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## New micropalaeontological studies on the type section of the Campanian-Maastrichtian at Tercis (SW France): new ostracodes obtained using acetolysis

Bernard ANDREU <sup>1</sup>

Gilles Serge ODIN <sup>2</sup>

**Abstract:** Through the use of acetolysis new micropalaeontological studies on the type section of the Campanian-Maastrichtian boundary at Tercis (SW France) we obtained additional information on ostracodes. Acetolysis on hard carbonates levels of the Tercis quarry found 22 species in addition to those of the studies published in 2001. Today, 75 species are recognized: they represent 34 known genera, and 4 currently unidentified. Small species usually rare of the genera *Aversovalva*, *Bythoceratina* and *Eucytherura* were collected. All of the assemblages (of both genera and species) are characteristic of a Campanian-Maastrichtian open carbonate platform environment.

**Key Words:** Ostracodes; Campanian; Maastrichtian; stratotype; Tercis; Aquitaine; France; acetolysis.

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**Résumé :** *Nouvelles études micropaléontologiques sur le stratotype de la limite Campanien-Maastrichtien à Tercis (SO France) : compléments sur les ostracodes extraits par acétolyse.*- Une nouvelle étude de la microfaune, obtenue par acétolyse des niveaux indurés dans le Campanien-Maastrichtien de la carrière de Tercis, a permis de récolter 22 espèces additionnelles au regard de l'étude publiée en 2001 et de porter ainsi à 75 espèces, réparties sur 34 genres reconnus et 4 indéterminés, la biodiversité en ostracodes de ce site. Des espèces de petite taille, généralement rares, rapportées aux genres *Aversovalva*, *Bythoceratina* et *Eucytherura* ont par ailleurs été recueillies. Les associations de genres et d'espèces d'ostracodes sont caractéristiques du Campanien-Maastrichtien, dans un environnement de plate-forme carbonatée ouverte.

**Mots-Clefs :** Ostracodes ; Campanien ; Maastrichtien ; stratotype ; Tercis ; Aquitaine ; France ; acétolyse.

### 1. Introduction

The stratotype section of the Campanian-Maastrichtian boundary at Tercis (Landes, France) was accepted in 2001 (ODIN & LAMAURELLE, 2001) following an extensive integrated study (ODIN, 2001a) including the documentation of 18 fossil groups illustrated in the second work and later in ODIN *et alii* (2006). This well-known section (Fig. 1) was an appropriate choice for the better establishment of the palaeobiodiversity of Upper Cretaceous deposits, at a time when dinosaurs were the top of the biological pyramid just before the Cretaceous-Palaeogene global crisis.

Among the possible ways to arrive at a better knowledge, it was suspected that an intensive study directed particularly at the indurated strata comprising the larger portion

of the Tercis series (Figs. 2-3) would be profitable. In 2001 the study of microfossils, with the exception of the investigation by thin section of planktonic foraminifera, was restricted to the easily disaggregated levels: those richest in clay. At Tercis, the clay content of these levels reached a maximum of 15 % (ODIN, 2001c). However, from the environmental point of view, these levels indicate an input of detritus which could influence the development of micro-organisms. The practical selection of the more clayish levels might have discriminated those organisms more tolerant to this detrital input and eliminated those requiring clean waters. This was why we attempted to dissociate rocks using more or less concentrated acetic acid at different temperatures.

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**Figure 1:** Aerial view of the geological site at Tercis (southern Aquitaine). North is located toward the top; strata are vertical; the Campanian levels are in the South followed to the North by those of the Maastrichtian, then the Danian. The quarry front, to the East/right, is made up of 5 platforms, 170 m wide, perpendicular to the strata, and moved along 400 m during quarrying (picture G.S.O., February 1997).

We obtained a satisfying disaggregation of the hard rocks in most of the levels investigated. Picking of the several size fractions of the resulting sands led to the obtention of new forms of previously investigated fossil groups as well as to the discovery of a number of previously unknown forms: microproblematica apparently needing clean waters (ODIN & LETHIERS, 2006; ODIN, 2007; ODIN *et alii*, 2007). Bryozoans, holothurian, crinoid and ophiuroid remains, benthic and planktonic foraminifera, ... will be studied later, we hope. The present work reports only the information obtained concerning ostracodes: previously unreported taxa of these microfossils were found and the distribution of known forms was made more nearly exhaustive.

## 2. Frame of the study

### 2.1. Geological section

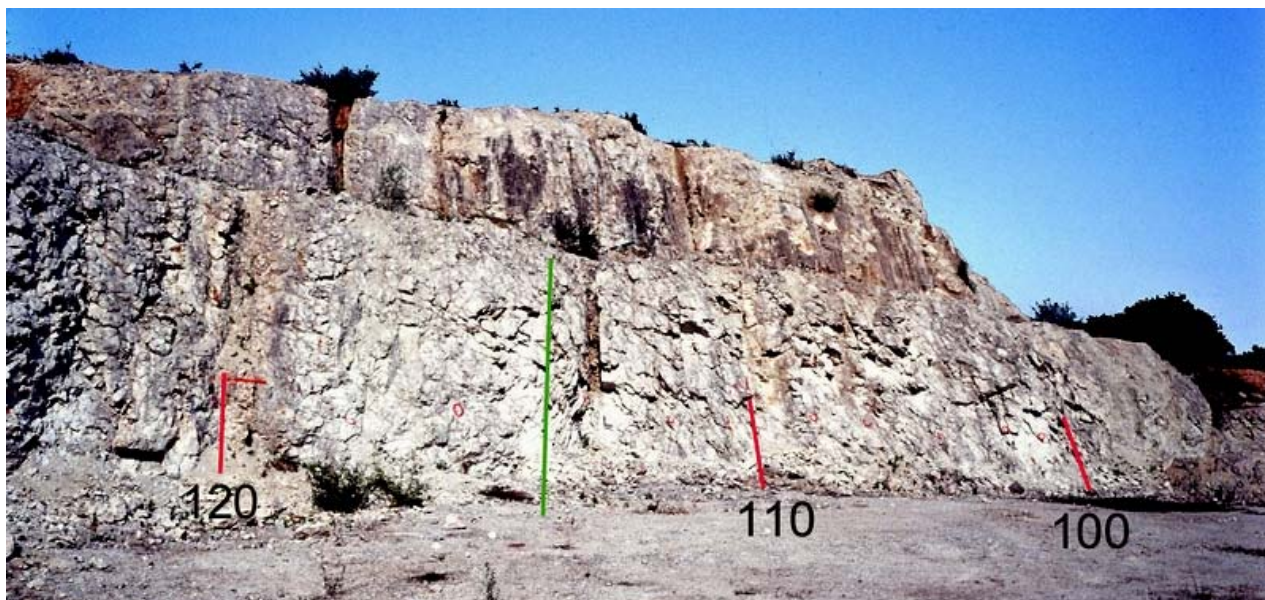
The stratotype section of the Campanian-Maastrichtian boundary is defined in the Grande Carrière at Tercis which was quarried until 1997. Tercis is located in the Landes near Dax, in southern Aquitaine, France, about 10 km north of the first North Pyrenean Thrusts (ROCHER, 2001). A continuous section about 200 m thick was described (ODIN & ODIN, 1994). It is 8 Ma of deposits bracketing the Campanian-Maastrichtian boundary which is conventionally sited at level 115.2 in accordance with an original approach: this convention involves the use of a combination of 12 biostratigraphical signals pertaining to 6 fossil groups contiguous

to a guide event selected by convention (ODIN, 2001b; ODIN & LAMAURELLE, 2001). The homogeneous lithology of the section is shown on Figure 4 which identifies 3 units. The d'Avezac Unit is a series of limestones of which the 5 sub-units (A1 to A5) are distinguished according to their respective content of glaucony (glaucony: facies as opposed to glauconite: mineral according to ODIN & MATTER, 1981) that alternates between very low and high. The Les Vignes Unit includes a sub-unit with light flint (V1) below and a sub-unit with dark flint (V2) above. The lithological column indicates the presence of glaucony (dotted) and of flint; flints are commonly concentrated in levels of dm thickness with a metric periodicity. The numerical ages are suggested according to 1- magnetostratigraphic and biostratigraphic correlations with radiometrically dated bentonite levels in the United States (LEWY & ODIN, 2001), 2- a uniformity in the rate of sedimentation is supported by the measurable (metric) periodicity of the deposits (orbital in origin), 3- the combination of this consistency with the examination (presence, abundance, and crystallinity) of glauconitic minerals (ODIN & AMOROSI, 2001). The age of the boundary suggested in 2001 is improved in accordance with recently established Europe-America correlations using inoceramids (ODIN & WALASZCZYK, 2003). The ages indicated alongside the column are estimates based on acceptance of 71.6 Ma as the date of the boundary with an uncertainty of  $\pm 0.6$  Ma (confidence level 95 %).





**Figure 2:** View of platform II, levels 5 to 30, the main outcrop of the Tercis geological site (southern Aquitaine). Carbonate strata are vertical (level 20.0 shown) with a few decimeter-thick marly horizons (picture G.S.O., July 1992).



**Figure 3:** View of platform III, levels 95 to 120, of the main section of the geological site at Tercis (southern Aquitaine). The Campanian-Maastrichtian boundary is shown (green). The flint-bearing strata display marls with low clay content near levels 97 and 118 (picture G.S.O., July 1992).

## 2.2. Previous results

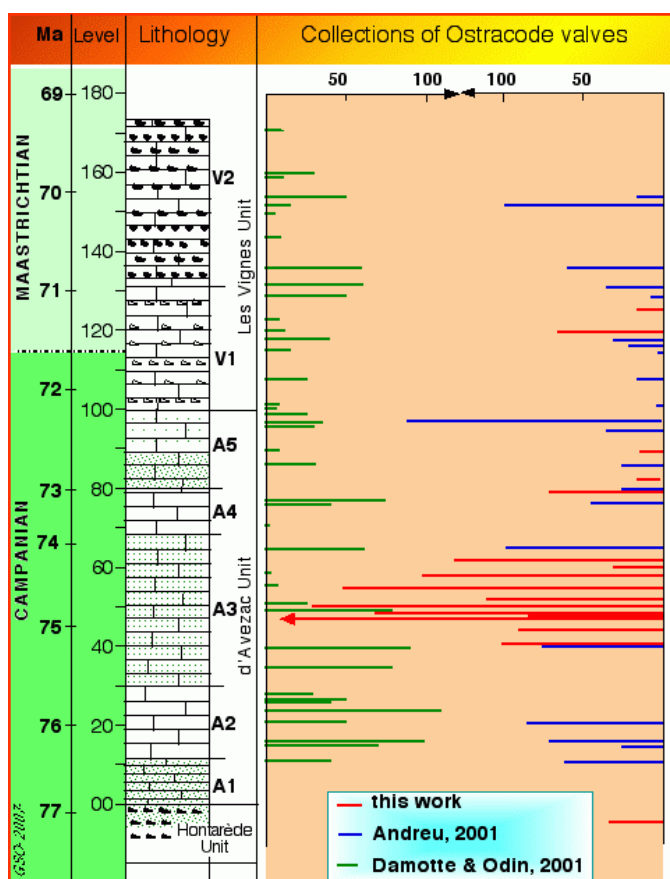
Figure 4 summarizes the quantitative results obtained in 2001 (DAMOTTE & ODIN, 2001; ANDREU, 2001). The first represents the collection of 1800 specimens (from about 45 levels) and the second, 2500 specimens (from 28 levels). A synthetic report (ANDREU & ODIN, 2001) cited 53 species pertaining to 28 known and 3 unidentified genera. All the genera mentioned were known from the Upper Cretaceous of Europe (mainly from north-western Europe due to the fact that few studies of the Aquitaine Basin existed) and, secondarily, from North Africa. About ten species known from NW Europe or other areas

in Europe have also been found in North America and on the southern margin of the Mediterranean. The conclusion was that no endemism existed in the North Pyrenean appendix of the Atlantic Ocean, the domain where Tercis was thought to have been located during the Late Cretaceous.

## 3. Results

### 3.1. New sampling

Acetolysis was employed first on sub-unit A3 of the d'Avezac Unit where *Radotruncana calcarata* (CUSHMAN, 1927) occurs; this is a recognized and precise biostratigraphical marker used by the experts on Upper Cretaceous



**Figure 4:** Ostracodes collected from the Tercis section. Previous collections by one of us (B.A.: blue, G.S.O.: green) were made from washed residues; the number of collected specimens was rarely more than 100 either single valves or complete shells (see scale to the top) per level. The new methods of collection used in this study (red bars, G.S.O.) were successful between levels 40 and 60.

planktonic foraminifers. From 100 to 200 g of treated sample 200 or more specimens of ostracodes were collected from a few levels (Fig. 4). Acetolyzed samples from the bottom of the quarry, between levels -5 and +25 produced no more fauna than water-washed sediments from those levels so they have not been extensively hand-picked and processed. Between levels 95 and 170 the fauna was meager and poorly preserved so few levels have been investigated. In all, about 1700 valves were collected from 15 selected levels, and these were considered for illustration and identification during the present study. Figure 5 illustrates some interesting forms observed using an optical microscope; they are pictured because we had not seen them in the boundary stratotype before.

The collected shells and valves are made fragile by the acetic acid treatment and are sometimes difficult to collect and picture. Their surface is commonly partly dissolved and the ornamentation poorly preserved; specimens obtained from water-washed residues were also poorly preserved.

### 3.2. Short description of genera, list of species

Diagnoses of the genera, as accepted by the authors, were given in the previous publications on the Campanian-Maastrichtian boundary stratotype at Tercis (DAMOTTE & ODIN, 2001; ANDREU, 2001). Although they might be open to question these diagnoses are necessary in order to inform the reader how and why the forms were segregated and named. The new names are proposed here and our interpretation of the genera is presented below. Generic identifications are based on external morphological characters of the shell; internal characters are not available. The previously identified genera are not described again.



**Figure 5:** Optical microscope views of valves obtained using acetolysis. Top: internal ventral view and external profile of a left valve of *Bythoceratina* sp. 1 (Pl. 3, figs. 33-34); bottom left: external profile and internal ventral views of a right valve of a representative of the genus *Bythoceratina* collected from level 57.9; bottom right: *Eucytherura* (*Vesticytherura*) *dorsotuberculata*: external and internal profile views of a right valve from level 57.9.



Species added to those in the 2001 publications are illustrated (see Appendix list of species), and the documentation of two previously described species is supplemented.

- *Asciocythere* SWAIN, 1952: middle-sized carapace, ovate-triangular in side view, with indistinct angles in lateral view; both ends rounded, turned toward the ventral margin; left valve overlapping all the way around the right; carapace smooth to punctate.

- *Cardobairdia* BOLD, 1960: small- to middle-sized carapace, generally thick, sub-elliptical and smooth; anterior end regularly rounded and turned toward the ventral margin; posterior end rather acuminate; left valve overlaps the right all the way around and more conspicuously on the dorsal and ventral margins.

- *Paracyprideis* KLIE, 1929: middle-sized carapace, sub-elliptical to triangular in lateral view; anterior end regularly rounded, rather turned toward the ventral margin, posterior end triangular near the ventral margin; some denticles or spines on the ends; highest before mid-length; surface generally smooth except when bored with wide pores.

- *Eucytherura* MÜLLER, 1894: small-sized carapace, rhombic to square in lateral view; dorsal margin straight, ventral margin rounded; anterior end widely rounded, posterior end triangular, with caudal process turned to the dorsal margin; eye spot on the antero-dorsal angle; tuberculate or reticulate surface.

- *Pterygocythere* HILL, 1954: triangular carapace in lateral view, inflated ventrally, with a strong posteriorly pointed alae in prolongation of the anterior flange, sometimes broken into a row of spines; acuminate posterior margin; surface smooth with some spines or tubercles; costa on the dorsal margin; distinct eye spot; sometimes with spines on the anterior and posterior ends; inflated ventral face with longitudinal costa; simple primary ornament; thick and robust carapace.

- *Diogmopteron* HILL, 1954: identical in all external morphological features to *Pterygocythere*, with the exception of the hinge (not distinct here); the right valve overlaps the left on the dorsal margin of *Diogmopteron*, this character is the opposite on *Pterygocythere* (not distinct on our individual).

- *Rehacythereis* GRÜNDEL, 1973: carapace triangular to rectangular in lateral view; anterior end regularly rounded, posterior end triangular; anterior flange connected with the ventral costa ended with a postero-ventral tubercle; independent dorsal costa, that ends with a postero-dorsal tubercle, and connected with a narrow costa running to the well-marked sub-central tubercle; surface reticulate; right valve overlaps the left particularly on the antero-dorsal angle.

- Genus indet. (Pl. 2, figs. 22-26): large-sized carapace, sub-rectangular; large frontal lobe; eye-spot on the antero-dorsal angle; anterior margin regularly rounded overtaking the ventral margin; posterior end triangular with concave dorsal margin and convex, rather spinely, ventral margin; discrete independent dorsal and ventral costa; indistinct sub-central tubercle; carapace inflated laterally; the left valve overlaps the right on the antero- and postero-dorsal angles; surface smooth, sometimes with granulation.

#### 4. Variety, distribution, and environmental information

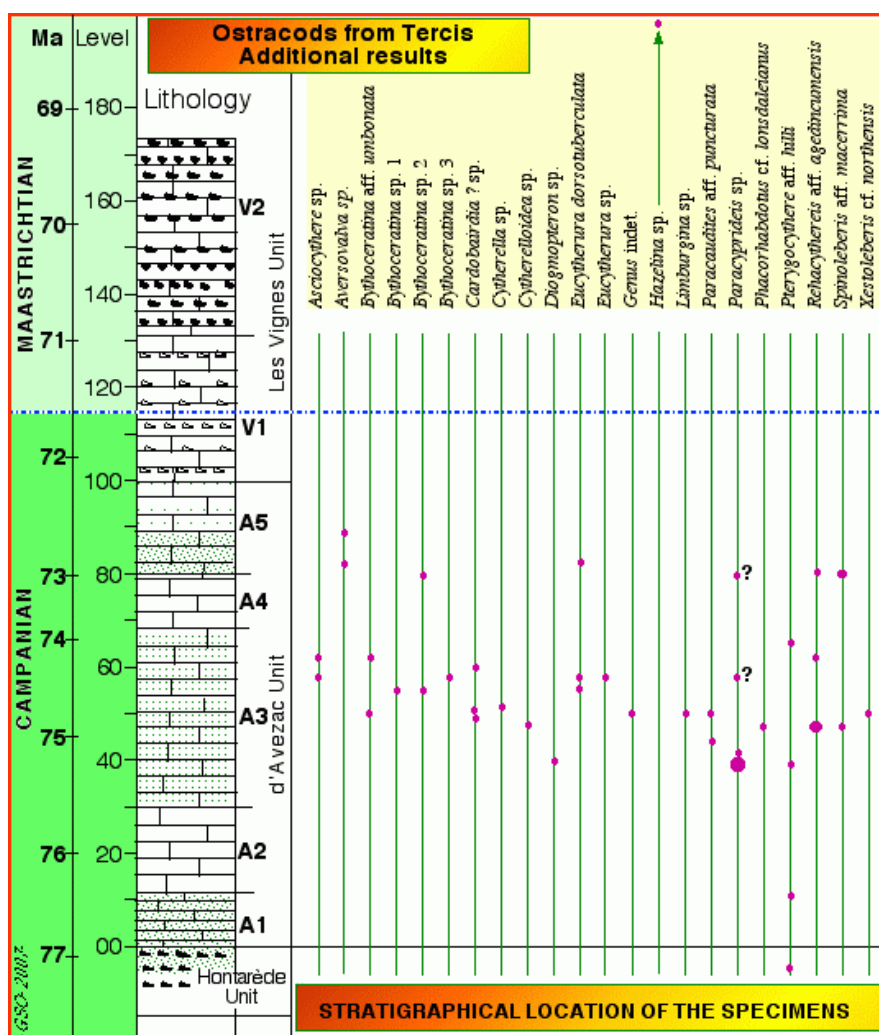
During the study preliminary to the designation of the boundary stratotype (ANDREU, 2001; ANDREU & ODIN, 2001; DAMOTTE & ODIN, 2001) 53 species of ostracodes were listed. Here, we supplement this first evaluation with 22 additional species. Thus, as a whole the ostracode fauna of the Campanian-Maastrichtian at Tercis comprises a total of 75 species pertaining to 34 known genera, including the 7 additional entities quoted in this work, and 4 non-identified genera. Disaggregation of the hard carbonate levels using acetolysis aided greatly in the discovery of species of the small genera *Aversovalva*, *Bythoceratina*, and *Eucytherura*. These minute specimens are comparatively rare and may often pass unnoticed in washed residues.

We have identified and named 8 species in this work, among them, 3 are cf. and 4 are aff.. The list is as follows: *Eucytherura* (*Vesticytherura*) *dorsotuberculata* (VAN VEEN, 1936), *Phacorhabdotus* cf. *lonsdaleianus* *lonsdaleianus* (JONES, 1849); *Xestoleberis* cf. *northensis* DEROO, 1966, *Bythoceratina* cf. *umbonata umbonata* (WILLIAMSON, 1848), *Paracaudites* (*Dumontina*) aff. *puncturata* (BOSQUET, 1854), *Pterygocythere* aff. *hilli* KEIJ, 1957, *Rehacythereis* aff. *agedincumensis* (DAMOTTE, 1964), *Spinoleberis* aff. *macerrima* (VAN VEEN, 1936).

The stratigraphical locations of the taxa identified in the present study are given in Figure 6. *Eucytherura* (*Vesticytherura*) *dorsotuberculata* is known from the upper Campanian of Dordogne, SW France, the upper Campanian-Palaeocene-Eocene? of Poland, the upper Campanian-Maastrichtian of Germany, the lower Maastrichtian of Belgium and the Netherlands, the Maastrichtian of Denmark (full references in COLIN, 1973, and CLARKE, 1983). *Phacorhabdotus lonsdaleianus lonsdaleianus* is reported from the upper Campanian-Maastrichtian of England, the upper Campanian of the Paris Basin in France, the Campanian-Maastrichtian of Germany, the lower Maastrichtian of Poland, the Maastrichtian of Belgium, the Netherlands, and Denmark (full references in CLARKE, 1983). *Xestoleberis northensis* is known from the upper Campanian-

Maastrichtian of Belgium and the Netherlands, the middle Campanian of Dordogne and the upper Campanian of the Paris Basin and the Charentes, SW France (full references in COLIN, 1973). *Bythoceratina umbonata umbonata* - sensu CLARKE (1983) - is a Campanian-Maastrichtian species: upper Campanian of Belgium, Campanian-Maastrichtian of Poland, lower Maastrichtian of the Netherlands and Denmark, Maastrichtian of Germany, Upper Cretaceous of England and Ireland (full references in COLIN, 1973, and CLARKE, 1983). *Paracaudites* (*Dumontina*) *puncturata* is collected from the Campanian of Dordogne and Charente, France (COLIN, 1973; BABINOT *et alii*, 1985), and the Maastrichtian of the Netherlands and Belgium

(DEROO, 1966). *Pterygocythere hilli* - sensu CLARKE (1983) - is known from the middle Santonian to the lower Campanian of Germany. The species is also known from the Eocene of Belgium and the Netherlands (CLARKE, 1983). *Rehacythereis agedincumensis* is dated Santonian-Campanian in the Paris Basin (DAMOTTE, 1964; BABINOT *et alii*, 1985); the species (or a closely related one, given the discrete stratigraphical location) is also quoted from the upper Cenomanian-lower Turonian of Corbières, S France (ANDREU & BILOTTE, 2006). *Spinoleberis macerrima* (VAN VEEN, 1936) is known from the Maastrichtian of the Netherlands (DEROO, 1966) and the Campanian of Aquitaine (*Spinoleberis* cf. *macerrima* in COLIN, 1973).



**Figure 6:** Location of the specimens documented in this paper. Species Genus indet. sp. (synonym of *Mauritsina* sp.) was documented in ANDREU (2001); *Rehacythereis* aff. *agedincumensis* is a synonym of *Spinoleberis* sp. 1 documented by ANDREU (2001); other taxa are new at the Tercis geological site.

The presence of these additional species confirms the stratigraphical location of the ostracode faunal associations of the Campanian-Maastrichtian. Accordingly, it appears that when compared with the fauna of the Atlantic ocean at this time no endemism exists at Tercis, then sited within a north Pyrenean sound (although the very small number of taxa fully identified at the species level might also be due, in addition to the state of preservation, to

the fact that some indication of original fauna is present here). According to the ostracode fauna, during Campanian times the Tercis area was part of the Boreal European Palaeobiogeographical Unit, with temperate warm waters as defined by SEELING *et alii* (2004). This Unit includes the Basco-Cantabrian Basin, the Aquitaine Basin, the Paris Basin, England, Belgium, the Netherlands, Germany, Poland, and Russia. Nevertheless, the genera

*Dumontina* and *Limburgina* present at Tercis are signs that point to the north-Tethyan margin. A Tethyan or Boreal assignment of the Tercis area thus depends on the criteria considered; BILOTTE & PLATEL (*in* BILOTTE *et alii*, 2001) argue that in Aquitaine the Tethyan domain is present as far North as the Charente because of the presence of large benthic foraminifera and rudists along with the absence of belemnites and of a true chalk facies; all these points are fully valid at Tercis.

The association of the genera *Dumontina*, *Limburgina*, *Mauritsina*, *Spinoleberis*, *Pterygocythere*, *Diogmopteron*, *Phacorhabdotus*, *Imhotepia*, *Cytherelloidea*, *Bythoceratina*, *Cardobairdia*, *Krithe* and *Eucytherura*, as identified by DAMOTTE & ODIN (2001), ANDREU (2001) and ANDREU & ODIN (2001), characterises the euphotic zone of an outer shelf carbonate platform at Tercis. It is intermediate between the two environments (shallow, high energy and a deeper water, low energy) suggested by SEELING *et alii* (2004), and distinguished in the Boreal European Palaeobiogeographical Unit by discrete associations of genera. The shallow high-energy environment is indicated by the genera *Dumontina*, *Kikliocythere*, *Limburgina*, *Mauritsina*, *Mosaeleberis* and *Spinoleberis*, and the deeper water, lower energy environment by the genera *Trachyleberidea*, *Pterygocythere*, *Alatacythere*, *Phacorhabdotus*, *Imhotepia*, and species of the Bythocytheridae family.

## 5. Conclusion

The present study is part of a comprehensive micropalaeontological investigation undertaken on the hard levels of the Campanian-Maastrichtian boundary stratotype at Tercis (southern Aquitaine). Here we report on ostracodes of which additional taxa were brought to light, and in particular some small forms found but rarely in the samples.

The palaeobiodiversity increased from the 53 species recognised in 2001 to a total of 75 species. Although this number should be regarded with caution due to the real difficulty of compiling a homogeneous terminology of the collected forms due to the nomenclatural differences among authors, these relative numbers (75 versus 53) prove the scientific value of the study of hard levels using acetolysis as a mean for disaggregation of the rocks. With this approach, the actual palaeobiodiversity of the regional basin is better documented and the relationship of this global reference section to that of nearby palaeobiogeographic domains can be better understood.

The genera and species of the ostracode associations at Tercis confirm its Campanian-Maastrichtian age, and a carbonate platform environment; ostracodes also provide unequivocal evidence of relationships with the Boreal

Domain while other faunas have shown that Tercis, and the whole Aquitaine Basin, is better interpreted as a portion of the Tethyan domain, at least during the younger portion of the Campanian and thereafter.

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## Notes added in proof

An additional specimen of *Eucytherura* (*Vesticytherura*) *dorsotuberculata* was collected from level 120.4, *i.e.* about 0.2 Ma above the Campanian-Maastrichtian boundary as defined at Tercis.

An additional specimen of *Aversvalva* sp. was collected from a level located 9.6 m below and consequently less than 0.4 Ma before the Maastrichtian-Danian boundary.

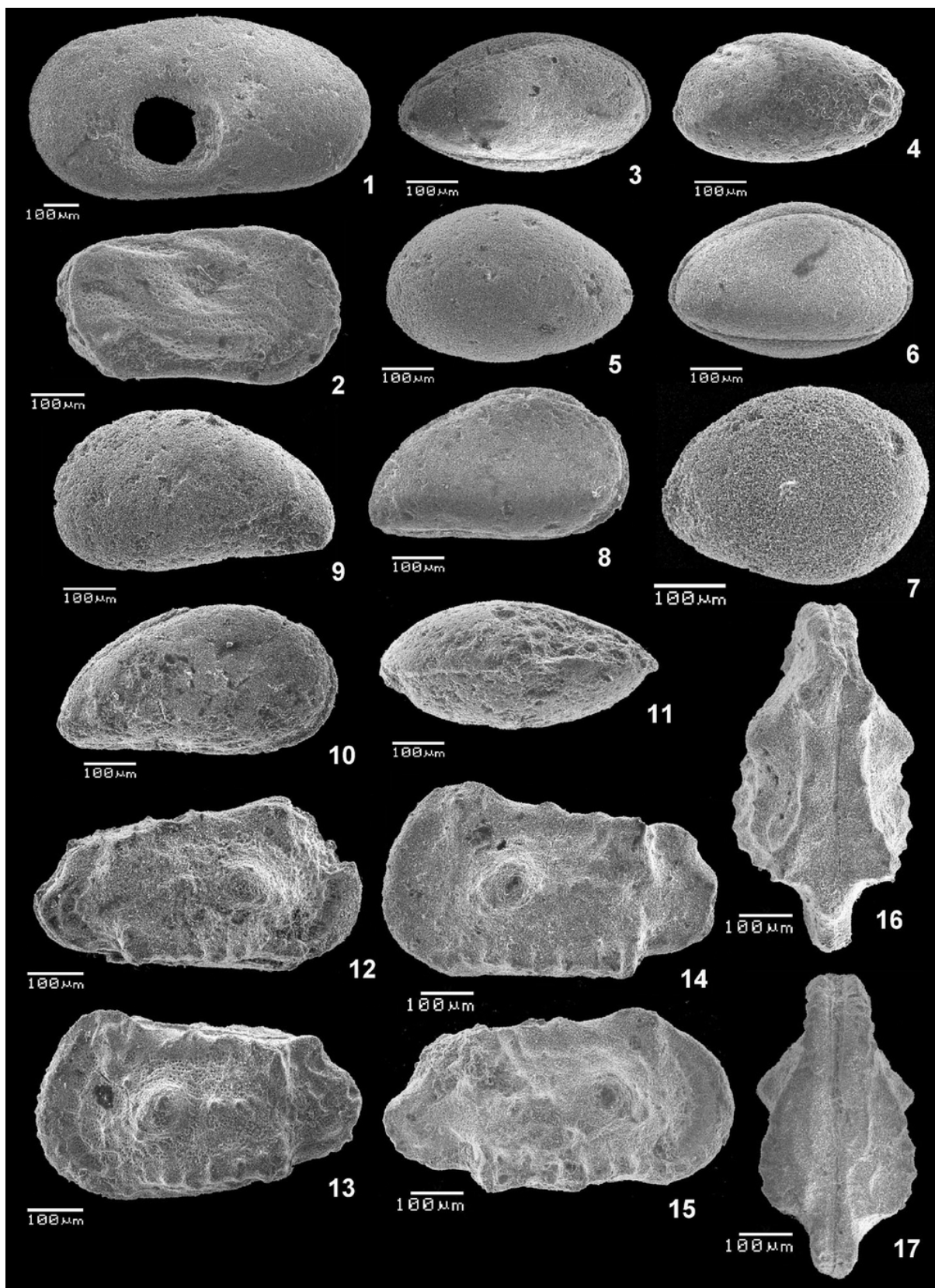
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- b- Les grands fossiles de la carrière de Tercis; une richesse et une diversité remarquable en macrofossiles.
- c- Les bivalves de Tercis ; des fossiles marqueurs de l'environnement et un groupe marqueur de temps (les inocérames).
- d- Les ammonites de Tercis ; un groupe disparu depuis 65 Ma, proche des nautilites et des seiches, très utile pour dater les sédiments de plate-forme.
- e- Les échinides de Tercis.
- f- Les astérides de Tercis; des fossiles communs sur la plate-forme continentale et utiles à la datation relative.
- g- Les petits fossiles de la carrière de Tercis.
- h- Les nannofossiles calcaires à Tercis.
- i- Les kystes de dinoflagellés ; outil stratigraphique de datation relative excellemment illustré à Tercis.
- j- Les foraminifères de la Grande Carrière de Tercis; une présence suffisante pour une datation relative acceptable.
- l- Datation comparée Continent-Océan à Tercis.
- m- Les sites préhistoriques à Tercis ; une grande carrière sur le plus grand site de plein air du sud-ouest de la France.
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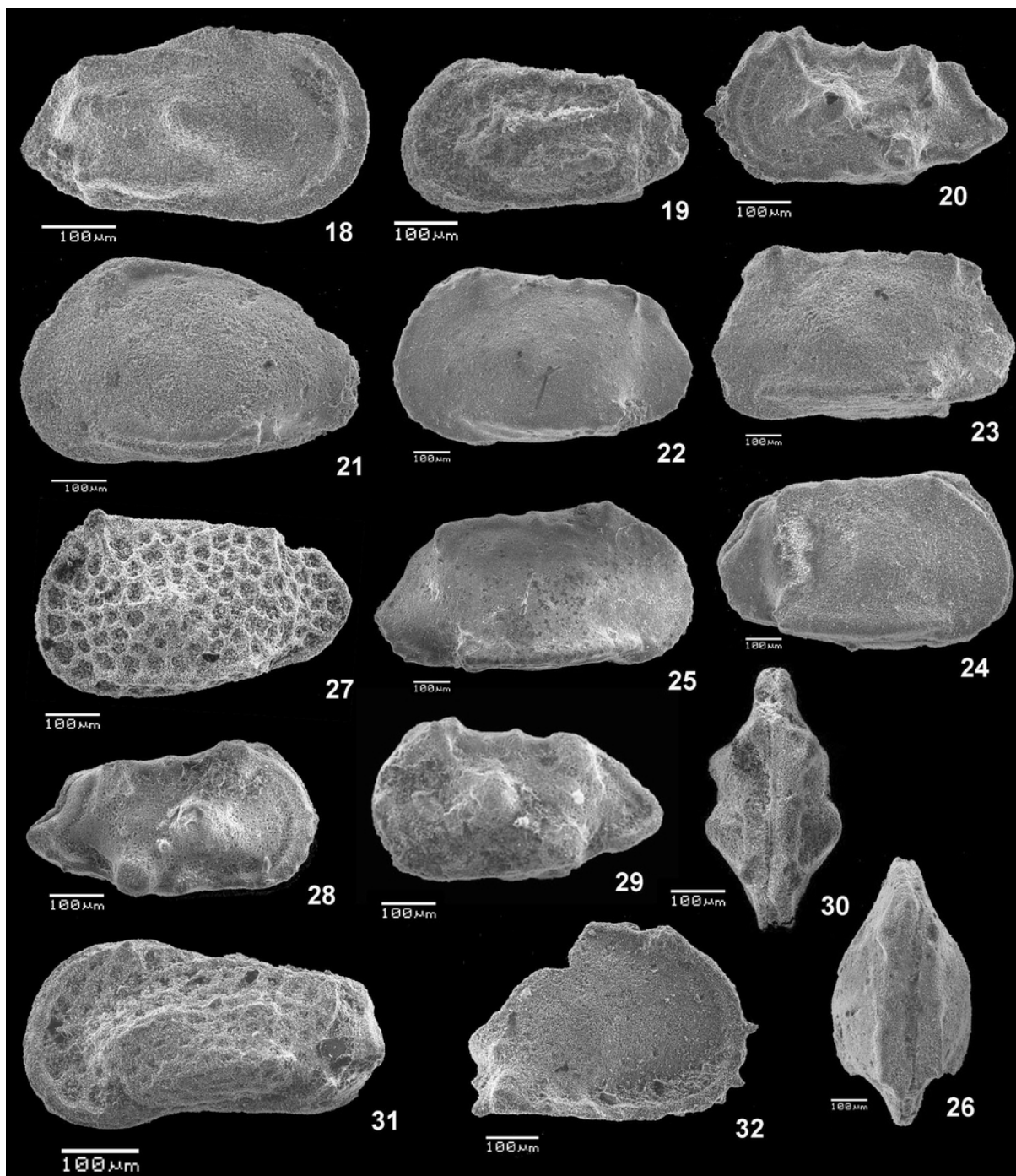
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**Plate 1:** **Fig. 1** Trace of gastropod predation on a LV of *Cytherella* sp., lv (level 52.2). **Fig. 2** *Cytherelloidea* sp., C, Rlv (level 47.2). **Figs. 3-4** *Cardobairdia* ? sp.: 3 C, Rlv (level 49.0); 4 C, Llv (level 50.05 to 50.25). **Figs. 5-6** *Asciocythere* sp.: 5 C, Llv (level 57.9); 6 C, Rlv (level 62.0-62.5). **Fig. 7** *Xestoleberis* cf. *northensis* DEROO, 1966; RV (level 50.05-50.25). **Figs. 8-11** *Paracyprideis* sp.: 8 C, Rlv; 9 C, Llv; 10 C, Rlv; 11 C, dv (level 39.5). **Figs. 12-17** *Rehacythereis* aff. *agedincumensis* DAMOTTE, 1964, 12 C, Rlv; 13 C, Llv (level 79.8); 14 LV, lv; 15 RV, lv; 16 C, dv; 17 C, vv (level 47.2).

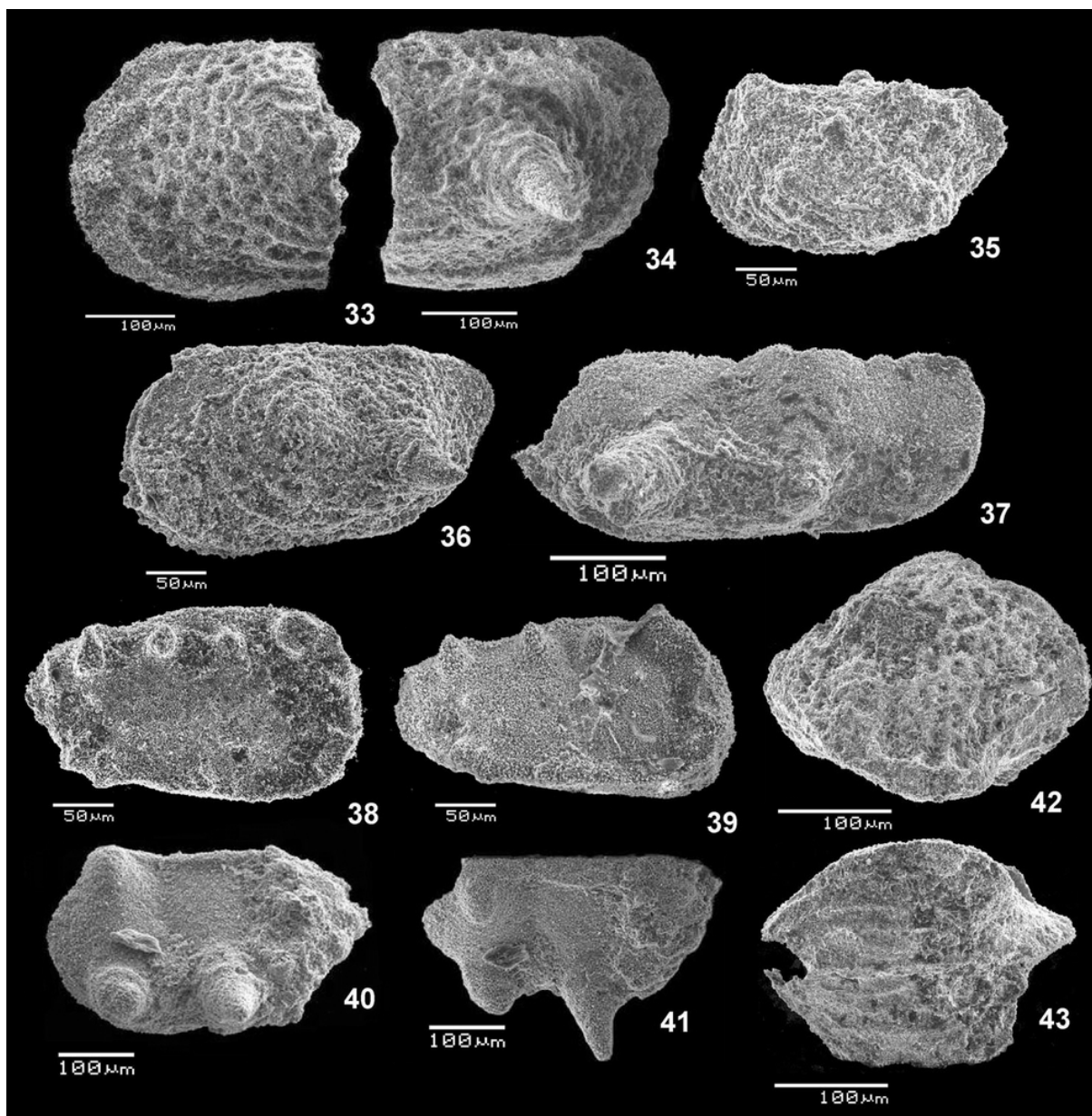
Abbreviations: C = carapace, RV = right valve, LV = left valve, R = Right, L = Left, lv = lateral view, dv = dorsal view, vv = ventral view, ind. = individual.





**Plate 2: Fig. 18** *Phacorhabdotus* cf. *lonsdaleianus* (JONES, 1849); C, Rlv (level 47.2). **Fig. 19** *Hazelina* sp., C, Llv (level B-29.5). **Figs. 20 & 28-30** *Spinoleberis* aff. *macerrima* (VAN VEEN, 1936); 20 C, Llv (level 47.2); 28 C, Rlv (level 79.8); 29 C, Llv (level 79.8); 30 C, dv (level 79.8). **Fig. 21** *Pterygocythere* aff. *hilli* KEIJ, 1957, *sensu* CLARKE (1983), C, Llv (level -5.0). **Figs. 22-26** Genus indet. sp.; 22 C, Llv; 23 C, Llv; 24 C, Rlv; 25 RV, lv; 26 C, dv (level 50.05-50.25). **Fig. 27** *Limburgina* sp., C, Llv (level 50.05-50.2). **Fig. 31** *Paracaudites* (*Dumontina*) aff. *puncturata* (BOSQUET, 1854) *in* DEROO (1966), C, Llv (level 45.3-43.0). **Fig. 32** *Diogmopteron* sp., portion of RV, lv (level 39.5-41.1).

Abbreviations: C = carapace, RV = right valve, LV = left valve, R = Right, L = Left, lv = lateral view, dv = dorsal view, vv = ventral view, ind. = individual.



**Plate 3: Figs. 33-34** *Bythoceratina* sp. 1, 2 portions of LV; 33 anterior part, 34 posterior part, lv (level 54.9). **Fig. 35** *Eucytherura* sp., C, Llv (level 57.9). **Fig. 36** *Bythoceratina* cf. *umbonata umbonata* (WILLIAMSON, 1848) *sensu* CLARKE (1983), C, LV, lv (level 62-62.5). **Fig. 37** *Bythoceratina* sp. 3, portion of RV, lv (level 57.9). **Figs. 38-39** *Eucytherura* (*Vesticytherura*) *dorsotuberculata* (VAN VEEN, 1936); 38 C, Rlv (level 54.9); 39 C, Rlv (level 57.9). **Figs. 40-41** *Bythoceratina* sp. 2; 40 LV, lv; 41 LV, dv (level 79.8). **Figs. 42-43** *Aversoalva* sp.; 42 C, Rlv (according to B.A.) or Llv (according to G.S.O.); 43 C, vv (anterior side to the left) of the same individual (level 89.0).

Abbreviations: C = carapace, RV = right valve, LV = left valve, R = Right, L = Left, lv = lateral view, dv = dorsal view, vv = ventral view, ind. = individual.

## Appendix 1: List of the species illustrated in this work

Bernard ANDREU

- *Asciocythere* sp., Pl. 1 , figs. 5-6; level 57.9 (1 ind.); 62.0-62.5 (1 ind.)
- *Aversovalva* sp., Pl. 3 , figs. 42-43; level 89.0 (1 ind.); 82.0 (1 ind.)
- *Bythoceratina* aff. *umbonata umbonata* (WILLIAMSON, 1848) *sensu* CLARKE (1983), Pl. 3 , fig. 36; level 62.0-62.5 (1 ind.); 50.05 (1 ind.)
- *Bythoceratina* sp. 1, Pl. 3 , figs. 33-34; level 54.9 (2 ind.)
- *Bythoceratina* sp. 2, Pl. 3 , figs. 40-41; level 79.8 (1 ind.); 54.9 (1 ind.)
- *Bythoceratina* sp. 3, Pl. 3 , fig. 37; level 57.9 (1 ind.)
- *Cardobairdia* ? sp., Pl. 1 , figs. 3-4; level 60.5 (1 ind.); 49.0 (2 ind.); 50.05-50.25 (2 ind.); note that, according to J.-P. COLIN (personal communication), figs. 3-4 would better illustrate a male of *Asciocythere*.
- *Cytherella* sp., Pl. 1 , fig. 1; level 52.2 (single perforated individual)
- *Cytherelloidea* sp., Pl. 1 , fig. 2; level 47.2 (1 ind.)
- *Diogmopteron* sp., Pl. 2 , fig. 32; level 39.5-41.1 (1 ind.)
- *Eucytherura* (*Vesticytherura*) *dorsotuberculata* (VAN VEEN, 1936); Pl. 3 , figs. 38-39; level 54.9 (1 ind.); 57.9 (1 ind.); 82.0 (1 ind.)
- *Eucytherura* sp., Pl. 3 , fig. 35; level 57.9 (2 ind.)
- Genus indet. sp., Pl. 2 , figs. 22-26; level 50.05-50.25 (8 ind.), synonym of *Mauritsina* sp. in ANDREU (2001)
- *Hazelina* sp., Pl. 2 , fig. 19; level B-29.5 (1 ind.)
- *Limburgina* sp., Pl. 2 , fig. 27; level 50.05-50.25 (1 ind.)
- *Paracaudites* (*Dumontina*) aff. *puncturata* (BOSQUET, 1854) in DEROO (1966), Pl. 2 , fig. 31; level 43.0-45.3 (1 ind.); 50.05-50.25 (1 ind.)
- *Paracyprideis* sp., Pl. 1 , figs. 8-11; level 39.5 (4 ind.); 41.1 (2 ind.); 79.8 (1 ind.); 57.9 (1 ind. ?)
- *Phacorhabdotus* cf. *lonsdaleianus* (JONES, 1849), Pl. 2 , fig. 18; level 47.2 (1 ind.)
- *Pterygocythere* aff. *hilli* KEIJ, 1957, *sensu* CLARKE (1983), Pl. 2 , fig. 21; level -5.0 (1 ind.)
- *Rehacythereis* aff. *agedincumensis* DAMOTTE, 1964, synonym of *Oertliella* cf. *pulchra* in DAMOTTE & ODIN, 2001, and of *Spinoleberis* sp. 1 in ANDREU (2001), Pl. 1 , figs. 12-17; level 62.0-62.5 (2 ind.); 47.2 (6 ind.); 79.8 (2 ind.)
- *Spinoleberis* aff. *macerrima* (VAN VEEN, 1936) in DEROO (1966), Pl. 2 , figs. 20 & 28-30; level 47.2 (1 ind.); 79.8 (3 ind.)
- *Xestoleberis* cf. *northensis* DEROO, 1966, Pl. 1, fig. 7; level 50.05-50.25 (1 ind.)

## Appendix 2: Illustration and tridimensional model of an individual of the genus *Aversovalva* obtained using acetolysis of an Upper Campanian level at the geological site at Tercis

Alexandre LETHIERS & Gilles Serge ODIN

The morphology of the shells referred to the genus *Aversovalva* in this work is difficult to understand from a single picture. Orientation of the shell itself has been interpreted diversely for the two pictures obtained using the Scanning Electron Microscope (see views 42 and 43 above). In this situation, we have tried to obtain a model showing all aspects of another reasonably well preserved individual. This specimen comes from the acetolysis residue of a sample collected from level 82.0 in the type section of the geological site at Tercis. Figure 1 in this appendix gives 6 views of this specimen obtained using the optical microscope.

The model in video 1 was derived from both microscopic observation and pictures in the literature like the one given for *Cytheropteron gadaloupense* CRANE, a Recent species illustrated in:

<http://www.ud.ac.uk/GeolSci/micropal/ostracod.html>

(incorrectly written *C. gadaloupense*) which shows a number of similar features both morphological and ornamental. Using this model, we hope that it will be possible to recognise the taxon when it was observed elsewhere and to compare it with other species of the same genus in order to obtain a specific name (not yet suggested).

Compared to the taxon previously called *Aversovalva* sp. (DAMOTTE & ODIN, 2001), and here called *Pterygocythere* aff. *hilli*, the most obvious difference is the size: *Pterygocythere* is 600-700 µm long while *Aversovalva* sp. of Tercis is only half that size according to the two specimens at hand. At Tercis, *Pterygocythere* sp. was known from level 39.5 in 2001; it has been found in the acetolytic residues at the same level, at level 11.0 and down to level -5.0 (1 to 2 specimens at each level) and probably at level 65.4 (single valve) too.

*N.B.*: in a former work (DAMOTTE & ODIN, 2001), the specimen of *Pterygocythere* pictured is incorrectly titled: once as *Aversovalva* sp. (view 16) and once as *Planileberis* (view 20 of the same specimen) in the caption of the plate (p. 399).





**Figure 1:** Optical microscope pictures of an ostracode collected from level 82.0 at Tercis. From left to right: lateral right, slightly ventral view; dorsal view, anterior part to the right; anterior ventral view (note the two ridges on the right valve to the left); lateral view of left valve, anterior part to the left; anterior dorsal view, anterior part to the bottom; ventral view, anterior part to the top (note the two ridges on the right valve to the left).



**Video:** Tridimensional panoramic views of a reconstruction of an individual of the genus *Aversovalva*. Note that the right valve is smaller than the left one. 3D model realised using software Blender (<http://www.blender.org/>) a facility already used for another micro-fauna (ODIN & LETHIERS, 2006).

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