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Paleocene sections in Spain: chronostratigraphical problems and possibilities

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The Paleocene in marine continuous facies outcrops in the Pyrenees and Betic Cordilleras. In Spain several sections are known that allow to study chronostratigraphically the Paleocene and Early Eocene. The best exposed continuous marine sections known so far are the Zumaya, Osinaga, and Caravaca (Fig. 1).

The Zumaya section is located in the Pyrenees (Basque-Cantabrian basin) and it is easily accessible because the exposure occurs along San Telmo beach, just north of the township of Zumaya (Guipuzcoa province, northern Spain). Lithologically the Lower Paleocene (Danian) consists of 50 m of limestones with intercalated thin layers of marl. The Middle Paleocene (Selandian) is composed of 60 m of marls with

Fig. 1. Location map of the Zumaya, Osinaga, and Caravaca sections.

interbedded limestones and calcarenite strata. The Upper Paleocene (Thanetian) consists of about 60 m of limestones alternating with marls in its lower and middle parts and marls in its upper part. The Lower Eocene (Ypresian) is composed of more than 300 m of marls with abundant interbeds of limestone and calcarenite. In general, the marls and limestones are pelagic but sporadically some turbiditic levels are intercalated, being frequent only in the upper part of the section (Middle Ypresian). Consequently, there are almost no reworking or discontinuity at the Danian–Selandian, Selandian–Thanetian and Thanetian–Ypresian boundaries since the depositional environment was that of a subsiding basin of 500–1000 m depth, almost unaffected by dissolution or erosion.

The Zumaya section is very well known because of the excellent exposure and continuity from the Late Cretaceous to the Early Eocene. Consequently, it has been much studied. Hillebrandt (1965) established the biostratigraphy of the Paleocene and Early Eocene by means of foraminifera and Kapellos (1974) studied the calcareous nannoplankton. The planktic foraminifera have been revised and up-dated in the present paper, but the calcareous nannoplankton have not yet been restudied, except for the Cretaceous–Paleocene and Paleocene–Eocene boundaries. Roggenthen (1976) accomplished the magnetostratigraphy of the Lower Paleocene, and Arenillas et al. (1993) restudied the bio- and chronostratigraphy of the Lower and Middle Paleocene. Finally, several studies trying to establish a high resolution biostratigraphy across the stage boundaries are in press or in preparation (e.g. Ortiz 1993; Núñez-Betelu pers. comm. 1993; Monechi in prep.) (Fig. 2).

The Osinaga section is also located in the Pyrenees, near the village of Osinaga (Navarra province, northern Spain). Lithologically it is similar to the Zumaya section but since the deposition occurred in a deeper basin the rocks are more marly and the sequence is not so thick (c. 105 m for the entire Paleocene). The section was studied by Canudo (1990) who established the biostratigraphy by means of planktic foraminifera.

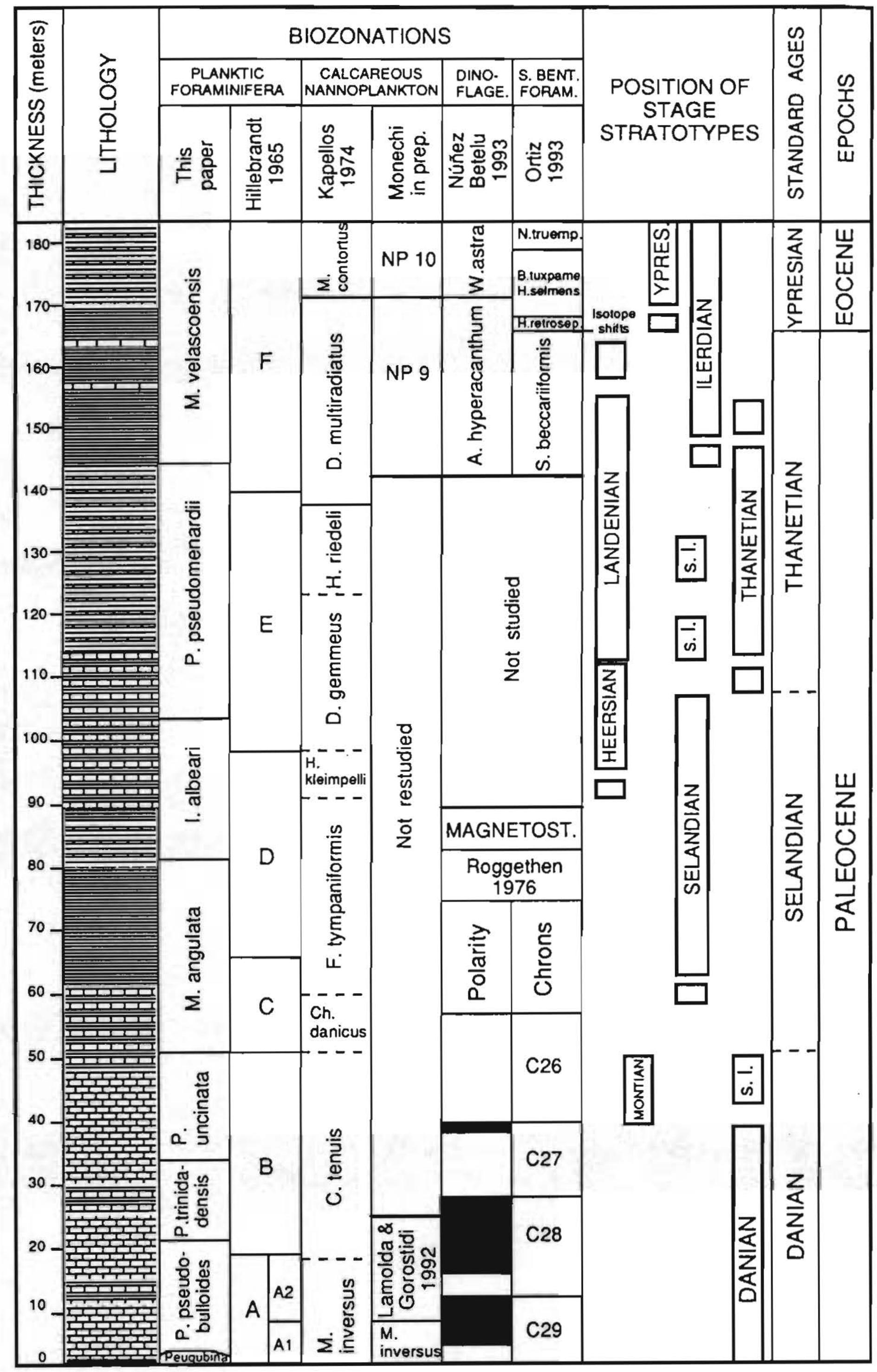

Fig. 2. Integrated stratigraphy of the Paleocene at the Zumaya section.

The Caravaca section is located in the Subbetic Zone of the Betic Cordillera, in the Barranco del Gredero, 4 km south of the town of Caravaca (Murcia province, southern Spain). The classical Caravaca section, very well known because of the Cretaceous–Paleocene and Paleocene–Eocene boundaries, contains a nearly continuous marine record spanning the Upper Cretaceous to the Middle Eocene. The Paleocene is predominantly marly and consists of 120 m of grey and red marls with few calcarenitic strata interbedded. The sediments contain rich calcareous microfossil assemblages. Planktic foraminifera and calcareous nannoplankton are abundant and well preserved, small benthic foraminifera are relatively few to common throughout the section, whereas larger foraminifera are present in certain Upper Paleocene and Lower Eocene strata. The foraminifera in the section was studied by Hillebrandt (1974) and the calcareous nannoplankton by Romein (1979). Lately, an integrated stratigraphical study of the Paleocene–Eocene boundary has been accomplished by Molina et al. (in press).

These three sections are very suitable for the study of the Paleocene chronostratigraphy because of their accessibility, marine continuous pelagic sedimentation, high sedimentation rate, good paleontological control, applicability of magnetostratigraphy and chemostratigraphy, etc. The Zumaya section is the best and could be a very good candidate for the Danian–Selandian, Selandian–Thanetian, and Thanetian–Ypresian boundary stratotypes.

The Danian–Selandian boundary is arbitrarily placed, by the specialists in planktic foraminifera, at the appearance of the typical *Morozovella* (FAD of *Morozovella angulata*). Nevertheless, the base of the Selandian stratotype apparently corresponds to a major sequence boundary in the middle part of *M. angulata* Biozone. The Danian–Selandian boundary time span is very well represented and exposed in the three sections, corresponding to a short carbonate dissolution event in Osinaga.

The Selandian–Thanetian boundary is placed on top of a limestone interval in the lower part of *P. pseudomenardii* Biozone, corresponding also to a major sequence boundary that can be studied in all three sections. As larger foraminifera are present in the Thanetian and Ypresian at Caravaca, the correlation between benthic and planktic foraminifera can be established.

The Thanetian–Ypresian (Paleocene–Eocene) boundary coincides with a sequence boundary between the Landenian and Ypresian, a bathyal and abyssal small benthic foraminifera mass extinction, and relevant isotopic shifts. This boundary falls in the *M. velascoensis*, *D. multirradiatus*, and *A. hyperacanthum* Biozones. At Osinaga it is not well exposed and at Caravaca it is close to a hiatus, but at Zumaya it is very continuous, excellently exposed and well characterized biostratigraphically and geochemically.

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