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THE PALEOGENE OF THE ZUMAYA SECTION

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El Paleoceno y Eoceno inferior del internacionalmente conocido corte de Zumaya es muy accesible y muestra un excelente afloramiento a lo largo de la playa de San Telmo, situada en la parte noroeste del pueblo de Zumaya (provincia de Guipúzcoa, país Vasco, norte de España), desde Punta Aitzgorri, donde se encuentra el famoso límite Cretácico/Terciario, hasta Punta Mariantón donde aflora el Ypresiense.

Litológicamente, el Paleoceno inferior consiste en unos 50 m de calizas con pequeñas intercalaciones margosas depositadas en una rampa carbonatada relativamente profunda. El Paleoceno superior está compuesto por aproximadamente 120 m de margas con intercalaciones de estratos calizos y areniscosos. En general las secuencias de Zumaya se tratan de sedimentos tipo flysch, con frecuentes trazas fósiles, de cuenca batial y de aproximadamente 1000 m de profundidad. Las intercalaciones turbidíticas distales son comunes en el Thanetiense medio y, especialmente, en el Ypresiense donde la tasa de sedimentación aumenta mucho. La cuenca estaba situada en latitudes medias templadas durante el Paleoceno, produciéndose un fuerte aumento de temperatura en el límite Paleoceno/Eoceno, lo cual se manifiesta en una incursión de foraminiferos planctónicos de bajas latitudes y en la anomalías negativas de los isótopos del oxígeno y del carbono.

La magnetoestratigrafía del Paleoceno inferior del corte de Zumaya fue establecida en 1976, reconociendose los crones 27, 28 y 29. Recientemente se ha realizado la magnetoestratigrafía del Paleoceno superior y Eoceno inferior, identificándose los crones 24, 25 y 26. Los datos bioestratigráficos y magnetoestratigráficos que se divulgan de forma integrada en esta guía son inéditos, ya que solo han sido presentados de forma preliminar en tesis o resúmenes de congresos.

El corte de Zumaya es muy conocido por su excelente exposición, continuidad y, sobre todo, por el límite Cretácico/Terciario. Además, este corte ha suscitado gran interés por sus posibilidades cronoestratigráficas para el establecimiento de estratotipos de límite para los pisos del Paleógeno inferior. En el Paleoceno se reconocen actualmente tres pisos estandar: Daniense, Selandiense y Thanetiense, pero la correlación del corte de Zumaya con los estratotipos de estos límites pone de manifiesto que el Selandiense y el Thanetiense se solapan excepto en el Selandiense inferior. En este sentido, la Subcomisión Internacional de Estratigrafía del Paleógeno tendrá que volver a replantearse la subdivisión del Paleoceno en dos o tres pisos. Mientras tanto se ha constatado que este corte presenta grandes posibilidades para el establecimiento del límite Daniense/Selandiense (o Daniense/Thanetiense), ya que existe un intervalo margoso con excelente exposición y registro fósil. Por otra parte, el límite Paleoceno/Eoceno (Thanetiense/Ypresiense) está muy bien precisado, ya que se ha reconocido un evento muy relevante que en Zumaya está representado por un intervalo de arcilla roja con disolución, en cuya base se produce la extinción en masa de los pequeños foraminíferos bentónicos batiales y abisales. Así pues, la buena exposición y registro fósil permite afirmar que este corte también tiene grandes posibilidades para la definición del estratotipo de límite del Paleoceno/Eoceno.

GEOLOGICAL ASPECTS

The Paleogene of the well known Zumaya section is easily accessible since exposure occurs along San Telmo beach, just north of the township of Zumaya (Guipúzcoa province, Basque country, northern Spain), from Punta Aitzgorri (K/T boundary) to Punta Mariantón (Ypresian).

The lithology of the lower Paleocene consists of about 50 m of limestones with intercalated thin marl layers, and the upper Paleocene is composed of about 120 m of marls with interbedded limestones and calcarenite strata. Turbidite strata are not frequent across the Paleocene, but become common in the middle Thanetian and in the upper part of the section, where the sedimentation rate increases a lot, from the *Morozovella subbotinae* Biozone (Early Eocene).

The Zumaya sediments were deposited in the deep part of a basin at about 1000 m deep, placed at the northern coast range of the Iberian peninsula. The flysch facies and trace fossils of the distal turbidites were described by Hanisch (1972) and Crimes (1973). The depositional sequences have been established by Pujalte *et al.* (1993, 1994, 1995).

The lower Paleocene magnetostratigraphy was studied by Roggenthen (1976), recognizing chrons 27, 28 and 29 and establishing the comparison between Spain and Italy. The correlation between magnetostratigraphy and lower Paleocene planktic foraminiferal biostratigraphy was discussed by Arenillas *et al.* (1993). Lately, the upper Paleocene and lower Eocene magnetostratigraphy have been studied by Luebbert (1996), recognizing chrons 24, 25 and 26. The Paleocene and lower Eocene planktic foraminiferal biostratigraphy was preliminary studied by Hillebrandt (1965), Molina (1994), and Arenillas and Molina (1995). More in detail was studied the Paleocene-Eocene transition (Canudo and Molina, 1992; Canudo *et al.*, 1995; Molina *et al.*, 1996) and the Danian-Selandian transition (Arenillas and Molina, 1996). Lately, a new sampling of the upper Paleocene allows us to revise in detail the planktic foraminiferal biostratigraphy and establish a most precise biomag-

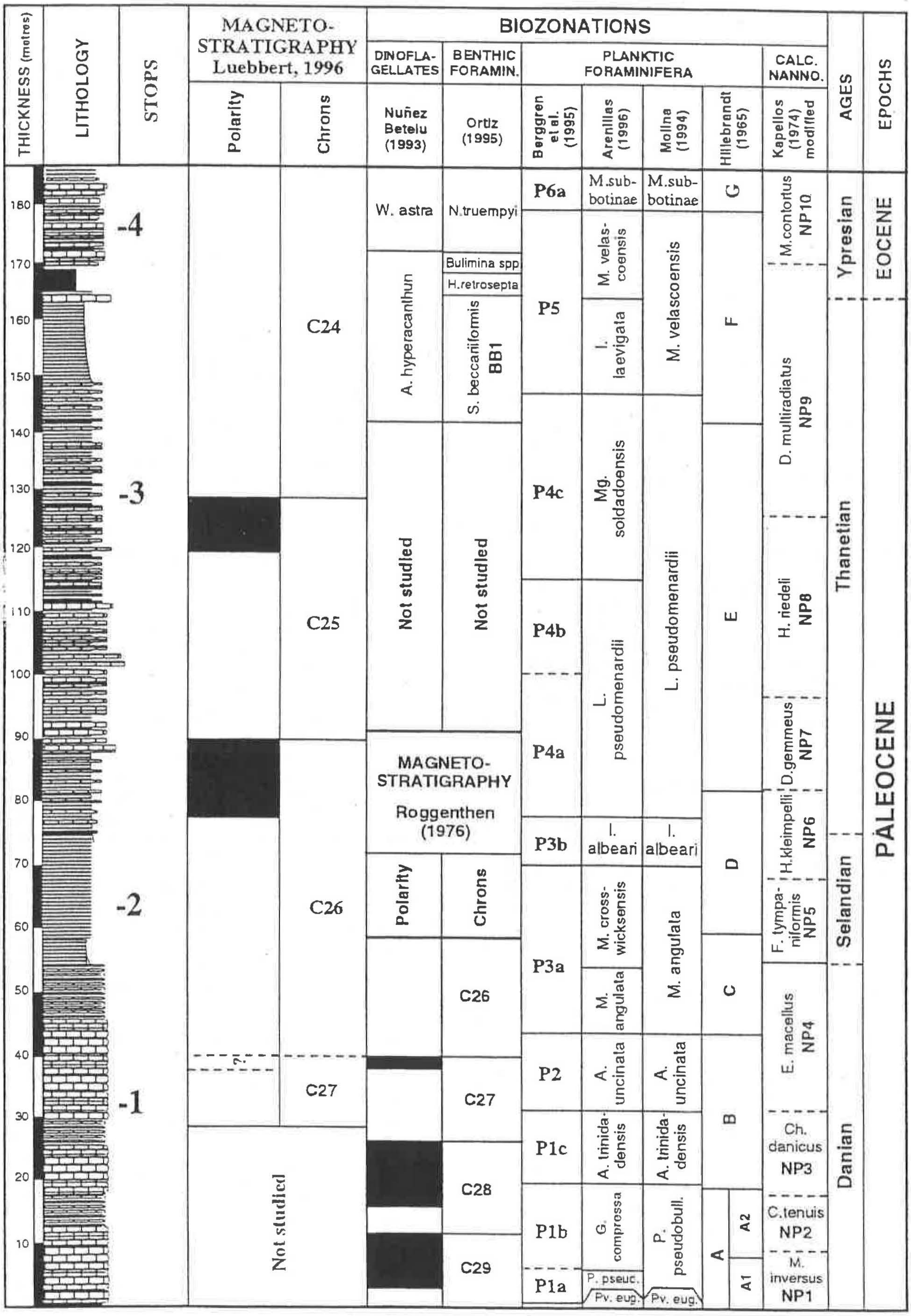

Fig. 1. Integrated stratigraphy across the Paleocene and lowermost Eocene at Zumaya section.

netostratigraphic calibration, which is still umpublished (Fig. 1).

The stable isotopes and other chemical elements have been analysed by Schmitz *et al.* (1997, 1998) and Le Callonnec (1998). In the interval in which the basal Selandian may be defined there is a negative $\partial^{13}C$ shift, although the most prominent is located at the Paleocene/Eocene boundary.

This section is very well known mainly due to the Cretaceous/Tertiary boundary (see Maastrichtian stop), but the chronostratigraphy of the Paleocene stage boundaries have also been studied in detail (Molina, 1994; Molina *et al.*, 1996; Canudo *et al.*, 1995). For the Paleocene three standard stages were proposed: Danian, Selandian and Thanetian. According to the integrated stratigraphy established at Zumaya section and the correlation with the European stage stratotypes, it is evident that the Selandian and Thanetian overlap except on the lower Selandian. Consequently, the International Subcommission of Paleogene Stratigraphy should restate the subdivision of the Paleocene in two or three stages. Anyway, the Zumaya section has excellent possibilities for the definition of the boundary stratotype for the Danian/Selandian (or Danian/Thanetian), since the red marls interval, which appears to correspond to the base of the Selandian, is very well exposed and rich in planktic microfossils (Molina *et al.*, 1996; Arenillas and Molina, 1996; Schmitz *et al.*, 1997, 1998).

The Zumaya section contains the most biostratigraphically complete Paleocene-Eocene transition known to date in deep sea sections, with about 30 metres representing Zone P5 of Berggren *et al.* (1995). The Paleocene/Eocene (Thanetian/Ypresian) boundary has been precisely located, being represented by a 4 metres thick red clay interval. This clay is devoid of original calcite except for a thin calcareous interval in the middle part and constitutes a very relevant event, since the bathyal and abyssal small benthic foraminifera became extinct at the base of the clay (Ortiz, 1993, 1994, 1995). Planktic foraminifera quantitative analysis shows an incursion of low latitude species (Canudo and Molina, 1992; Canudo *et al.*, 1995; Arenillas y Molina, 1995; Arenillas *et al.*, 1996). Furthermore, stable isotopes analyses show strong negative excursions indicating a decrease in productivity and an increase in temperature, reaching the higher values of the Cenozoic (Schmitz *et al.*, 1997, 1998 and Le Callonnec, 1998).

In conclusion, the Zumaya section is located in a very accessible place, has a very continuous, expanded, well exposed, and good micropaleontological, magnetostratigraphical and geochemical records. Consequently, Zumaya is a classical section that allow a precise integrated stratigraphy and chronostratigraphy, being a good candidate to define the Paleocene/Eocene and the Danian/Selandian (or Danian/Thanetian) boundary stratotypes.

MICROPALEONTOLOGICAL ASPECTS

Microfossils are frequent in the Paleogene of Zumaya, whereas macrofossils are very rare, the only exception are ichnofossils (Hanisch, 1972). Larger foraminifera are very rare and only can be found reworked in few turbiditic levels (Hillebrandt, 1965). Small benthic foraminifera (Ortiz, 1993, 1994 y 1995), dinoflagellates (Nuñez-Betelu, 1993) and ostracodes occur in low percentage (<10%). Planktic foraminifera and calcareous nannofossils are the major fossil components in the hemipelagic sediments. Hillebrandt (1965) established the planktic foraminifera biostratigraphy and Kapellos (1974) the correlation with the calcareous nannoplankton biozonation. Lately, Von Salis in Schmitz *et al.* (1998) restudied the Danian/Selandian transition and Monechi and Von Salis in Schmitz *et al.* (1997) the Paleocene/Eocene transition. Canudo and Molina (1992) established a more detailed planktic foraminiferal biostratigraphy across the Paleocene/Eocene boundary and, lately, Arenillas (1996) has reestudied the planktic foraminifera from the Upper Cretaceous to the Lower Eocene, applying the data to the paleoenvironmental reconstruction and the chronostratigraphy (Arenillas y Molina, 1995, 1996; Arenillas *et al.*, 1993, 1996). The figure 1 is a modified version of the Molina (1994) and Arenillas (1996) integrated stratigraphy after the revision of the upper Paleocene planktic foraminiferal biostratigraphy.

FIRST STOP

On the top of the cliff of punta Aitzgorri, near a small ruins hut. Sample Z94-1,30 belongs to the base of *Acarinina uncinata* Zone, which can be correlated to the base of P2 Zone of Berggren *et al.* (1995). The followings species of planktic foraminifera can be identified:

Eoglobigerina fringa (Subbotina), *E. trivialis* (Subbotina), *E. edita* (Subbotina), *E. spiralis* (Bolli)

Subbotina triloculinoides (Plummer), *S. triangularis* (White)

Globanomalina compressa (Plummer), *G. caucasica* (Khalilov), *G. haunsbergensis* (Gohrbandt) *G. chapmani* (Parr)

Parasubbotina varianta (Subbotina), *P. pseudobulloides* (Plummer), *P. quadrilocula* (Blow)

Praemurica inconstans (Subbotina)

Acarinina uncinata (Bolli), *A. trinidadensis* (Bolli)

Chiloguembelina midwayensis (Cushman)*Ch. subcylindrica* Beckmann

SECOND STOP

At the base of the cliff, nortwest side of San Telmo beach. Sample ZY-6 belongs to *Morozovella angulata* Zone (*Morozovella crosswickensis* Subzone), which can be correlated to the upper part of P3a Zone of Berggren *et al.* (1995). The followings species of planktic foraminifera can be identified:

Subbotina triloculinoides, S. triangularis, S. eocaenica (Terquem), *S. velascoensis* (Cushman)

Globanomalina haunsbergensis, G. chapmani

Luterbacheria ehrenbergi (Bolli)

Parasubbotina quadrilocula, P. ferreri

Acarinina praepentacamerata (Shutskaya) *A. praeaqua* Blow

Morozovella angulata (White), *M. crosswickensis* (Olsson), *M. simulatilis* (Schwager) s. Luterbacher

Chiloguembelina crinita (Glaessner),*Ch. midwayensis*

THIRD STOP

In the corner at the west stairway to San Telmo beach. Sample ZY-55 belongs to the *Luterbacheria pseudomenardii* Zone (*Muricoglobigerina soldadoensis* Subzone), which can be correlated to P4c Zone of Berggren *et al.* (1995). The followings species of planktic foraminifera can be identified:

Subbotina triangularis, S. eocaenica, S. velascoensis, S. hornibrooki (Broennimann)

Globanomalina haunsbergensis, G. luxorensis (Nakkady)

Luterbacheria pseudomenardii (Bolli), *L. troelseni* (Loeblich & Tappan), *L. australiformis* (Jenkins)

Parasubbotina quadrilocula, P. pseudoimitata (Blow)

Acarinina pseudotopilensis Subbotina, *A. acarinata* Subbotina, *A. primitiva* (Finlay), *A. triplex* Subbotina, *A. nitida* (Martin), *A. subsphaerica* (Subbotina)

Igorina pusilla (Bolli), *I. albeari* (Cushman & Bermúdez)

Muricoglobigerina aquiensis (Loeblich & Tappan), *Mg. chascanona* (Loeblich & Tappan), *Mg. mckannai* (White), *Mg. soldadoensis* (Broennimann)

Morozovella angulata, M. conicotruncata (Subbotina), *M. velascoensis* (Cushman), *M. acuta* (Toulmin), *M. parva* (Rey), *M. tholiformis* (Blow), *M. aequa* (Cushman & Renz), *M. lacerti* (Cushman & Renz), *M. crosswickensis, M. occlussa* (Loeblich & Tappan)

Chiloguembelina midwayensis, Ch. crinita, Ch. wilcoxensis (Cushman & Ponton)

FOURTH STOP

On the upper part of the east ramp to San Telmo beach. Sample ZUMA-61 belongs to the upper part of *Morozovella velascoensis* Zone, which can be correlated to the upper part of P5 Zone of Berggren *et al.* (1995). The followings species of planktic foraminifera can be identified:

Subbotina triangularis, S. eocaenica, S. hornibrooki, S. finlayi (Broennimann), *S. incisa* (Bermúdez)

Acarinina pseudotopilensis, A. acarinata, A. primitiva, A. triplex

Muricoglobigerina aquiensis, Mg. chascanona, Mg. soldadoensis, Mg. esnehensis (Nakkady), *Mg. senni* (Beckmann)

Morozovella velascoensis, M. acuta, M. parva, M. crosswickensis, M. occlussa, M. tholiformis, M. aequa, M. lacerti, M. dolabrata (Jenkins), *M. subbotinae* (Morozova), *M. gracilis* (Bolli), *M. marginodentata* (Subbotina), *M. edgari* (Premoli Silva), *M. lensiformis* (Subbotina)

Chiloguembelina midwayensis, Ch. crinita, Ch. wilcoxensis, Ch. strombiformis Beckmann, *Ch. subtriangularis* Beckmann

Zeauvigerina aegyptiaca Said & Kenawy

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