in general, the acquisition of updated knowledge on the evolution of the Upper Jurassic epicontinental basins in Mexico.

In this paper presented data have been obtained from the study of a section south of Cuencamé (Durango), in which an accurate biostratigraphic control was carried out by means of the collected ammonites. This research is part of the program begun by the authors in 1985 on the Upper Jurassic — Lower Cretaceous in central and northern Mexico.

THE SECTION STUDIED

The section examined is located to the east of the Durango state (*see* Text-fig. 1), 24°42'-24°43'N and 103°30'-103°31'W on the "Cuencamé" topographic sheet. On the ground (*see* Text-fig. 2) it is situated in a slight depression to which introduced herein is the informal name of "*Barranquito del Alacrán*" (in Spanish: "*A gully of scorpions*") because of the profusion of the poisonous Durango scorpion *Centruroides suffusus* Pocock. The outcrop forms a part of the southern extreme of the Palotes anticline, which contains a sedimentary succession considered by ENCISO DE LA VEGA (1968) to have intermediate characteristics between those of the La Caja and La Casita Formations. OLÓRIZ & al. (1988) recognized the relatively proximal character of the area during the Middle and Upper Kimmeridgian.

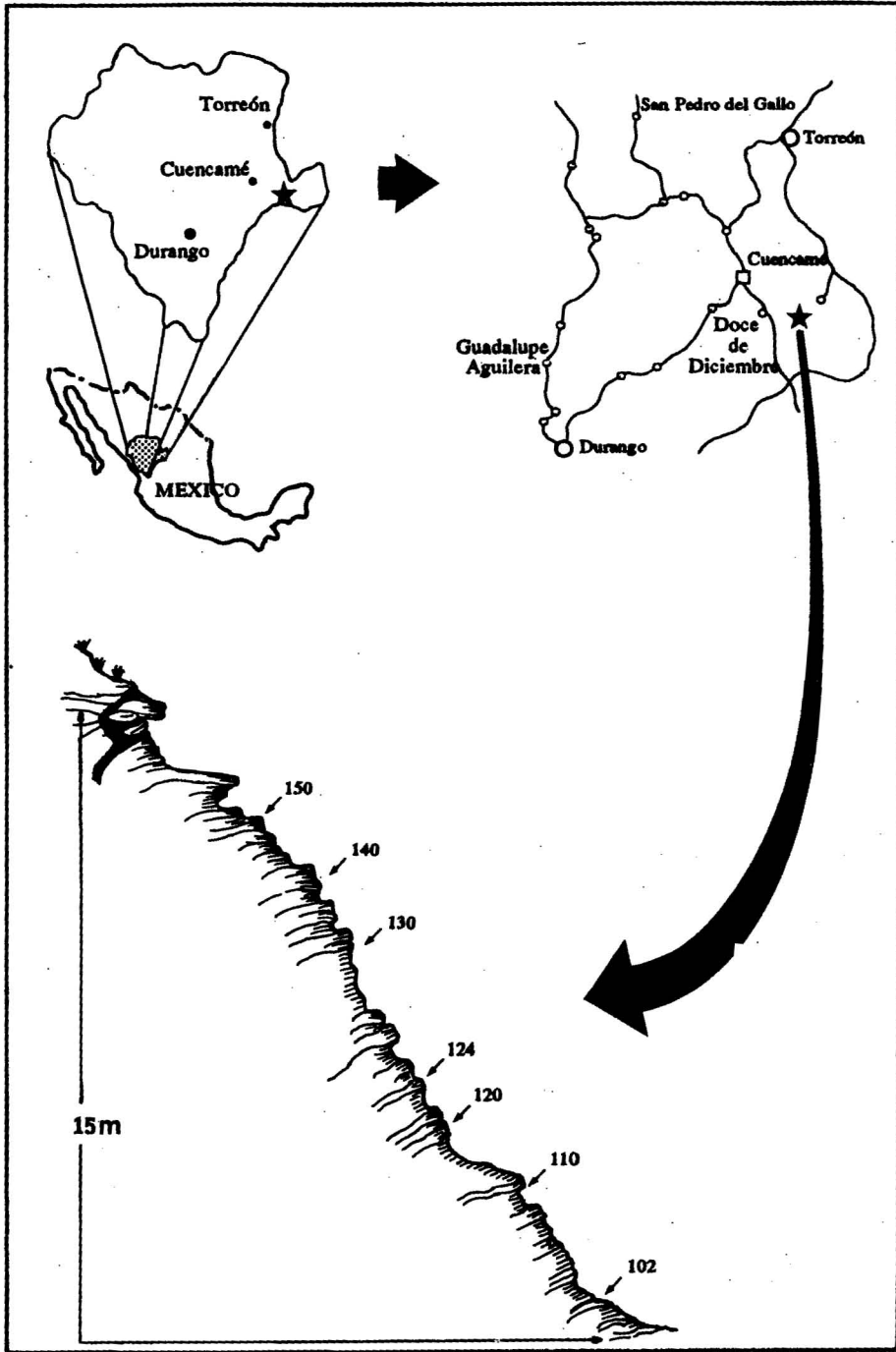
The succession studied is 15m thick and made up of pink siltstones intercalated by some "yellowish-ochre horizons" traditionally referred to as "gypsum-bearing intercalations" (*see* Text-figs 1-2). Stratification is fine in this monotonous succession, with irregularly spaced limonitic horizons and slightly more clayey intercalations being only just distinguishable. Carbonate concretions were recorded at beds 120 and 124. No sedimentary structures related to bottom currents were found. The boundaries of the succession were mainly determined by outcrop conditions. This was particularly true of the lower boundary, which could be related to a fracture zone reducing possibilities for precise correlation with other profiles studied in the area. The upper boundary was established in the last stratified interval, which has very scarce fossils and is soil covered.

The difficulty of individualizing decimetric beds required to make a selective sampling of the most favorable horizons for obtaining a minimum sample size of 50 specimens. Sampling interval is therefore not regular. Under these conditions the maximum thickness of the sampled intervals was not more than 20 cm.

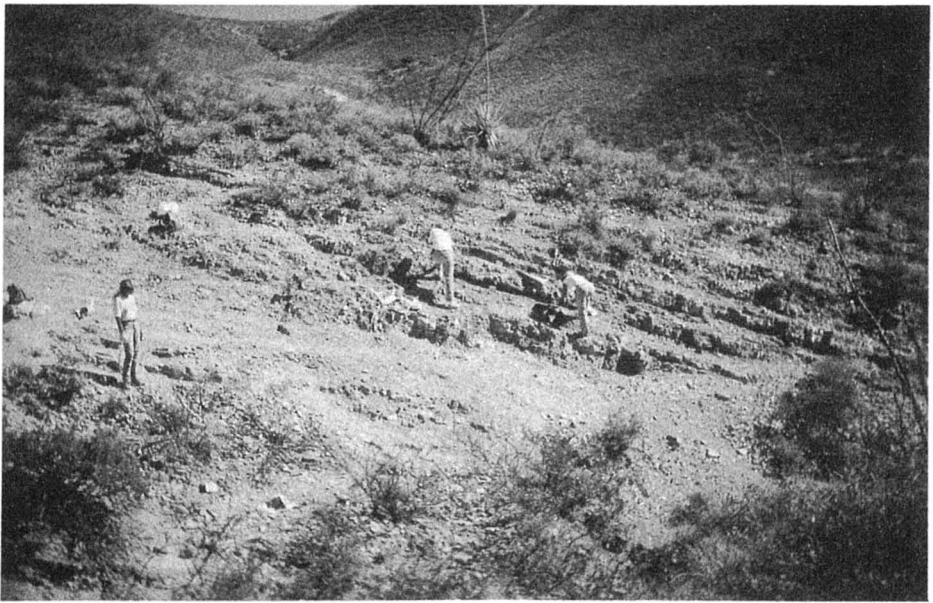
NOTES ON PRESERVATION AND TAPHONOMY

A total of 885 macroinvertebrate specimens was collected, made up almost exclusively of bivalves and ammonites. Preservation is restricted to internal casts with no evidence of individuals or fragments with the preserved shell.

The collected material is heavily compressed, but other types of deformation that could be related to reworking and redeposition of fossil remains are not common. Fractures are comparatively more frequent in the ammonites and are related to the collapse of the shell under sedimentary load, particularly in the unsculptured to almost smooth platycones (haploceratids). The most frequent fracture patterns are longitudinal and they are related to flattening of the



Location and schematic outcrop at the "Barranquito del Alacrán" (Cuencamé, Durango) in Mexico



Landscape at the “*Barranquito del Alacrán*” section showing the studied succession of siltstones belonging to the Lower Tithonian

outermost whorl on the inner whorls. This causes periumbilical and peripheral differential reliefs and, at times, reliefs on a flank zone corresponding to the ventral margin of the previous whorl. In the case of strongly sculptured specimens such as the hybonoticeratids, marginal crushing is especially marked by the basal parts of the spines, seen as circular pits in the internal cast. These circular marks are herein regarded as an effect of differential compression undergone by the carcasses before dissolution of aragonite and perhaps after a phase in which recrystallization would have irregularly affected the shell interior, and particularly such narrow structures as the hollow spines. Marks related to telescope fractures (see SEILACHER & *al.* 1976) were also observed in 40% of the haploceratids collected, which is significant for recognition of the position of the end of the phragmocone, since the suture line is not normally preserved. Other fractures observed had variable orientation (perisphinctids), some of them representing comparatively late stages of collapse and flattening. The near absence of expressive fracture patterns in the bivalves must be related to the greater resistance of their shells to fracturing.

Peristomal structures are frequently preserved in the haploceratids (50% approx.) and some hybonoticeratids, but not in the perisphinctids. Aptychi are frequent in the lower levels of the section, where haploceratids abound. They can be found inside the body chamber or close to the ammonite, but they never formed accumulations that were particularly impoverished in other fossil remains.

Due to limitations for preservation in siltstones, it is not easy to make detailed observation of bivalves and, therefore, it is hard to reliably evaluate the degree of disarticulation, although there is no doubt that disarticulated specimens must be present among the collected material. The presence of the Buchiidae, the Astartidae, and the Paralleodontidae is particularly noteworthy on the flanks and umbilicus of hybonoticeratids and some perisphinctids, whereas they are very scarce on haploceratids. Some preference in these bivalves for location on the ammonite phragmocones is recorded. Although a definitive interpretation cannot be made, since it has not been possible to analyze both flanks of a single ammonite, it is considered that the implantations observed on the ammonites are very probably due in part to cases of "stamping" of the bivalves (Astartidae, Paralleodontidae ?) on the ammonites as a result of compaction. Compression of the ammonites is in all cases coherent with this hypothesis, as too is the absence of any epizoans on them. Even so, not discounted is the possibility of cases of colonization by the Buchiidae, as opposed to "stamping". These could have occurred when alive or post-mortem, the latter preferentially on "benthic or shell islands" (see KAUFFMAN 1982, SEILACHER 1982), since no traces were observed that could be related to the existence of "epizoaires intrathalames" (see TINTANT 1980, 1983). The lower incidence of implantations on less well-floating and more easily buried ammonite shells (haploceratids) could support the hypothesis of colonizations of ammonite shells by byssate bivalves, such as buchiids, before the shells sank to the bottom.

According to the foregoing observations, it is considered that the recorded ammonite assemblages, in which there is a noticeable absence of shells with a high capacity for floating (globulose forms of REYMENT 1973), represent either autochthonous faunas, or faunas with very little post-mortem transport, especially the haploceratids and hybonoticeratids. As regards the perisphinctids, they probably underwent somewhat greater post-mortem transport, or their peristomal structures were more easily detached after death.

AMMONITE FAUNAS

One of the most outstanding characteristics of the recorded ammonite assemblages is the low diversity at the family/subfamily and the genus level. In fact, among the hundreds of specimens collected bed-by-bed, the only sub-

families identified, in order of relative abundance, are the Glochiceratinae HYATT, 1900, *sensu* ZIEGLER (1974); the Hybonoticeratinae OLÓRIZ, 1978; the Lithacoceratinae ZEISS, 1968, *sensu* TAVERA (1985); and the Haploceratinae ZITTEL, 1884, *sensu* ZIEGLER (1974). Diversity of the genera is similarly very low in the recognized subfamilies. At most two genera have been identified in each subfamily, with the exception of the last, but within the subfamily one of the two recognized genera was always clearly predominant.

SYSTEMATIC ACCOUNT

Superfamily **Haplocerataceae** ZITTEL, 1884

Family **Oppeliidae** DOUVILLÉ, 1890

Subfamily **Glochiceratinae** HYATT, 1900; *sensu* ZIEGLER, 1974

Genus *Glochiceras* HYATT, 1900

Subgenus *Lingulaticeras* ZIEGLER, 1958

Glochiceras (*Lingulaticeras*) sp. cf. *semicostatum* (BERCKHEMER, 1913)
(Pl. 1, Fig. 2)

1958. *Glochiceras* (*Lingulaticeras*) cf. *crenosum* (QUENSTEDT); B. ZIEGLER, p. 139, Pl. 13, Fig. 16.

1958. *Glochiceras* (*Lingulaticeras*) *semicostatum* BERCKHEMER; B. ZIEGLER, p. 159.

MATERIAL: About twenty more or less complete, small-sized (29-40 mm) specimens.

DESCRIPTION: The umbilicus is medium-sized (25-35%, exceptionally 40%). Although crushing is considerable, the umbilical edge can be recognized as rounded. Broad flanks with height of 30-47% approximately. When preservation is favorable, prorsiradiate and concave ribs can be seen on the outer part of the flanks. At times a poorly marked lateral channel can be recognized. The peristome has lappets and right-angled dorsal branches. No data on whorl section or suture line.

REMARKS: The state of preservation of a considerable amount of the material prevents its precise specific identification.

OCCURRENCE: Beds 96 to 110 in the "Barranquito del Alacrán" section (Cuencamé, Durango); Upper Kimmeridgian (Upper Eudoxus? — Beckeri Zone).

Glochiceras (*Lingulaticeras*) sp. cf. *contractum* (QUENSTEDT, 1848) — *planulatum* (BERCKHEMER, 1931)
(Pl. 1, Figs 3 and 5)

1848. *Ammonites lingulatus contractus*; F.A. QUENSTEDT, p. 130.

1887-88. *Ammonites lingulatus contractus* QUENSTEDT; F.A. QUENSTEDT, p. 1083, Pl. 125, Fig. 19.

1958. *Glochiceras* (*Lingulaticeras*) *contractum* (QUENSTEDT); B. ZIEGLER, p. 148, Pl. 14, Figs 14-16.

1958. *Glochiceras* (*Lingulaticeras*) *planulatum* BERCKHEMER; B. ZIEGLER, p. 146, Pl. 15, Figs 9-10.

MATERIAL: Twenty-nine small-sized (18-44 mm) individuals and fragments.

DESCRIPTION: Specimens are involute (20-36%) with slightly convex, generally smooth flanks, although very fine ribbing is occasionally observed. Lateral groove is more or less developed in the body chamber. No data on whorl section and ventral region. The peristome is frequently preserved and shows no distal expansion of the lappets.

REMARKS: More detailed analysis is difficult because of restrictions for preservation. Of the species from similar stratigraphic levels, *contractum* ZIEGLER is the closest because of its lightly sculptured shell and the type of peristome. Other more sculptured "species" are clearly different (*falcatoberosum* BERCKHEMER, *procurvum* ZIEGLER); while *solenoides* of QUENSTEDT develops highly characteristic distal expansion on the lappets. The species *G. (Glochiceras) lens* BERCKHEMER and *G. (G.) politulum* (QUENSTEDT) are morphologically close.

OCCURRENCE: Beds 98, 104, 105 and 110 in the "Barranquito del Alacrán" section (Cuencamá, Durango); Upper Kimmeridgian (Upper Eudoxus? — Beckeri Zone).

Family Haploceratidae ZITTEL, 1880; *sensu* ZIEGLER, 1974
Subfamily Haploceratinae ZITTEL, 1880; *sensu* ZIEGLER, 1974
Genus *Haploceras* ZITTEL, 1880

Haploceras sp.
(Pl. 1, Fig. 4)

DESCRIPTION: The specimen illustrated (Pl. 1, Fig. 4) is 42 mm in size with an umbilicus of about 16%. Fine, arched, prorsiradiate ribbing can be seen on the last part of the outer whorl. At smaller diameters the shell was basically smooth. No lateral channel is observed and it is thought that the body chamber occupies half of the last preserved whorl, as deduced from the fracture zone, which is usually located on the boundary between the phragmocone and the body chamber. No data on the suture line. The peristome is not preserved.

REMARKS: Although the peristome is not preserved, the absence of a lateral channel, the style of ornamentation and the structure of the shell with a small umbilicus distinguish this specimen of the genus *Haploceras* from those belonging to *Glochiceras* (*Lingulaticeras*), which when of the same size, are easily recognizable by the lateral channel and/or the elaborated peristome. Even the most involute species of *Glochiceras* (*Lingulaticeras*), such as *solenoides* QUENSTEDT and *planulatum* BERCKHEMER, normally developed some mid-flank structure occupying the place of the lateral channel, which is fairly typical in this subgenus (see ZIEGLER 1958).

The Mexican *Haploceras* studied by BURCKHARDT (1906) come from somewhat lower horizons. Of these the *transatlanticum*, *zacatecanum* and *cornutum* "species" are more evolute, and *felixi* presents better developed ribbing with more relief. The specimen described as "*Haploceras* sp. ind." by BURCKHARDT (1906, Pl. 24, Fig. 1) is morphologically similar, as too is the *castatum-ordonezi* group (see BURCKHARDT 1906, Pl. 25, Fig. 1 and Pl. 26, Figs 1-7). The closest and most stratigraphically compatible European form is *subeliratum* FONTANNES, but this is more evolute and thus compares better with the *transatlanticum*, *zacatecanum* and *cornutum* "species" mentioned above.

OCCURRENCE: Bed 98 in the "Barranquito del Alacrán" section (Cuencamé, Durango); Upper Kimmeridgian (Upper Eudoxus? — Lower Beckeri Zone).

Superfamily *Perisphinctaceae* STEINMANN, 1890
 Family *Aspidoceratidae* ZITTEL, 1895
 Subfamily *Hybonoticeratinae* OLÓRIZ, 1978
 Genus *Hybonoticerias* BREISTOFFER, 1947
 Subgenus *Hybonoticerias* BREISTOFFER, 1947

Hybonoticerias (Hybonoticerias) beckeri harpephorum (NEUMAYR, 1873)
 (Pl. 2, Fig. 4)

1873. *Aspidoceras harpephorum* NEUMAYR; M. NEUMAYR, p. 203, Pl. 39, Figs 4-5.

1873. *Aspidoceras beckeri* NEUMAYR; M. NEUMAYR, p. 202, Pl. 38, Fig. 4.

1879. *Waagenia harpephorum* NEUMAYR; F. FONTANNES, p. 85, Pl. 12, Fig. 2.

1906. *Waagenia* sp. ind.; C. BURCKHARDT, p. 103, Pl. 27, Fig. 5.

1915. *Waagenia harpephorum* (NEUMAYR); T. SCHNEID, p. 126, Pl. 6, Fig. 13.

1959. *Hybonoticerias beckeri harpephorum* (NEUMAYR); F. BERCKHEMER, & H. HÖLDER, p. 28, Pl. 4, Figs 14, 16.

1978. *Hybonoticerias (Hybonoticerias) beckeri harpephorum* (NEUMAYR); F. OLÓRIZ, p. 348, Pl. 31, Figs 4, 6; Pl. 32, Figs 1, 3.

1990. *Hybonoticerias* nov. sp. (*harpephorum/autaris* group); A. BENETTI, N. PEZZONI & A. ZEISS, Pl. 1, Figs 28-29.

DESCRIPTION: Incomplete specimen is featured by small size ($D=42$ mm), broad umbilicus (45%), and well defined umbilical wall due to the development of periumbilical tubercles. Ribs are very straight, radial and even slightly prorsiradiate. At larger diameters one or two ribs develop on the periumbilical tubercles, ending in an external tubercle, on which gentle prorsiradiate costae can appear. Some ribs with larger relief stand out on the inner whorls. The ventral groove is not observed, but its serrate edge is. No data on the peristome or the suture line.

REMARKS: BURCKHARDT (1906, p. 103) referred to the species *harpephorum* NEUMAYR on comparing his specimens of *Waagenia* from Puerto Blanco. However, the specimen compared by this author with *knopi* NEUMAYR is in fact closest to the European type of *harpephorum* NEUMAYR. The specimen studied herein, together with that of BURCKHARDT which is included into the synonymy, are really close to the types described by FONTANNES (1879) and BERCKHEMER & HÖLDER (1959, Pl. 4, Fig. 16). The juvenile specimen described by BENETTI & *al.* (1990) is also similar. The subspecies *Hybonoticerias beckeri harpephorum* (NEUMAYR) is an uppermost Kimmeridgian — lowermost Tithonian form according to BERCKHEMER & HÖLDER (1959) and OLÓRIZ (1978).

OCCURRENCE: Bed 120 in the "Barranquito del Alacrán" section (Cuencamé, Durango); Upper Kimmeridgian (Upper Beckeri Zone).

Hybonoticerias (Hybonoticerias) beckeri extraspinum BERCKHEMER & HÖLDER,
 1959
 (Pl. 2, Fig. 2)

1959. *Hybonoticerias beckeri extraspinum* n. subsp.; F. BERCKHEMER & H. HÖLDER, p. 2, Text-fig. 14; Pl. 4, Fig. 17.

1978. *Hybonoticerias (Hybonoticerias) beckeri extraspinum* BERCKHEMER & HÖLDER; F. OLÓRIZ, p. 353, Pl. 31, Fig. 5.

DESCRIPTION: Incomplete specimen is approximately 65 mm in diameter, with a wide umbilicus of about 46-49%. The umbilical wall is indistinct due to the gentle fall of the convex inner part of the flank on the anterior whorl. The periumbilical tubercles occupy a relatively high, characteristic position on the flank. The external tubercles are also prominent. There are no genuine ribs, but only the raised parts of the shell joining the tubercles of the inner and outer rows, this being better developed towards the inner whorls. Ventral groove, suture line and peristome were not observed.

REMARKS: Shell structure and ornamentation make this species easily distinguishable from the other known species of the genus. In comparison with the European forms, the specimen described presents a higher density of tubercles, which does not seem to be a valid criterion for its individualization. The *Hybonoticeras* specimens described from Mexico are clearly different. Only *Waagenia* cf. *hybonota* (OPPEL) of BURCKHARDT (1919-21, Pl. 4, Fig. 12) is closer, but its stratigraphic horizon is unknown and the periumbilical tubercles could be closer to the umbilical seam (deformation?). Both BERCKHEMER & HÖLDER (1959) and OLÓRIZ (1978) recognized *beckeri* *extraspinum* as occurring in the uppermost Kimmeridgian and lowermost Tithonian.

OCCURRENCE: Bed 127 in the "Barranquito del Alacrán" section (Cuencamé, Durango); Basal Tithonian (lower part of the Hybonotum Zone).

Hybonoticeras sp. gr. *beckeri* (NEUMAYR, 1873)
(Pl. 1, Fig. 6)

1873. *Aspidoceras beckeri* NOV. SP.; M. NEUMAYR, p. 202, Pl. 38, Fig. 3; Pl. 38, Fig. 4(?).
 1879. *Waagenia beckeri* NEUMAYR; F. FONTANNES, p. 83, Pl. 12, Fig. 1.
 1906. *Waagenia* sp.; C. BURCKHARDT, p. 103, Pl. 27, Figs 2-4; Pl. 27, Fig. 1(?); non Pl. 27, Fig. 5.
 1914. *Waagenia beckeri* NEUMAYR; T. SCHEIDT, p. 126, Pl. 6, Fig. 12.
 1931. *Waagenia beckeri* NEUMAYR; L.F. SPATHI, p. 648, Pl. 123, Fig. 1.
 1959. *Hybonoticeras beckeri* NEUMAYR; F. BERCKHEMER & H. HÖLDER, p. 26, Pl. 1, Figs 2-3; Pl. 4, Figs 13, 15.
 1960. *Hybonoticeras beckeri* NEUMAYR; H. CHRIST, p. 123, Pl. 9, Fig. 3.

MATERIAL: Over fifty small (< 68 mm), evolute (30-57%), incomplete specimens.

DESCRIPTION: The specimens display rounded umbilical edge and slightly sloping umbilical wall. The shell presents a H/D ratio of 27-51%. In the inner whorls the ribs are simple and fine. With ontogenetic growing ribs become sinuous and periumbilical and outer tubercles appear. Some geminate ribs are observed and also a variable tendency to weakening of the ribs towards the outermost whorls. Although limited preservation prevented the study of the ventral region, impressions and/or fragmented inner casts of ventral regions typical of the genus *Hybonoticeras*, with a ventral groove limited by beaded keels, are discernible. No data on the whorl section, suture lines or peristomes.

REMARKS: Excluding the species described above, the incomplete nature of the collected specimens and their small size do not permit identification of different species in the *Hybonoticeras beckeri* group as considered by OLÓRIZ (1978). The recognized characteristics prevent assignation to *Hybonotella*. The presence of rib ornamentation permits clear differentiation as regards *Hybonoticeras pressulum* (NEUMAYR).

The collected material is considerably equivalent to that studied by BURCKHARDT (1906) from the regions of Mazapil (Zacatecas) at Puerto Blanco and in the Cañon del Aire.

OCCURRENCE: Beds 104 to 135 in the "Barranquito del Alacrán" section (Cuencamé, Durango); Upper Kimmeridgian (Beckeri Zone) — lowermost Tithonian (lower part of the Hybonotum Zone).

Subgenus *Hybonotella* BERCKHEMER & HÖLDER, 1959
Hybonoticerias (Hybonotella) sp.
 (Pl. 2, Fig. 6)

DESCRIPTION: Small specimen (35 mm) with broad umbilicus (47%). The umbilical wall is low and there is practically no umbilical edge. Ornamentation consists of simple ribs with prominent, pointed external ends. These ribs are radial or slightly rursiradiate and number 30-33 in the last whorl. In some cases the ribs tend to join together at the base of the flank, but no tubercles developed. No data on section or suture line. Only the proximal extreme of the peristome can be recognized by a narrow angle of the anterior edge of the shell before the last rib. Peristomal structure is preceded by flexure of the last three ribs.

REMARKS: The presence of the peristome and the structure of the shell identify this specimen as belonging to *Hybonotella*. It is distinguished from *H. mundulum* (OPPEL), which is the closest known species, by the persistence of ribbing up to the vicinity of the peristome, and also by denser and more conspicuous ribbing. Other known species of *Hybonotella* are clearly different. The species *Hybonotella mundulum* (OPPEL) has been found in the uppermost Kimmeridgian and the base of the Tithonian, according to BERCKHEMER & HÖLDER (1959) and OLÓRIZ (1978).

PLATE I

Ammonites from the "Barranquito del Alacrán" section (Cuencamé, Durango);
 all in natural size

1 — *Glochiceras (Lingulaticeras)* sp.; specimen No. IGM-6179

Note longitudinal fractures around the periphery and the umbilical shoulder, and small bivalves (Corbiculidae?) indicated by arrows; uppermost Kimmeridgian — lowermost Tithonian

2 — *Glochiceras (Lingulaticeras)* sp. cf. *semicostatum* (BERCKHEMER); specimen No. IGM-6180

Note special collapse at the phragmocone-body chamber boundary and a rather wide spaced sculpture in the anterior part of the body chamber; bed 98, Upper Kimmeridgian (Upper Eudoxus? — Lower Beckeri Zone)

3 — *Glochiceras (Lingulaticeras)* sp. gr. *contractum* (QUENSTEDT) — *planulatum* (BERCKHEMER); specimen No. IGM-6181

Note a small lamellaptychus near the peristome, long lappets without distal enlarging, and telescope fractures (arrowed) at the phragmocone-body chamber boundary; bed 98, Upper Kimmeridgian (Upper Eudoxus? — Lower Beckeri Zone)

4 — *Haploceras* sp.; specimen No. IGM-6182

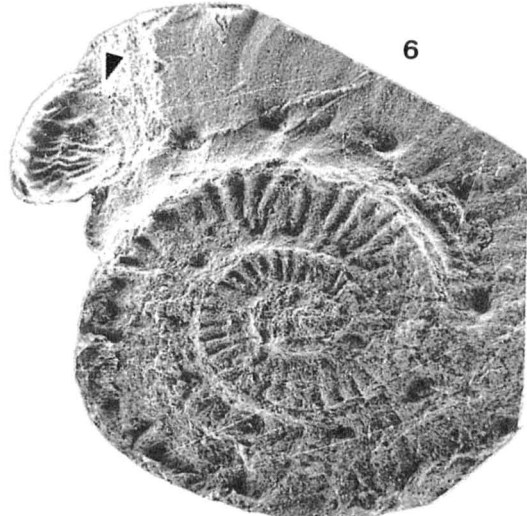
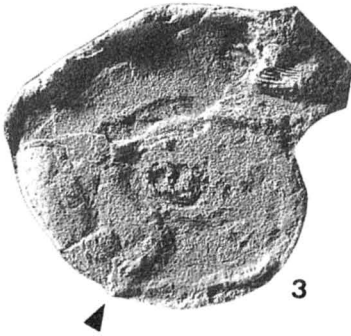
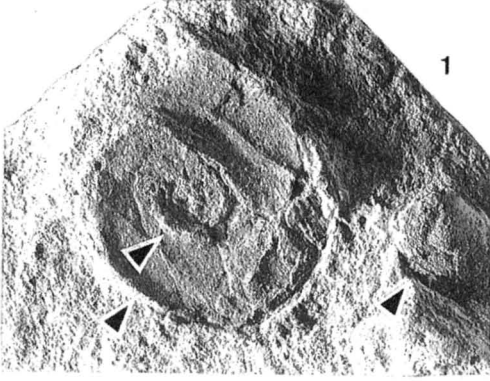
Inner cast with removed rear half of the body chamber and collapse structures around the end of the phragmocone; bed 98, Upper Kimmeridgian (Upper Eudoxus? — Lower Beckeri Zone)

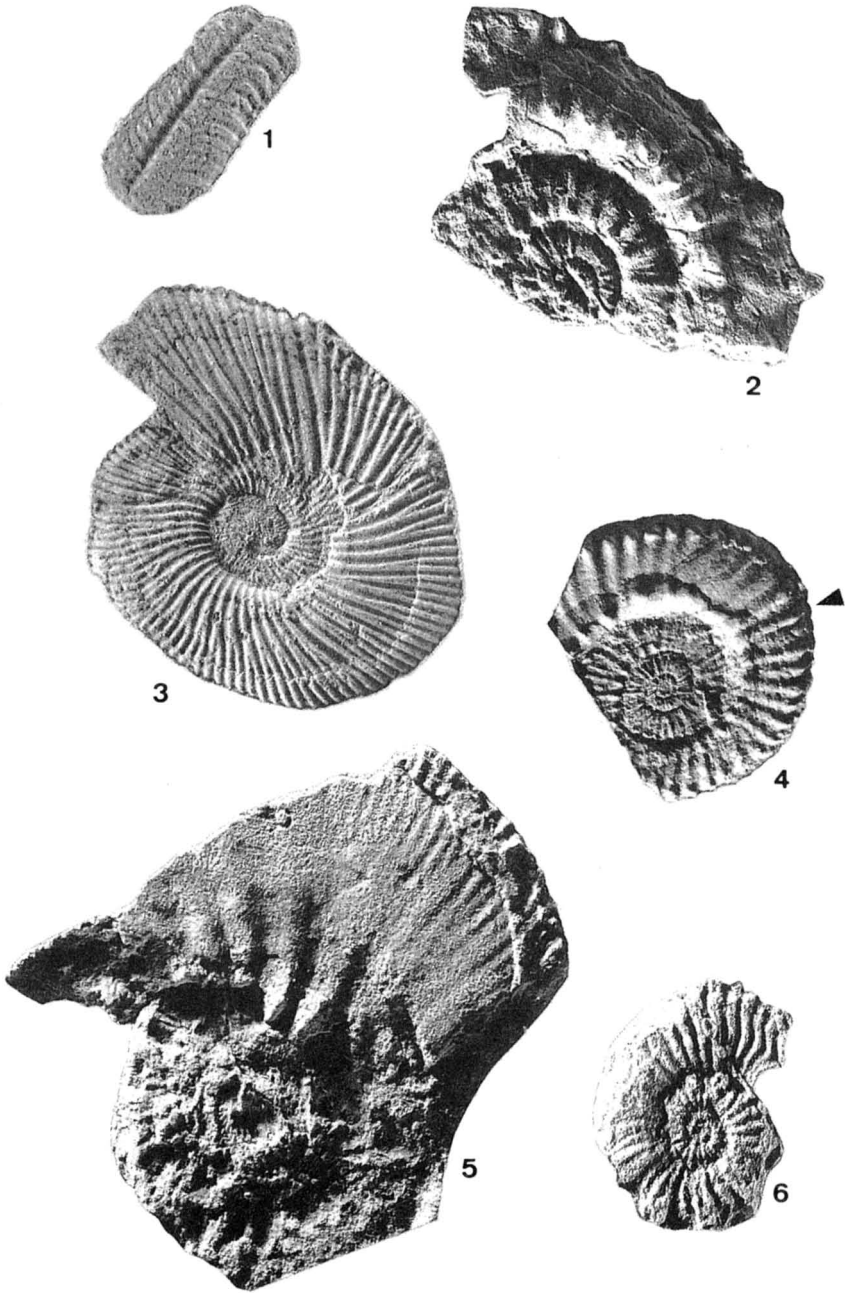
5 — *Glochiceras (Lingulaticeras)* sp. gr. *contractum* (QUENSTEDT) — *planulatum* (BERCKHEMER); specimen No. IGM-6183

Note lateral groove on the body chamber, elaborated peristome without distal enlarging of lappets, and differential collapse of the body chamber; arrow indicates the umbilical fracture close to the steep umbilical shoulder; bed 100, Upper Kimmeridgian (Upper Eudoxus? — Lower Beckeri Zone)

6 — *Hybonoticerias (Hybonoticerias)* sp. gr. *beckeri* (NEUMAYR); specimen No. IGM-6184

Outer half a whorl preserved in negative imprint and showing ornamental weakness; note small bivalve (Parallelodontidae?) "stamped" close on the inner cast of the shell; bed 126, lowermost Tithonian (Lower Hybonotum Zone)





OCCURRENCE: Bed 122 in the "Barranquito del Alacrán" section (Cuencamé, Durango); uppermost Kimmeridgian (upper part of the Beckeri Zone).

Family Ataxioceratidae BUCKMAN, 1890
Subfamily Lithacoceratinae ZEISS, 1968; *sensu* TAVERA, 1985
Genus *Subplanitoides* ZEISS, 1968; *sensu* OLÓRIZ, 1978

Subplanitoides siliceum (QUENSTEDT, 1858)
(Pl. 2, Fig. 3)

1858. *Ammonites planulatus siliceus* QUENSTEDT; F.A. QUENSTEDT, p. 775, Pl. 95, Fig. 27.
1887. *Ammonites planulatus siliceus* QUENSTEDT; F.A. QUENSTEDT, p. 1073, Pl. 125, Figs 2-5.
1914. *Perisphinctes siliceus* QUENSTEDT; T. SCHNEID, p. 115, Pl. 6, Fig. 6.
1959. *Perisphinctes siliceus* (QUENSTEDT); F. BERCKHEMER & H. HÖLDER, p. 41, Pl. 14, Figs 69-70; Pl. 16, Fig. 73.
1968. *Usseliceras (Subplanitoides) siliceum* (QUENSTEDT); A. ZEISS, p. 64, Pl. 4, Fig. 1.
1990. *Usseliceras (Subplanitoides) siliceum* (QUENSTEDT); F. CECCA, p. 43, Pl. 1, Fig. 2.

MATERIAL: Seven small-sized specimens and fragments (60-65 mm).

DESCRIPTION: The umbilicus is 30-34% wide, the umbilical edge is rounded and the umbilical wall is moderately developed. The whorl section cannot be observed because of the crushing of the material analyzed. Ribbing is fine, dense and somewhat prorsiradiate in the inner whorls. Covering of the outermost preserved whorl does not permit observation of the rib divisions in the inner whorls, but it should consist exclusively or predominantly of bifurcations with not very divergent secondary ribs (isocostate type of ENAY 1966, and OLÓRIZ 1978) as seen in most of the outer whorl. Division points are located around the middle of the flanks. Some polygyrate, subpolyplocoid and polyplocoid ribs are observed in the last preserved whorl. There are narrow constrictions, slightly oblique to the preceding ribbing, so that false polygyrate ribs may occur. No data on the peristome or suture line.

PLATE 2

Ammonites from the "Barranquito del Alacrán" section (Cuencamé, Durango);
all in natural size

1 — Ventral region of *Hybonotoceras* sp. showing the ventral groove; specimen No. IGM-6185; bed 124, lowermost Tithonian (base of the Hybonotum Zone)

2 — *Hybonotoceras (Hybonotoceras) beckeri extraspinum* BERCKHEMER & HÖLDER; specimen No. IGM-6186

Note comparative large-sized tubercles with the periumbilical row located far from the umbilical seam, and raised shell connecting elements of the two rows in the inner whorls; bed 127, lowermost Tithonian (Lower Hybonotum Zone)

3 — *Subplanitoides siliceum* (QUENSTEDT); specimen No. IGM-6187

Partially crushed specimen with isocostate ribbing, with some polyplocoid/subpolyplocoid ribs, and narrow constriction in the outer preserved whorl; bed 126, lowermost Tithonian (Lower Hybonotum Zone)

4 — *Hybonotoceras (Hybonotoceras) beckeri harpephorum* (NEUMAYR); specimen No. 6188

Note probable, but poorly preserved traces of suture lines towards the end of the phragmocone (arrowed); bed 120, uppermost Kimmeridgian (Upper Beckeri Zone)

5 — *Lithacoceras* sp.; specimen No. IGM-6189

Incomplete and poorly preserved specimen with typical sculpture for macroconchiate Ataxioceratidae (*Lithacoceras* or *Usseliceras*); bed 126, lowermost Tithonian (Lower Hybonotum Zone)

6 — *Hybonotoceras (Hybonotella)* sp.; specimen No. IGM-6190

Almost complete specimen with elaborated peristome; bed 122, uppermost Kimmeridgian (Upper Beckeri Zone)

REMARKS: This species is well known in the lowermost Tithonian in Europe and regroups small forms with fine ribbing that are scarcely differentiated by development of polygyrate ribs. Since the inflexion of the ribs around the same height of the peristome (coinciding approximately with the height of the division points) is characteristic in the last quarter whorl, it is considered that slightly less than half a whorl is missing in the specimens described here. The group of forms similar to *Pseudodiscosphinctes ardescicus* (FONTANNES) presents no inflexion of ribs on the flank and their ornamentation is slightly weaker. There are no comparable illustrations of Mexican material from the same biostratigraphic horizons. The fragments of macroconchiate specimens collected at the same horizons present signs of evolution towards periumbilical tuberculation at equivalent diameters.

OCCURRENCE: Beds 124, 126, 130, 140, and 150 in the "Barranquito del Alacrán" section (Cuencamé, Durango); lowermost Tithonian (lower part of the Hybonotum Zone).

Genus *Lithacoceras* HYATT, 1900; *sensu* OLÓRIZ, 1978

Lithacoceras sp.

(Pl. 2, Fig. 5)

DESCRIPTION and REMARKS: Eleven incomplete specimens showing the particular attributes of the macroconchiate of the subfamily Lithacoceratinae as considered here, *i.e.*, a more or less accentuated, unmistakable trend to reinforcement of the primary ribs on the umbilical edge and weakening of ribbing on mid-flank of the outer whorl. The defective preservation prevents the obtention of parameters defining the shell and also means that any possible rib indexes are not reliable. There is no doubt that these forms should present "isocostate" rib-style in the inner whorls and a variable trend toward subpolyplacoid and fasciculate ribs in the outer whorl. For the foregoing reasons these forms must be referred to as *Lithacoceras* sp. in the broad sense.

At least partial presence of the genus *Usseliceras* can not be discounted, but *Lithacoceras* with marked weakening of ornamentation and short, reinforced primary ribs are known to exist in comparable stratigraphic levels; some of these forms are *Lithacoceras ulmensis* (OPPEL) forma *fascifera* (NEUMAYR) and *Lithacoceras* cf. *pubescens* (SCHNEID), illustrated by BERCKHEMER & HÖLDER (1959, Pl. 11, Figs 52-53 and 55). Other macroconchiate Lithacoceratinae can be easily differentiated.

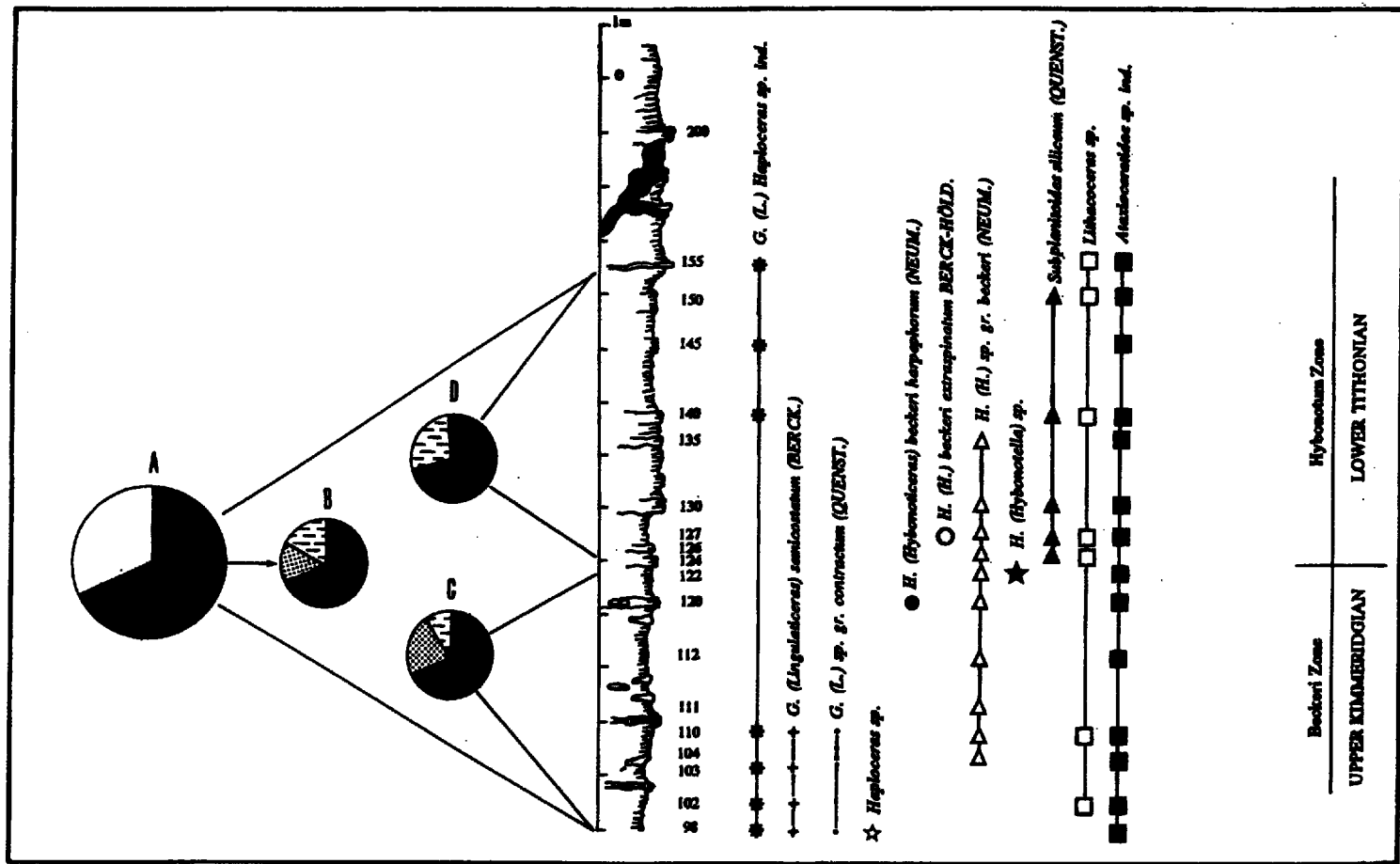
No comparable material has been found among the forms depicted by BURCKHARDT (1906, 1912, 1919-21).

OCCURRENCE: Beds 102, 110, 124, 126 and 140 in the "Barranquito del Alacrán" section (Cuencamé, Durango); uppermost Kimmeridgian (Upper Eudoxus? — Beckeri Zone) — lowermost Tithonian (lower part of the Hybonotum Zone).

CHRONOLOGY

According to the ammonites recognized, it is easy to admit that the section studied represents a time interval around the Kimmeridgian/Tithonian boundary. As is the case of other Upper Jurassic boundaries in Mexico, this boundary had not previously been biostratigraphically characterized. As recently analyzed by OLÓRIZ & *al.* (1992), the interval containing *Hybonotoceras* in Mexico has been accurately assigned to the uppermost Kimmeridgian

Lithologic column with averaged faunal spectra, ammonite distribution and chronostratigraphy at the "Barranquito del Alacrán" section



— lowermost Tithonian by IMLAY (1984), OLÓRIZ & *al.* (1990b, 1992) and OLÓRIZ (1992). On the other hand, BURCKHARDT (1906b, 1930), IMLAY (1939), CANTU (1971), CONTRERAS & *al.* (1988) gave more or less heterodox interpretations of the Kimmeridgian and Tithonian (Portlandian for some of these authors) stages and zonal boundaries are in none of these cases based on precise biostratigraphic data from bed-by-bed sampling.

Although recognition of Mexican forms related to the *Hybonoticer* *beckeri* (NEUMAYR) group is basically correct since BURCKHARDT (1906b), reference to forms close to the *Hybonoticer* *hybonotum* (OPPEL) group by BURCKHARDT (1919-21, 1930) and IMLAY (1939) is more problematic. The small size and incomplete nature of the specimens, together with the lack of precise biostratigraphic data, mean that such interpretations cannot be considered completely reliable. Analysis of associated fauna in sections studied bed-by-bed is therefore necessary for an up-to-date biostratigraphic interpretation.

In the “*Barranquito del Alacrán*” section (Cuencamé, Durango), diversification of the ammonite fauna accompanying *Hybonoticer* is exceptionally low and, according to the data obtained, it could be said largely to be mutually exclusive (*see* Text-fig. 3). In fact, it was only possible to identify five different taxa other than *Hybonoticer* out of a total collection of about three hundred specimens, and fragments, with a state of preservation such as to permit interpretation at least at the genus or family/subfamily level in the least favorable cases. The haploceratids such as *G. (Lingulaticer)* sp. cf. *semicostatum* (BERCKHEMER), *G. (L.)* sp. gr. *contractum* (QUENSTEDT) and similar forms, and the lithacoceratins such as *Lithacoceras* (and *Usseliceras* ?) sp., *Subplanitoides siliceus* (QUENSTEDT) and similar forms, are the only ammonites that can be used to improve a detailed biostratigraphic interpretation of the collected *Hybonoticer*. Of the species mentioned, only *Subplanitoides siliceus* (QUENSTEDT) provides the most reliable information, if we accept that its stratigraphic distribution in Mexico was sufficiently “isochronous” with that known in Europe for its correlation to be significant. The QUENSTEDT’s species has usually been assigned to the lowermost Tithonian (QUENSTEDT 1887-1888; BERCKHEMER & HÖLDER 1955, 1959; ZEISS 1968).

This permits to interpret that the first appearance datum (FAD) of *Subplanitoides siliceus* (QUENSTEDT) in bed 124 of the section studied marks the beginning of the Tithonian. The *Hybonoticer* sp. gr. *beckeri* (NEUMAYR) record in higher beds does not contradict this hypothesis, according to the distribution of forms of this group in southern Spain (OLÓRIZ 1978).

The overall absence of *Mazapilites* in the section studied is particularly important. Only a poorly preserved fragment found between beds 140 and 145 could possibly be interpreted as belonging to this genus. Given that *Mazapilites* has been observed in association with *Hybonoticer* at Symón, Durango (BURCKHARDT 1919-21; and unpublished observations by the authors since 1985), it may be said that this association takes place above the first records of

Subplanitoides in association with *Hybonoticerias*, at least in the section studied. Consequently, the FAD of *Mazapilites* permits recognition of the lower part, but not the very base, of the Tithonian (*i.e.*, the base of the Hybonotum Zone).

FAUNAL ASSEMBLAGES AND ECOSTRATIGRAPHIC INTERPRETATION

The recorded macroinvertebrates assemblages are made up of bivalves and ammonites. Study of the bivalves is just beginning and forms have been identified belonging to the Buchiidae, Astartidae, Arcticidae, Pholadomyidae, Lucinidae, Corbiculidae, Oxytomidae and Posidoniidae families. In other words, the presence of suspension feeders from different trophic levels is recognized (*e.g.*, Oxytomidae, Buchiidae, Astartidae, Lucinidae), although those of low and middle level predominate (*e.g.*, Buchiidae, Astartidae, Arcticidae, Corbiculidae), and the epifauna and shallow infauna appear to be better represented than the more specialized infauna, according to the hypotheses of STANLEY (1970), HALLAM (1976), FÜRSICH (1981, 1982, 1984), and PEDERSEN (1985). As mentioned above, the degree of disarticulation cannot be determined with certainty, but it can be accepted that some of the components of the bivalve assemblages recorded could have undergone some transport.

A remarkable feature of the recorded ammonite assemblages is the low diversity and the absence of components, such as the tolerant Phylloceratidae (*Sowerbyceras*) and the Aspidoceratidae, which are usually present in sediments of the same age in other parts of the world. Apart from the low diversity, another noteworthy feature is the quasi-exclusive relation between the Haplocerataceae and the Perisphinctaceae (mainly *Hybonoticerias*) according to the record obtained. This is interpreted as an evidence of a decidedly reduced ecospace, in which the evolution of the ammonite record shows a case of ecological replacement that can be related to a previous deterioration in life conditions for ammonites.

An overview of the eco-sedimentary system can be obtained by analyzing the ratio of bivalves to ammonites in the sedimentary and taphonomic context described above (Text-fig. 3). The total faunal spectrum shows 69.3% bivalves to 30.7% ammonites, divided into 13.3% Haplocerataceae and 17.4% Perisphinctaceae. If the total faunal spectrum is then subdivided and comparison made of the spectra belonging to the Upper Kimmeridgian and the lowermost Tithonian, we find confirmation of the stability of the bivalve record (68% in the Beckeri Zone and 70.2% at the base of the Hybonotum Zone), and the substitution of the Haplocerataceae by the Perisphinctaceae at the beginning of the Tithonian. The high amount of bivalves undoubtedly indicates a proximal, non-deep environment, even admitting that a certain but not exactly determined low percentage of bivalves could have undergone some transport. This is acceptable if we consider that taphonomic analysis of the ammonites allows to

conclude that there was no significant reworking of their remains after accumulation (frequent preservation of delicate structures such as peristomes and aptychi practically *in situ*), and that any post-mortem displacement was no doubt brief (absence of "intrathalames" epizoans and of unequivocal colonizations of floating shells). In addition to the lack of evidence of energetic currents affecting the sea-floors, the preservation of sedimentary lamination in fine grain deposits containing no trace fossils indicates poor oxygenation inside the substratum.

It is therefore concluded that around the Kimmeridgian/Tithonian boundary the section studied formed part of a relatively proximal, low energetic and hydraulically confined environment, at least at bottom level. The "yellowish-ochre" intercalations recorded in beds 110b-112, 130 and 145 of the studied section are particularly interesting, since only bivalves and no ammonites were recorded. These crises in the ammonite record seem to be equivalent to those studied in nearby sectors by OLÓRIZ & *al.* (1988), who correlated them with possible inflows of continental waters according to the isotopic record. If we accept this, the image of a proximal environment, definitely disconnected from open seas and sporadically subjected to continental influence (presence of plant remains in nearby sections) seems compatible with the record of low diversity ammonite assemblages representing populations subjected to an *r*-type ecological strategy. In a confined ecospace for ammonites, ecological replacement was a dynamics of local occupation during the interval studied.

Interpretation of the studied section in terms of sequence stratigraphy is not easy. The lithological column does not present significant changes and perhaps only sets of less clayey levels can be distinguished higher in the section (beds 120-124 and, especially 130-140). The "yellowish-ochre" intercalations mentioned above, which are related to crisis in the cephalopod record, are located inside comparatively more marly intervals. In this context, we interpret the lithological expression of the transgressive peaks in relation to the recurrent less clayey intervals, which, moreover, correlate well with the trends towards recuperation of the cephalopod record, although they do not correspond to the maxima of the ammonite record. The fluctuations in the eco-sedimentary environment can therefore be recognized, but, typically, an exact parallelism cannot be established between the traces of the changes in the two interacting systems.

At present there are basically two proposals concerning interpretation of the interval containing *Hybonoticerias* in the cycle charts based on the model of sequence stratigraphy. HAQ & *al.* (1987, 1988) and MARQUES & *al.* (1991) consider that this interval corresponds to an interval of highstand deposits (*i.e.*, the Transgressive and Highstand System Tracts), so that it would not include any sequence boundary except, possibly, in the uppermost part of the Hybonotum Zone or around the Hybonotum-Darwini/Albertinum Zone boundary. On the other hand, PONSOT & VAIL (1991) and PONSOT-JACQUIN (1992) suggest that

the Kimmeridgian/Tithonian boundary would correspond to a sequence boundary.

According to the proposed hypothesis of eco-sedimentary reconstruction, it is remarkable that in a relatively proximal environment are found no sufficiently expressive traces of a sequence boundary as this is understood in sequence stratigraphy. The faunal replacements indicate ecological changes (ecospace fluctuations), but the packages of set-beds seem more easily interpreted as turnovers at parasequence level. This hypothesis agrees well with the relation between thickness and temporal range analyzed in the section studied, in the unequivocal context of an epicontinental environment. In this section, as in others studied in the Mexican altiplano, there are no combinations of facies changes and macroinvertebrate assemblage changes to permit recognition of a sequence boundary in the terms proposed by the sequence stratigraphy.

Departamento de Estratigrafía y
Paleontología
e Instituto Andalus de Geología
Mediterránea (CSIC),
Facultad de Ciencias,
Universidad de Granada,
18002 Granada, Spain

(F. Olóriz)

Departamento de Paleontología,
Instituto de Geología, UNAM,
040510 Mexico D.F., Mexico

(L. Lara, A. de la Mora,
A.B. Villaseñor
& C. González-Arreola)

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