

## The Cretaceous-Tertiary Boundary in a Sector of the South Limb of the Miranda-Treviño Synclinal: the First Appearance of Chelonia and Archosauria in the Basque Country

H. Astibia, F. Garcia-Garmilla, X. Orue-Etxebarria, J. Rodriguez-Lazaro

*Departamento Geologia, Facultad Ciencias, Universidad Pais Vasco, Aptdo, 644, 48080 Bilbao, Spain*

A.D. Buscalioni, J. L. Sanz

*Departamento Zoologia, Facultad Ciencias U.A.M. Cantoblanco, 28049 Madrid, Spain*

and E. Jimenez-Fuentes

*Facultad Ciencias Universidad Salamanca, 37008 Salamanca, Spain*

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H. Astibia, F. Garcia-Garmilla, X. Orue-Etxebarria, H. Rodriguez-Lazaro, A. D. Buscalioni, J. L. Sanz and E. Jimenez-Fuentes. The Cretaceous-Tertiary Boundary in a sector of the South Limb of the Miranda-Treviño Synclinal: The First Appearance of Chelonia and Archosauria in the Basque Country. *Cretaceous Research* (1987) 8, 15-27. This paper presents a study of the Cretaceous-Tertiary boundary in the Miranda-Treviño Synclinal (Basque-Cantabric basin) where two main sequences have been recognised; the lower is regressive and the upper one has a marked transgressive trend. They are separated by a low angled un-conformity which is indicative of the Maastrichtian-Danian boundary.

The lower sequence (S1) indicates a clear transition between the shoreface and backshore sub-environments. Bone accumulations are located in the sandy sediments of the upper foreshore and backshore, associated with ferruginous hardgrounds and gypsum efflorescences.

The upper sequence (S2) indicates the beginning of a marine transgression. It is composed of a dominantly carbonate-rich sediments and the fauna suggests a deposition in environmental conditions ranging from stenohaline, to littoral, and to a coastal lagoon and inner carbonate-rich platform.

In the lower sequence (Maastrichtian Unit S<sub>1</sub>U<sub>3</sub>), the following herpetofauna have been identified; an eusuchian alligator, and two dinosaurs (an ornithopod and a sauropod). Several plates of chelonia have been identified as ? *Adocus* sp.

Departamento Geologia, Facultad Ciencias, Universidad Pais Vasco, Aptdo. 644, 48080 Bilbao, Spain

Departamento Zoologia, Facultad Ciencias U.A.M. Cantoblanco, 28049 Madrid, Spain  
Facultad Ciencias Universidad Salamanca, 37008 Salamanca, Spain

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### 1. Introduction

The study of the sequences of the Miranda-Treviño synclinal is important from two different points of view: (1) As new data on the Cretaceous-Tertiary boundary in the Basque-Cantabric basin, (2) To

understand the Upper Cretaceous herpetofauna better since suitable upper Cretaceous outcrops are relatively scarce in Europe.

The Laño site lies between the village of Laño and Faido (Figure 1), 20 km. SE of the city of Vitoria (Alava province), in an unused sand quarry. Geologically, Laño and the adjacent area are on the southern limb of the Miranda-Treviño Synclinorium (central Navarro-Cantabric trough, Basque-Cantabric basin). The core of this structure comprises mainly continental Tertiary strata. Both to the north and to the south are very thick Upper Cretaceous sequences (Martin *et al.*, 1978).

The Laño site is included in a stratigraphical series comprising the Cretaceous-Tertiary boundary. Previous studies (Mangin, 1958; Plaziat and Mangin, 1969; Plaziat, 1970*a*, 1970*b*, 1973, 1974; Martin-Alafont *et al.*, 1978), reveal the existence of an important regressive event which characterises this stratigraphic level.

The definition of formal stratigraphic units is not the aim of this work, because these may be recognised only after regional studies (see Amiot, 1982). Our field observations are concentrated on three stratigraphic sections. From west to east, they are; Laño, the La Lucia ravine and Arluzea. The first is the most complete. The Laño section shows two different

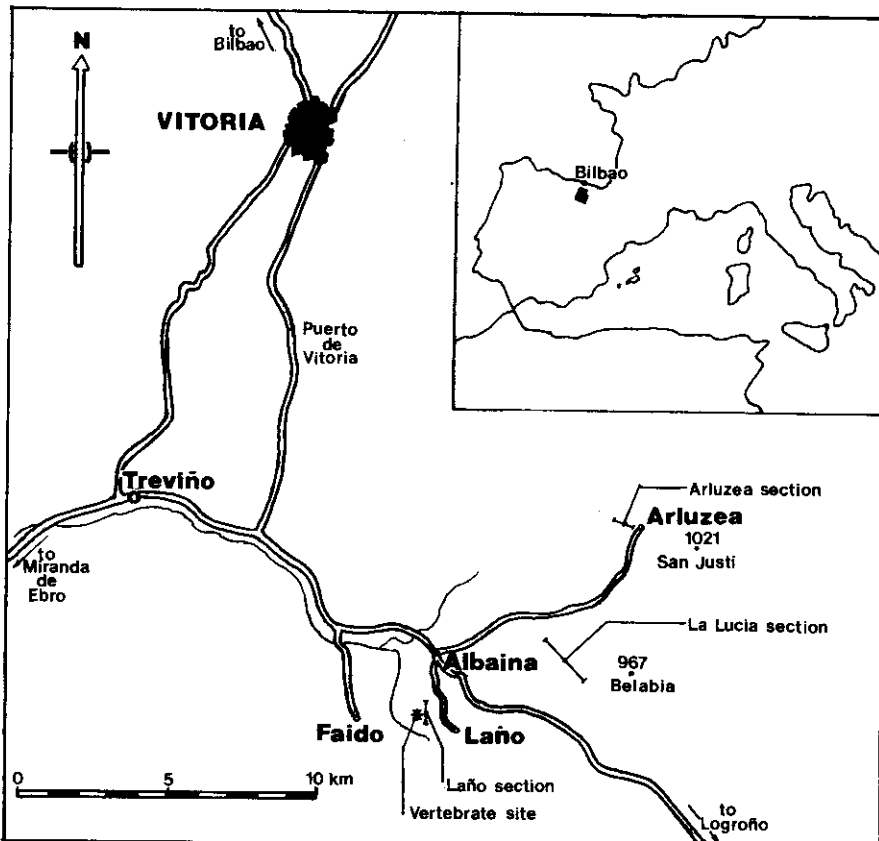


Figure 1. Map showing the location of the outcrops in the Basque Country, northern Spain.

stratigraphical sequences separated by a low-angled unconformity. They will be called S1 (the lower) and S2 (the upper), respectively (Figure 2).

The Laño vertebrate-site has been discovered recently by one of the authors (X.O.). It is the first site of its kind found in the Basque-Cantabrian Basin. The exceptional outcrops lead us to believe that it is possible that other sites may exist in this area.

## 2. The S1 sequence

In the lower sequence, it has been possible to distinguish three units, which, from the bottom up, have been called S1U1, S1U2, S1U3.

### 2.1. The S1U1 unit

It is composed of calcareous sands and sandstones with interbedded marls that are more frequent towards the top of the succession. The sedimentary style of the sandstone beds is very characteristic, appearing in the shape of sand-bars (30 cm) with planar cross-bedding, frequently intersected by erosion surfaces which truncate the earlier structures. In the lower part of this unit, the bars are entirely formed by bivalve lumachelles (oysters and pectinids) and show a certain degree of lateral continuity. The energy gradient represented by these strata is higher than the interbedded marls.

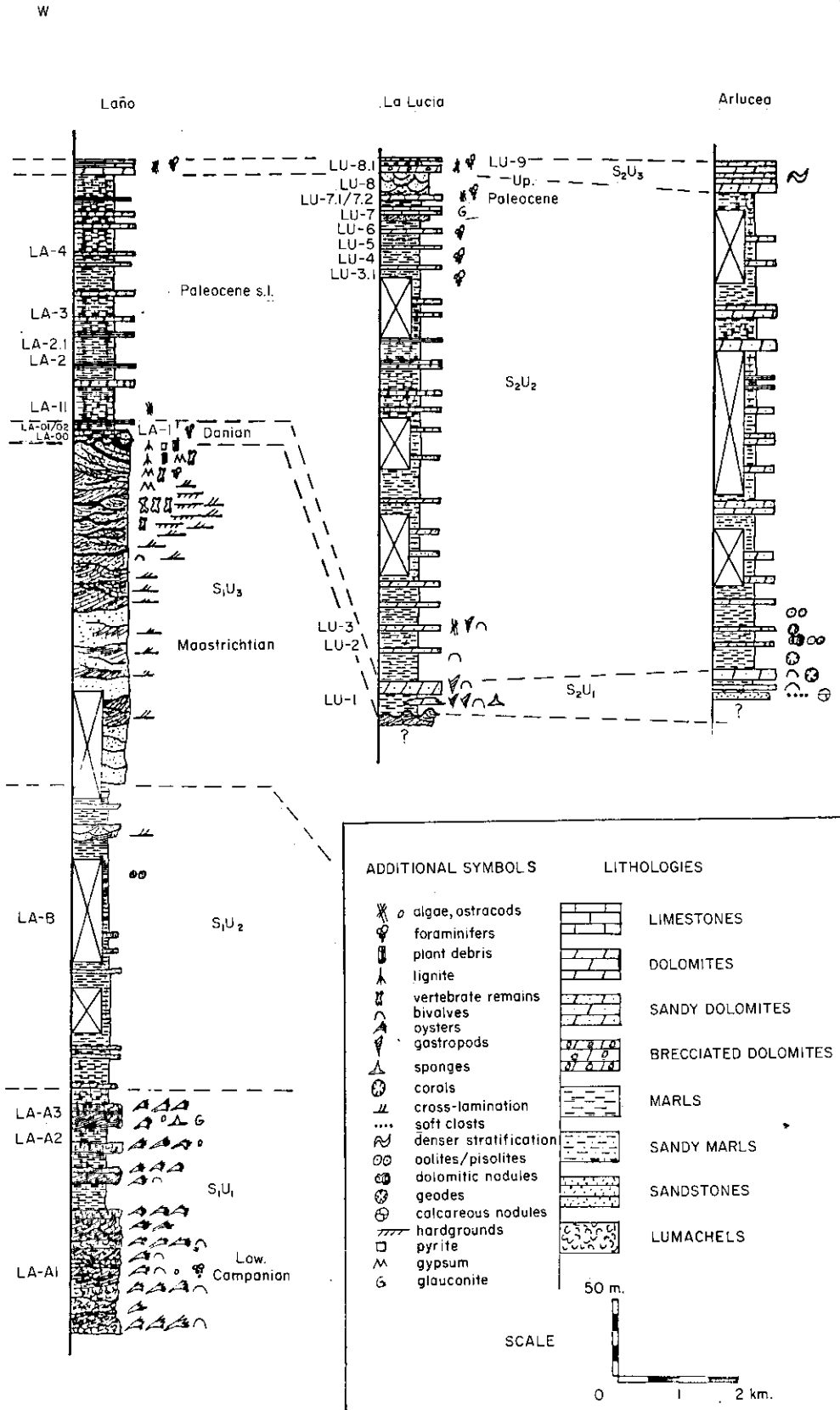
The ostracods are found in moderate levels of specific diversity; associations that become poorer towards the top. We have determined, among others, the following species; *Asciocythere* aff. *bonnemai* Deroo, *Limburgina* aff. *senonensis* (Damotte), *Limburgina* sp., *Mauritsina* aff. *hieroglyphica* (Bosquet), *Mauritsina* sp., *Paracaudites* (D.) gr. *puncturata* (Bosquet), *Parapokornyella* sp., *Karsteneis* (*Karsteneis*) sp.?, *Mosaeleberis* sp., *Neocythere* (P.) aff. *verbosa* (Damotte), *Tumidoleberis* aff. *bonnemai* (Deroo), *Spinoleberis* sp., *Planileberis* sp., *Cytherella* sp.

This association is characteristic of the Late Santonian–Early Campanian of the Navarro–Cantabrian trough. The LA–A1 sample is the only one in which it has been possible to find planktonic foraminifera. In order of abundance they are *Globotruncana linneiana* (d'Orbigny), *Rosita formicata* (Plummer), *Globotruncana bulloides* (Vogler), *Globotruncana arca* (Cushman), *Globigerinelloides* sp., The benthonic forms found are *Gavelinella* sp., *Astacolus* sp., *Cibicides* sp., *Nummofallotia* sp., *Neoflabellina* sp., *Lenticulina* sp. Rotaliids and sponge spicules are also present. This association suggests a Campanian age. The lithology and identified fauna indicate an upper offshore-lower shoreface environment, with sporadic, more important, storm-event winnowing, caused by a lowering of the wave base.

### 2.2. The S1U2 unit

This is the most poorly exposed part of the succession and because of this, it has not been intensively sampled. This unit displays an increase in fine-grained sediments and terrigenous contamination, particularly in the silts and fine-grained bands.

The lower part shows parallel lamination. At the top, there are dolomitic



sandstone bars with bipolar crossbedding, probably the result of a surge and undertow regime. The presence of sandy, pisolite-shaped, nodules leads us to think about sporadic tidal-fall periods. It has not been possible to find a representative fauna and this, together with the sedimentology suggests a possible shoreface environment, perhaps with a transition to a lower foreshore environment.

### 2.3. *The S1U3 unit*

This unit is very well exposed in the wide quarry situated NW of Laño village. It consists of multidirectional cross-laminated sands with microconglomerates in the bottom-sets. The laminated beds are rarely more than one meter thick. Towards the top of this unit, the strata become massive. They are frequently intersected by abrasion surfaces showing an iron-mineralised crust or "hard-ground". Mangin (1958) recorded *Orbitoides socialis* Leymerie from this unit, ascribing it to a Maastrichtian age. On our part, we have collected some pectinids and vertebrate remains. The most important accumulation of the latter is about 40 m below the unconformity separating the two sequences and which is related to an important hardground. Towards the top of the unit, the sandstones become parallel-laminated or, even, ill-structured. Here there are reddish-gypsum efflorescences on several stratigraphic surfaces. This suggests intermittent sub-aridity episodes. The unit is topped by two black silt beds with bone remains and plant debris; the latter sometimes pyritised. The S1U3 unit concludes the well-defined regressive character of the S1 sequence, including the upper foreshore and backshore environments and reaching a subcontinental, plant-rich, perhaps swampy environment.

The S1 sequence, as a whole, shows certain similarities with that described by Dabrio, (1984) for a sandy progressive beach in Neurath (Miocene of Germany). In our case, the sequence is thicker and it has a marked transitional development between shoreface and foreshore environments.

## 3. The S2 sequence

The lithological and faunal characteristics of the S2 sequence are very different from those of S1. It has a mainly calcareous-dolomitic composition, lacking, in general, the current structures. It consists of three mappable units, which are called S2U1, S2U2, S2U3, from base to top.

### 3.1. *The S2U1 unit*

Mangin (1958) says: "... upon sandy Maastrichtian sediments, lies a carbonate thick bed: the 'Belabia limestones', whose character is more sandy towards the W (Laño) and more calcareous at E (Arluzea)". This author comments on the "Rognacian Facies" of Belabia (this word alludes to a continental character), which includes sandy sediments of Maastrichtian age

Figure 2. Laño, La Lucia and Arluzea sections. Sequence S1, lower sequence with a regressive character; S2, upper sequence with a transgressive development.

which pass vertically into littoral sediments of Danian age. Nevertheless, Plaziat (1983) demonstrates that the lack of continental deposits of Danian age involves a mistaken correlation between "Rognacian" and Danian. On the other hand, the relationship between "Rognacian" and Late Maastrichtian is correct; the latter includes the vertebrate-bone-bearing sediments.

Plaziat and Ellenberger (1982) made the following observations with regional conclusions: during the late Campanian there was an important continental uplift, succeeded by a strong tectonic activity in the middle Maastrichtian which is within the Pirenaic Orogenical Stage.

The epirogenesis of the French-Belgian range began early in the Tertiary. All these circumstances led to the existence of sharp lateral changes within the Maastrichtian sediments. These materials can be wholly marine (Spanish Aren marls, French "Nankin" limestones) or continental ("Rognacian" facies). The Rognacian facies of Ariège and Haute Garonne are calcareous (Bessiere *et al.*, 1981), but those of Coll de Nargo (Lérida, Spain) consist of sands, conglomerates and lignites, in which dinosaur bones are found. These sediments are overlain by carbonate sediments with *Lychnus* sp. (Plaziat, 1972). This situation is very similar to ours. Indeed, in the Laño section, the "Belabia limestones" appear in the form of a 15 m thick bank. It is composed of well-exposed dolomitic sandstones and sandy dolomites, with human-excavated caverns of the Visigothic period.

It is not easy to see sedimentary structures in this unit. In the La Lucia section, there are slightly sand coin-bedded dolomites, in which Magin (*op. cit.*) recorded *Paleostoa* cf. *hispanica* Oppenh, *Dissostoma branni* Noulet, and *Charydobia characeum* Stache. The following have also been found; *Lychnus giganteus*, *Viviparus cingulatus* and *Clausilia matheroni*. All these are gastropods of fresh-water environments.

In the Arluzea section, this unit consists of dolomitic limestones with corals and marine bivalves. There are also irregularly-shaped dolomitic nodules. The deposit could have been produced in a shallow-marine environment. Magin (*op. cit.*) notes also that the thickness of the "Belabia limestones" decreases towards the North, and that they are Early Danian image. From the above data, it is possible to reconstruct the lateral changes in facies of the "Belabia limestones" for the area studied. This hypothesis is compatible with the results of other authors in their studies on the Early Cenozoic of the same area (Plaziat, 1970a, 1974).

A microfauna of ostracods and foraminifers has been found in the Laño section. The former are represented by poorly preserved, strongly decalcified faunas and because of this only internal casts can be used for the identification of the fauna. It is therefore impossible to be precise but members of the Cytherideinae and Trachyleberidinae have been recognised together with *Cytherella* spp.. There are also rare ill-preserved, marine benthonic foraminifers; mainly rotaliids, lituolids and ataxophragmids. From these data, it is reasonable to conclude that this unit was deposited in a stenohaline, marine-littoral environment, perhaps with a greater bathymetry in the eastern part of the area studied.

### 3.2. The S2U2 unit

This is the thickest, and most poorly exposed unit of this sequence which has been called the "San Justí couches" by Mangin (*op. cit.*). There are similarities between all the three sections studied as it everywhere appears as a monotonous series of alternations between sand and 40 cm thick marls. There are no current sedimentary structures, except in the upper portion of the unit, where planar-cross-bedded, current-rippled calcareous sandstones are seen. These suggest a tidal-dominated depositional environment. This was probably an integral part of a later destroyed washover-fan or tidal-channel environment.

The limited fauna collected from the S2U2 unit is quite diverse. Towards the top of the unit, the following ostracods appear; *Bairdia* sp., *Parakrithe* sp., *Paracaudites* (*Paracaudites*) sp., *Murrayina* sp., *Oertliella* sp., *Schizocythere?* sp., *Mosaeleberis?* sp..

A study of material in thin-section reveals a uniform association of echinoderm and mollusc fragments, echinoid spines, miliolids, rotaliids, several agglutinating foraminifera, and corallineous algae. Furthermore, the samples LU-7.2 and LU-8 contain typical forms of *Ranikothalia* sp., *Lockhartia* sp., *Lenticulina* sp. and *Discocyclina* sp.. This association suggests a late Paleocene age. The foraminiferal tests frequently show dissolution features.

The environmental interpretation of the "San Justí couches" is not straightforward but the data suggest a shallow, restricted, marine environment that was probably deeper towards the east. The lack of fauna in several beds may indicate the presence of even more restricted episodes related to the appearance of coastal lagoons. These were probably affected by tidal channels or washover-fans which were periodically supplied by terrigenous material.

### 3.3. The S2U3 unit

At the top of the S2 succession there is a 15–20 m thick bank of calcareous/dolomitic sediment. In the La Lucia section these are brecciated but also includes very thin, marly interbedded strata, which according to Mangin (*op. cit.*), contain *Planorbulina* sp., *Discocyclina seunesi* and algae. Mangin gives this assemblage a Montian age, which does not coincide with our conclusions. The S2U3 unit is overlain by Oligocene conglomerates from which the following microfauna has been collected: Ostracoda-*Bairdia* sp., *Parakrithe* sp., *Paracaudites* (*Paracaudites*) sp., *Murrayina* sp., *Oertliella* sp., *Schizocythere?* sp. and *Mosaeleberis?* sp.; Foraminifera-*Cibicides* sp., *Lenticulina* sp. and *Lockhartia* sp.. Miliolids, rotaliids, several species of agglutinating foraminifera, orbitoidids, echinoderm and molluscan fragments, echinoid spines, corallineous algae and bryozoans have also been found. The faunal evidence, and its position within the sequence, leads us to think that the S2U3 unit was deposited in an infra-littoral, inner, carbonate platform environment. The S2 sequence, taken as a whole, has a marked transgressive trend, that is more evident in the upper unit, and perhaps with some recurrent episodes during the "San Justí couches" interval.

In summary, therefore, two sequences have been recognised; the lower

sequence (S1) has a regressive character and includes sediments of Early Campanian-Maastrichtian age while the upper sequence (S2), resting unconformably upon the first one, has a transgressive development during the Danian-Late Paleocene.

#### 4. Systematic paleontology

##### ORDER CHELONIA

###### Suborder Cryptodira

*Material.* Thirty shell fragments of Chelonia from the Maastrichtian of Laño have been considered. The material will be housed in The País Vasco University, being at present in the Universidad de Salamanca (Dto. De Geología).

*Description.* Out of all the pieces, twenty have a characteristic ornamentation of the external surface. This ornamentation seems to be granular (with different density) and could diverge in meandered or a vermiculed type. Nevertheless, some variability can be appreciated in several scutes. The different ornamentation appears simultaneously. There are also pits and alveolar patterns [Figure 3(a), (b), (c)].

*Discussion.* The ornamentation of the studied plates can be attributed to the family Dermatemydidae Gray, 1870 (s.l.), represented at present by only one genus and species, *Dermatemys mawii* 1847. Though other families, like Trionychidae and Carettochelyidae, have a similar ornamentation, the absence of a dermal cover (except *Anosteira*) rules them out.

The Dermatemydidae are widespread in sediments of the Cretaceous and Lower Palaeogene, especially in North America, China, Mongolia and the U.S.S.R. This family includes many genera with problematical phylogenetic relationships. Even though we have compared the Laño Chelonia with many other forms, we have not met anything with a similar morphology; especially when one considers the superficial canal or neural sutures of some of our plates. The material available does not allow us to identify, exactly, the genus of this form. The curvature of the shell and the ornamentation relate our specimen to some species of *Adocus*, and probably *A. foveatus*, from the Upper Cretaceous of Kansai (Tadjik SSR, U.S.S.R.). We therefore include, (with some reservations) the ornamentated Chelonia from Laño within the genus *Adocus* as *Adocus* sp.

##### ORDER ORNITHISCHIA

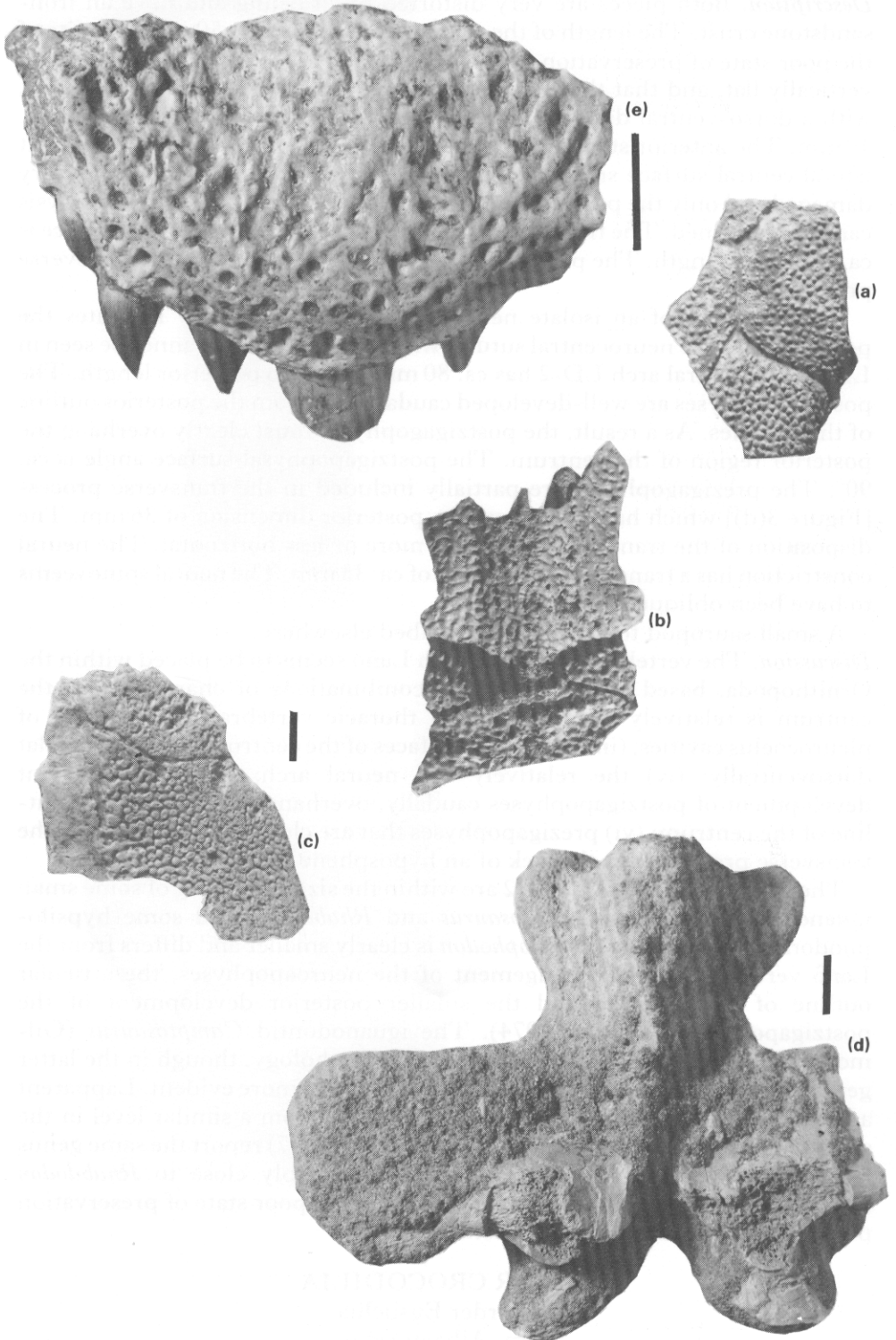
###### Suborder Ornithopoda

###### *Ornithopoda* sp. *indet.*

*Material.* LD-1. Thoracic vertebra. LD-2. Neural arch of a thoracic vertebra [Figure 3,(d)]. The material is provisionally housed in the Departamento de Zoología, Universidad Autónoma de Madrid.

Figure 3. Laño outcrop. Maastrichtian. 3(a), (b), (c), Chelonia ornamentated plates, ? *Adocus* sp. (a), peripheral from the bridge, (b), couple of two neurals; (c), posterior peripheral, (d), dorsal view of the neural arch (LD-2) of a thoracic vertebra, Ornithopoda; (e), lateral view of the left maxillary fragment (LC-3) of an eusuchian crocodile (Alligatoridae *indet.*). Scale bar 1 cm.





*Description.* Both pieces are very distorted by crushing and have an iron-sandstone crust. The length of the centrum of LD-1 is ca. 50 mm. In spite of the poor state of preservation, it seems that the lateral centrum surfaces are vertically flat, and that the articular outline of the centrum is subelliptical, with a dorso-ventral diameter of ca. 47 mm and a traverse diameter of ca. 40 mm. The anterior surface of the centrum is slightly concave. On the left lateral central surface small foramina can be seen. The neural arch is very damaged and only the position and morphology of the right prezigapophysis can be ascertained. The transverse diameter of the prezigapophysal surface is ca. 23 mm in length. The prezigapophyses are associated with the transverse process.

The existence of an isolate neural arch (LD-2) probably indicates the persistence of the neurocentral suture, which, nevertheless, cannot be seen in LD-1. The neural arch LD-2 has ca. 80 mm in antero posterior length. The postzigapophyses are well-developed caudally, far from the posterior outline of the pedicles. As a result, the postzigapophyses must clearly overhang the posterior region of the centrum. The postzigapophysal surface angle is ca. 90°. The prezigapophyses are partially included in the transverse process [Figure 3(d)] which has a distal antero-posterior dimension of 36 mm. The disposition of the transverse process is more or less horizontal. The neural constriction has a transverse dimension of ca. 35 mm. The neural spine seems to have been oblique.

A small sauropod tooth will be described elsewhere.

*Discussion.* The vertebrate material from Laño seems to be placed within the Ornithopoda, based on the following combinations of characters: (i) the centrum is relatively elongated (for a thoracic vertebra); (ii) the lack of pleurocoelus cavities; (iii) the lateral surfaces of the centrum are probably flat dorsoventrally; (iv) the relatively low neural arch; (v) the prominent development of postzigapophyses caudally, overhanging the posterior outline of the centrum; (vi) prezigapophyses that are clearly associated with the transverse process; (vii) the lack of an hyosphene.

The vertebral remains LD-1/2 are within the size variability of some small iguanodontids such as *Camptosaurus* and *Rhabdodon* and some hypsilophodontids. The genus *Hypsilophodon* is clearly smaller and differs from the Laño vertebrae by the arrangement of the neuroapophyses, the articular outline of the centrum and the smaller posterior development of the postzigapophyses (Galton, 1974). The iguanodontid *Camptosaurus* (Gilmore, 1909) seems to be closer in size and morphology, though in the latter genus the relative development of the neural arch is more evident. Lapparent and Aguirre (1956) report the genus *Rhabdodon* from a similar level in the succession of the Tremp basin. Lapparent *et al.* (1957) report the same genus from Cubilla (Soria, Spain). LD-1/2 are probably close to *Rhabdodon* (Nopcsa, 1921, 1923; Lapparent, 1947), but their poor state of preservation precludes any accurate comparison.

## ORDER CROCODILIA

Suborder Eusuchia

Fam. Alligatoridae

Alligatoridae *indet.*

*Material.* Left maxillary fragment (LC-3); Provisionally housed at Universidad Autónoma, Madrid (Dpto. Zoología).

*Description.* The piece is 50 mm in antero posterior length and 32 mm in maximum transverse width. Six teeth are associated with the maxillary. The dorsal ornamentation is coarse and grooved. A characteristic pitting appears laterally. A total of 15 subcircular foramina are lined up just above the labial border of the maxilla. The piece is caudally convex and concave in the anterior region. Two planes could be distinguished in the maxillary: the lateral margin (labial border of the maxilla) and the dorsal surface [Figure 3(e)]. In lateral view the piece has a curved outline with the largest tooth of the series at the maximal point of curvature of the maxilla. The alveolar border is slightly alveolate. The premaxilla-maxilla suture is not complete, lacking a part of the medial zone. The anterior portion of the suture has a radial structure of bony ridges. This complex is clearly convex and higher than the maxillary surface. No maxilla-nasal suture is visible.

There is no maxillary palate and the dental pieces can be seen with their roots. They also lack interalveolar walls. All the teeth keep their natural position, except one which must have fallen away later. The first three teeth are moderate sized, the fourth is large and long while the fifth and sixth are similar to the first ones. All are functional and resorptional pits can even be seen in the 3rd, 4th and 5th. The interalveolar distance is short. Between the first socket and the premaxilla-maxilla suture there is a short diastema. The general tooth morphology is of pointed teeth, laterally compressed crowns, with slight mesial and distal carenae that reach the base of the crown. The enamel is smooth on both faces and very thin. The fourth maxillary tooth is broken away at the middle of the crown, but differs from the others in being larger (almost double) and more subcircular in the section of the crown.

*Discussion.* We consider the piece LC-3 as falling within the Alligatoridae for the following reasons. Amongst the eusuchians, the enlargement of the fourth maxillary tooth is presented mainly in the Alligatoridae. No mesosuchians, except ziphodont ones, present single or few enlarged maxillary tooth. Some extant alligatorids have developed a single 4th maxillary tooth (*Caiman latirostris*, *Paleosuchus*). Other alligatorids enlarged more than one maxillary tooth (3rd and 4th in *Alligator prenasalis* or 4th and 5th in *Diplocynodon* (Berg, 1966) or *Albertochampsia* (Erickson, 1972)). There is a slight swelling over the 4th alveoli. The general tooth morphology, of pointed and laterally compressed crowns, and the short interalveolar space, would appear to be related to the caimans (Langston, 1965; Mook, 1921).

## 5. Conclusions

The stratigraphic data suggests the presence of a regressive-transgressive sedimentary cycle, represented by two depositional sequences. We have identified them as S1 and S2 respectively. The most important bone accumulation located at the present time, is about 40 m below the base of the S2 sequence, and closely related to a hardground (Figure 2). The present erosion has exposed small, intersecting, hardground channels, in which a large quantity of fossils had accumulated. This accumulation is located near the top of a clearly regressive sequence, S1. The bone remains are placed in

subenvironments varying from the upper foreshore and backshore. The associated sandy sediments display hardgrounds and gypsum efflorescences both of which suggest intermittent periods of subaerial exposition in a subarid climate.

The S2 sequence represents a new, and different, sedimentary history. The lithofacies and biofacies are characteristic of a typically marine environment, oscillating between the marine-littoral and the inner carbonate-rich platform; the central episode (S2U2), known as the "San Justí beds", suggest quiet sedimentation, probably into a coastal lagoon, that represents a more restricted environment.

The material collected mainly consists of teeth and isolated post-cranial pieces, or more frequently, fragments. Many pieces are fractured and/or deformed as a result of compactation and other diagenetic processes. Many bone-remains are iron-enriched in different grades, with the subsequent partial or total loss of their inner structure.

Esteban & Klappa (1983) report that the particles below a hardground may undergo replacement processes as a result of fluids percolating through the sediment. According to these authors, this phenomenon, which could have influenced the fossil material, is controlled by several factors: climate, intensity and endurance of diagenetic processes, location of phreatic waters and the sediment petrofabric.

The reptile remains from Laño are still too scarce to allow us to compare them with other Upper Cretaceous European outcrops (Babinot *et al.*, 1983), which, in any case, are not very well known. However, the Laño remains may be considered as representing a "normal" archosaurian fauna. The ornithopod remains are quite rich (*Rhabdodon* and *Orthomerus* are common in other Upper Cretaceous outcrops) while the sauropod tooth seems to be long within the Titanosauridae (Sanz, *in press*). Most of the little known Late Cretaceous crocodiles are included in the Alligatoridae (Buffetaut, 1980).

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