

## Correlation of calcareous nannofossil zones to the local first occurrence of *Pachydiscus neubergicus* (von Hauer, 1858) (Ammonoidea) in European Upper Cretaceous sections

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### Abstract

The first occurrence (FO) of the ammonite *Pachydiscus neubergicus* (von Hauer, 1858) has been correlated to calcareous nannofossil zonations in several European sections along the northern margin of the Tethyan palaeobiogeographic realm. Both the proposed stratotype section of Tercis (SW France) and complete, ammonite-bearing sections in northern Spain document the FO of *P. neubergicus* within standard nannofossil zone CC23a (UC16), below the LO of *Broinsonia parca constricta*. Other sections such as the type locality Neuberg (Austria), Nagoriani (the Ukraine) and Bjala (Bulgaria) indicate considerable diachroneity of local FOs and show *P. neubergicus* to range up to nannofossil zone CC25b/c (UC20; Late Maastrichtian).

**Keywords:** Ammonoidea, calcareous nannoplankton, Maastrichtian, Europe, correlation

### Introduction

The incomplete definition of Cretaceous stages by stratotype sections has been discussed in previous decades, leading to proposals for the designation of boundary sections during the Brussels meeting on Cretaceous stage boundaries in 1995 (Rawson et al., 1996). For the lower boundary of the Maastrichtian Stage, the Tercis section (Landes, SW France) was proposed for the definition of a Global Boundary Stratotype Section and Point, since this displayed a more continuous section than the type section of the Maastrichtian in the Maastricht area (the Netherlands). The first occurrence (FO) of the ammonite *Pachydiscus neubergicus* (von Hauer, 1858) was chosen as the biostratigraphic boundary criterion (Odin, 1996, 2001).

The present paper provides an overview concerning the correlations of calcareous nannofossil zones with the FO of *P. neubergicus* in several European sec-

tions along the transition from the Tethyan into the Temperate realm, e.g. in northern Spain, Austria and Bulgaria (Fig. 1). We demonstrate that *P. neubergicus* has a rather long stratigraphical range, from the base of the Maastrichtian up to the 'late' Maastrichtian in nannofossil terms (e.g., Burnett, 1998), and that the local first appearance of this ammonite is diachronous.

### Definition of the Campanian-Maastrichtian boundary and nannofossil zonations

A number of macrofossil and microfossil events occur around the Campanian-Maastrichtian boundary interval (see Birkelund et al., 1984; Hancock et al., 1992; Odin, 1996). During the Brussels meeting on Cretaceous stage boundaries (1995), the FO of *P. neubergicus* was proposed as the boundary criterion (Odin, 1996), based on the proposed stratotype section at the Tercis quarry, which was chosen on ac-

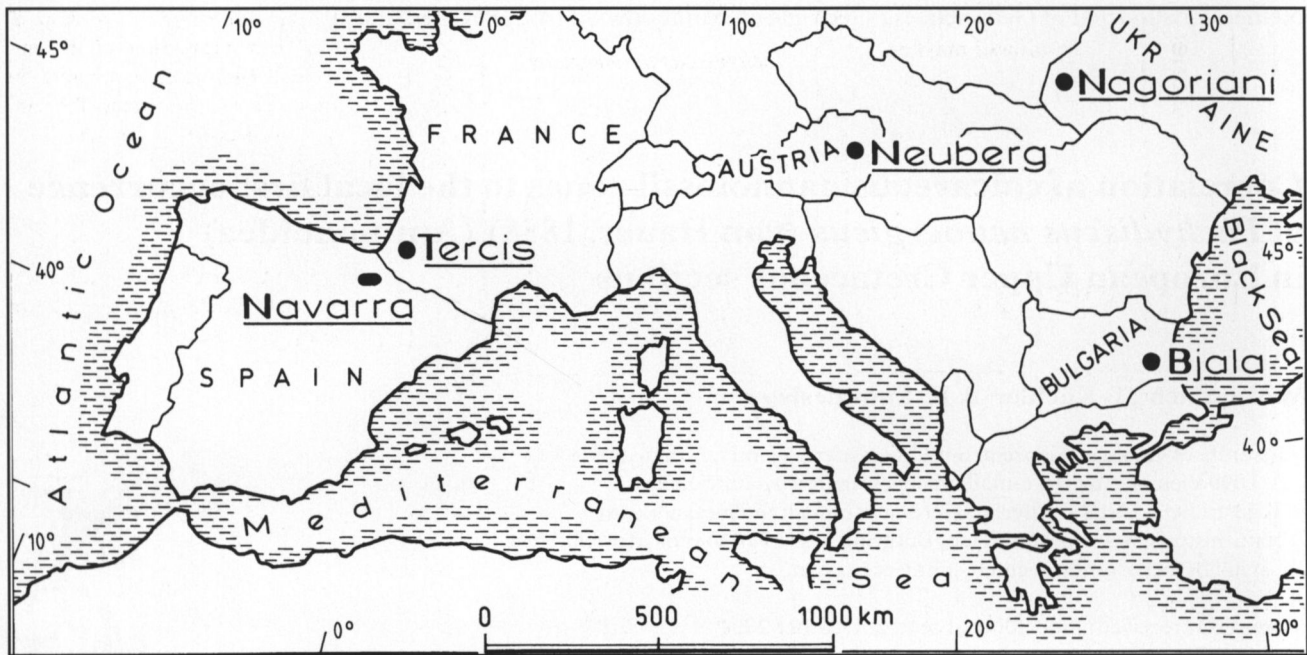


Fig. 1. Sketch map indicating the positions of European sections mentioned in the text.

count of its rich macrofossil content and its transitional position from the Tethys to the temperate/boreal biogeographic realms. The type locality for *P. neubergicus* is in Austria, at Krampen near Neuberg (Steiermark). The Neuberg section was described by Kennedy & Summesberger (1986); that paper also included data on nannofossil assemblages by Wagneich.

Published correlations between the FO of *P. neubergicus* and nannofossil zones either indicate a level within nannofossil zone CC23a/UC16 (e.g., Hancock et al., 1993; Barchi et al., 1997; Wagneich et al., 1998), below the last occurrence (LO) of *Broinsonia parca constricta*, or a level within CC23b/UC17 (e.g., Burnett et al., 1992; Cunha et al., 1997; Burnett, 1998), above the LO of *B. p. constricta*, and below the LO of *Uliplanarius trifidus* and *Tranolithus orionatus*. The sequence of FOs and LOs of primary nannofossil marker species during this time interval is well established both for the Tethyan and the temperate/boreal realms (Perch-Nielsen, 1985; Burnett, 1998), but secondary markers are still under debate. In the latest Campanian and Early Maastrichtian, nannofossil marker events for standard zonations of low to mid-latitudes (Sissingh, 1977; Perch-Nielsen, 1985; Burnett, 1998) are almost exclusively based on the last occurrences of a number of species, namely *Eiffelolithus eximius*, *Reinhardtites anthophorus*, *Tranolithus orionatus*, *Broinsonia p. parca* (= *Aspidolithus p. parvus* of Perch-Nielsen, 1985), *Broinsonia p. constricta* (= *A. p. constrictus* of Perch-Nielsen, 1985), and *Reinhardtites levis* (Fig. 2). These LOs of marker species are prone to reworking, which therefore may intro-

duce a significant error to age interpretations of nannofossil assemblages around this time interval, especially in turbiditic deep-water sections (e.g., Wagneich & Krenmayr, 1993). Some of the secondary nannofossil events of Perch-Nielsen (1985) such as the LOs of *Uliplanarius trifidus* and *Uliplanarius sissinghii* may be truly diachronous from one palaeogeographic domain to another, as it is known for the FO of *Nephrolithus frequens* in the Maastrichtian (e.g., Burnett, 1998).

Considering these secondary markers the sequence of nannofossil events around the Campanian-Maastrichtian boundary as described for the Bottaccione section (Italy; see Monechi & Thierstein, 1985; Gardin et al., 1995) and the Tercis section (France) varies in parts from the sequence of events given in the standard zonations by Perch-Nielsen (1985) and Burnett (1998), i.e. the LO of *U. trifidus* is below the LO of *B. parca constricta* both in the Bottaccione section (Gardin et al., 1995) and at Tercis (Barchi et al., 1997), but above the LO of *B. p. constricta* in the standard schemes of Perch-Nielsen (1985) and Burnett (1998).

#### **Tercis-les-Bains: proposed Global Boundary Stratotype Section and Point for the lower boundary of the Maastrichtian**

Biostratigraphic data from Hancock & Kennedy (1993), Hancock et al. (1993), Odin et al. (2001) and magnetostratigraphic data by Barchi et al. (1997) from the Tercis section demonstrate a complete Cam-

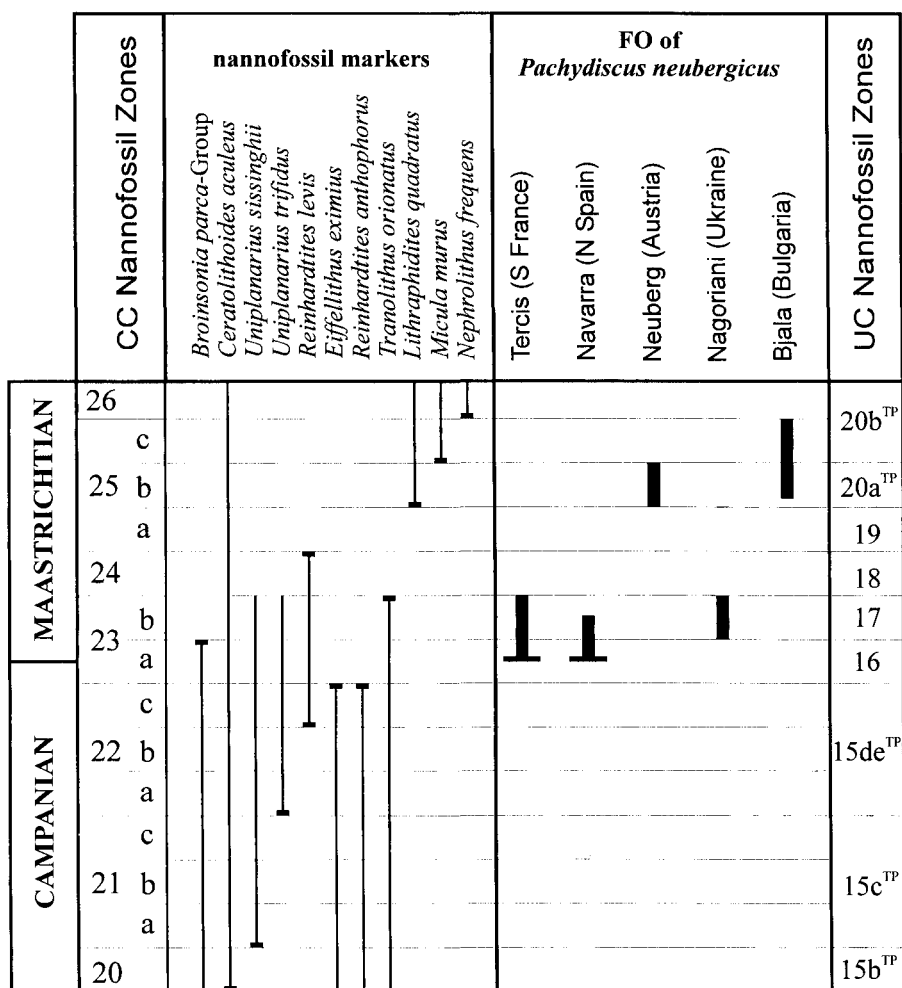


Fig. 2. Stratigraphical position of local first occurrences of the ammonite *Pachydiscus neubergicus* in European sections against the nanofossil standard zonations (CC zones) of Sissingh (1977) and Perch-Nielsen (1985), modified according to Wagreich & Krenmayr (1993), and the nanofossil zonation of Burnett (1998; UC zones). Standard CC (sub)zones are shown in equal durations.

panian-Maastrichtian boundary interval. Although preservation of nanofossils is poor, a detailed nanofossil stratigraphy was established by Barchi et al. (1997), differing slightly from results of former investigations by Burnett in Hancock et al. (1993).

The sequence of events within the Tercis section based on Barchi et al. (1997) is as follows:

FO *Geratolithoides aculeus*, FO *Uniplanarius gothicum* (= *U. sissinghii* in the present paper), FO *U. trifidus*, LO *Eiffellithus eximius*, LO nannoconids, LO *U. gothicum*, LO *U. trifidus*, LO *Tranolithus phacelosus* (= *T. orionatus* in the present paper) and *B. parca*.

Nannofossil assemblages were interpreted by Barchi et al. (1997) to indicate the predominance of Tethyan taxa; typically high temperate/boreal taxa are not present.

The FO of *Pachydiscus neubergicus* according to Odin (in Christensen et al., 2000; see also Odin et al., 2001) is at level 115.7 m; this is practically contemporaneous with the LO of forms referred either to *P. perfidus* or to an intermediate *P. perfidus/neubergicus*. This event lies above the LO of *Uniplanarius gothicum*

(96 m) and below the LO of *Uniplanarius trifidus* (129 m) and *Broinsonia parca* (144 m) and may be correlated with the standard nanofossil zone CC 23a of Perch-Nielsen (1985) or UC16 of Burnett (1998).

Correlations of these biostratigraphic data for the Tercis section to the magnetostratigraphic scale indicate a long interval of normal polarity (C33n) in the lower part followed by a short reversed polarity zone (C32r2; Barchi et al., 1997). The C32r2 transition appears considerably below the FO of *P. neubergicus* (80–81 m). According to Barchi et al. (1997), this level can be correlated to the *Globotruncanella havanensis* Zone of the Tethyan foraminiferal zonation of the Bottaccione section (Monechi & Thierstein, 1985; Premoli Silva & Sliter, 1994) and the lower part of the *Belemnitella langei* Zone of the boreal Lagerdorf-Kronsmoor section (northern Germany; see Schönfeld et al., 1996), thus indicating a late Late Campanian age for this transition.

#### The type locality of *Pachydiscus neubergicus*

The type material of *Pachydiscus neubergicus* was restudied by Kennedy & Summesberger (1986). At

the type locality, a disused quarry near Krampen (Neuberg an der Mürz, Austria), basal conglomerates and sandstones without ammonites grade into marly sandstones containing *P. neubergicus*, *Pachydiscus epiplectus* (Redtenbacher, 1873) and *Hoploscaphites constrictus* (J. Sowerby, 1817). Nannofossil samples from the Neuberg section have yielded a nannoflora including *Lithraphidites quadratus*, which indicated standard nannofossil zone CC25b/UC20a, i.e. a 'late' Maastrichtian age according to nannofossil scales (e.g. Sissingh, 1977; Perch-Nielsen, 1985; Burnett, 1998), although the occurrence of *P. epiplectus* suggests an Early Maastrichtian age. Correlations with German sections by means of nannofossils (Kennedy & Summesberger, 1986) provided evidence for a middle Early Maastrichtian age (*Belemnella sumensis* Zone) of the type locality of *P. neubergicus*.

### Campanian-Maastrichtian boundary sections in Navarra (northern Spain)

Sections in northern Spain provide important data for the correlation of Late Cretaceous macrofossil and microfossil scales, in view of the co-occurrence of ammonites, echinoids, inoceramids, foraminifera and calcareous nannoplankton (Küchler & Kutz, 1989; Kutz 1995; Wägreich et al., 1998; Küchler & Wägreich, 1999; Küchler et al., 2001). Several sections comprise a nearly continuous ammonite record across the Campanian-Maastrichtian boundary, including well-defined FOs of *P. neubergicus*. Two ammonite zones could be distinguished, a 'Late' Campanian *Nostoceras hyatti* Zone and an 'Early' Maastrichtian *Pachydiscus neubergicus*/*P. epiplectus* Zone. In the Erro section, the FO of *P. neubergicus* was found to overlie a *Nostoceras* bed, which could be assigned to nannofossil zone CC23a, characterised by the presence of *Broinsonia p. constricta* and *Uniplanarius trifidus* and the absence of both *Reinhardtites anthophorus* and *Eiffellithus eximius*. In Burnett's (1998) nannofossil zonation, this interval corresponds to zone UC16. In all the investigated localities in northern Spain, e.g. the Imiscoz, Juandechaco and Barranca sections (Eric II), the FO of *P. neubergicus* can be correlated consistently to a level within nannofossil zone CC23a/UC16.

The *Nostoceras hyatti* Bed, as defined in the Erro II section, lies near the base of CC23a, about 2 m above the LO of *Eiffellithus eximius*. Also in the Juandechaco and Eric II sections, at least portions of the latest Campanian *Nostoceras hyatti* Zone may be assigned to nannofossil zone CC23a.

### *Pachydiscus neubergicus* at Bjala (Bulgaria) and Nagorianiy (the Ukraine)

*Pachydiscus neubergicus* has previously been recorded from sections at Bjala (Bulgaria; Ivanov & Stoykova, 1994; Rögl et al., 1995) and at Nagoriani (the Ukraine; Kennedy & Summesberger, 1987). In the Bjala section, *P. neubergicus* ranges up to nannofossil zone CC25b/c (*Micula murus* Zone of Ivanov & Stoykova, 1994), i.e. into the Upper Maastrichtian. The Bjala section also allows a correlation with planktonic foraminifera, indicating the LO of *P. neubergicus* to be within the *Abathomphalus mayaroensis* Zone (Rögl et al., 1995).

At Nagoriani, samples from ammonite specimens including *P. neubergicus*, indicated nannofossil zone CC23b (Wägreich, 1987). Similar to the type section of *P. neubergicus* in Austria, these sections provided evidence for a rather long stratigraphical range of this ammonite, with respect to nannofossil and foraminiferal zonations.

### Nannofossil zones and the base of the Maastrichtian in European sections

Both at Tercis, the proposed Global Boundary Stratotype Section and Point for the base of the Maastrichtian, and in sections in northern Spain (between c. 50 and 80 km south of Tercis), *P. neubergicus* first appears within nannofossil zone CC23a/UC16 (Fig. 2). Nannofossil standard zone CC23a is characterised by the absence of *E. eximius* and *R. anthophorus* and the presence of *B. p. constricta* and *U. trifidus*. Nannofossil assemblages from both areas show Tethyan affinities, providing evidence for a palaeogeographic position along the northern Tethyan margin.

Nannofossil data from these sections and their correlation to other European key sections such as the Lägerdorf-Kronsmoor section (northern Germany; Schönfeld et al., 1996) yield convincing evidence for the assumption that the event defining the base of the Maastrichtian in the Boreal realm, i.e. the FO of the belemnite *Belemnella lanceolata* (von Schlottheim, 1813), defines a level within the same nannofossil zone, CC23a/UC16 (Schönfeld & Burnett, 1991). The nannofossil assemblages from the Lägerdorf-Kronsmoor sections are generally quite different from those found in Spain, because some low-latitude species (e.g., *U. trifidus*) are missing (see Wägreich et al., 1999). Nevertheless, the marker events are similar across this boundary interval, so that nannofossil zone CC23a could still be determined in these Boreal sections (Burnett, 1990, 1998; Schönfeld et al., 1996). Comparison to nannofossil data from the



Maastrichtian type area is hampered by a considerable hiatus across the Campanian/Maastrichtian boundary and by strong reworking in this area (Manivit in Robaszynski et al., 1985; Burnett, 1996; see also Jagt & Felder, 2003).

Our nannofossil data also support the conclusions reached by Schönfeld & Burnett (1991), Hancock et al. (1992) and Simmons et al. (1996), in that the extinction level of *Globotruncanita calcarata*, a widely used marker in Tethyan planktonic foraminiferal zonations (e.g., Caron, 1985), is considerably older than the base of the Maastrichtian as defined either by *P. neubergicus* or by *B. lanceolata*. The extinction of *G. calcarata* is commonly reported from nannofossil zone CC22b/c (Schönfeld & Burnett, 1991; Wagreich & Krenmayr, 1993), at least one zone below the FO of *P. neubergicus* as indicated by our data.

Correlations of nannofossil zones to other key sections containing *P. neubergicus* indicate considerable diachroneity in the local FO of this marker species. Evidence from the local first appearance at the type locality near Neuberg (Austria), as well as from Bjala (Bulgaria) and Nagoriani (the Ukraine), indicate a stratigraphical range of this ammonite into the 'Late' Maastrichtian up to nannofossil zones CC25b/c (Wagreich in Kennedy & Summesberger 1986; Ivanov & Stoykova, 1994). The total known range of *P. neubergicus* thus spans at least five nannofossil subzones, starting from CC23a/UC16 and extending into CC25c/UC20b<sup>TP</sup>. As a consequence of the long stratigraphical range of *P. neubergicus*, local first appearances in non-continuous ammonite sections may be diachronous. It is recommended that checks be made against other fossil groups, or a magnetostratigraphical scale, before age interpretations are attempted.

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## References

Barchi, P., Bonnemaïson, M., Galbrun, B. & Renard, M., 1997. Tercis (Landes, Sud-Ouest France): point stratotype global de la limite Campanien-Maastrichtien. Résultats magnétostratigraphiques et premières données sur la nannoflore calcaire. Bulletin de la Société géologique de France 168: 133-142.

Birkelund, T., Hancock, J.M., Hart, M.B., Rawson, P.F., Remane, J., Robaszynski, F., Schmid, F. & Surlyk, F., 1984. Cretaceous Stage Boundaries-Proposals. Bulletin of the Geological Society of Denmark 33: 3-20.

Burnett, J., 1990. A new nannofossil zonation scheme for the Boreal Campanian. International Nannofossil Association Newsletter 12: 67-70.

Burnett, J., 1996. Nannofossils and Upper Cretaceous (sub-)stage boundaries - state of the art. Journal of Nannoplankton Research 18: 23-32.

Burnett, J., 1998. Upper Cretaceous. In: Bown, P.R. (Ed.): Calcareous nannofossil biostratigraphy. Cambridge (Chapman & Hall): 132-199.

Burnett, J.A., Hancock, J.M., Kennedy, W.J. & Lord, A.R., 1992. Macrofossil, planktonic foraminiferal and nannofossil zonation at the Campanian-Maastrichtian boundary. Newsletters of Stratigraphy 27: 157-172.

Caron, M., 1985. Cretaceous planktic Foraminifera. In: Bolli, H.M., Saunders, J.B. & Perch-Nielsen, K. (Eds): Plankton stratigraphy. Cambridge University Press (Cambridge): 17-86.

Christensen, W.K., Hancock, J.M., Peake, N.B. & Kennedy, W.J., 2000. The base of the Maastrichtian. Bulletin of the Geological Society of Denmark 47: 81-85.

Cunha, A.S., Antunes, R.L. & Burnett, J.A., 1997. Calcareous nannofossils and the Santonian/Campanian and Campanian/Maastrichtian boundaries on the Brazilian Continental Margin: historical overview and state of the art. Cretaceous Research 18: 823-832.

Gardin, S., Del Panta, F., Monechi, S. & Pozzi, M., 1995. Calcareous nannofossil biostratigraphical events at the Santonian/Campanian and Campanian/Maastrichtian boundary in western Tethys. Abstracts of the Second International Symposium on Cretaceous Stage Boundaries, Brussels: 172.

Hancock, J.M. & Kennedy, W.J., 1993. The high Cretaceous ammonite fauna from Tercis, Landes, France. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 63: 149-209.

Hancock, J.M., Peake, N.B., Burnett, J., Dhondt, A.V., Kennedy, W.J. & Stokes, R.B., 1993. High Cretaceous biostratigraphy at Tercis, south-west France. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 63: 133-148.

Hancock, J.M., Russell, E.E., Taylor, R.H. & Gale, A.S., 1992. The relative stratigraphic position of the foraminiferal and belemnite standards for the Campanian-Maastrichtian boundary. Geological Magazine 129: 787-792.

Ivanov, M.I. & Stoykova, K.H., 1994. Cretaceous/Tertiary boundary in the area of Bjala, eastern Bulgaria - biostratigraphic results. Geologica Balcanica 24: 3-22.

Jagt, J.W.M. & Felder, W.M., 2003. The stratigraphic range of the index ammonite *Pachydiscus neubergicus* (von Hauer, 1858) in the type area of the Maastrichtian Stage. Netherlands Journal of Geosciences 82: 261-268.

Kennedy, W.J. & Summesberger, H., 1986. Lower Maastrichtian ammonites from Neuberg, Steiermark, Austria. Beiträge zur Paläontologie von Österreich 12: 181-242.

Kennedy, W.J. & Summesberger, H., 1987. Lower Maastrichtian ammonites from Nagorjany (Ukrainian SSR). Beiträge zur Paläontologie von Österreich 13: 25-78.

Küchler, T. & Kutz, A., 1989. Biostratigraphie des Campan bis Unter-Maastricht der E-Barranca und des Urdiroz/Imiscoz-Gebietes (Navarra, N-Spanien). In: Wiedmann, J. (Ed.): Cretaceous of the Western Tethys. Proceedings of the Third International Cretaceous Symposium, Tübingen 1987. Schweizerbart (Stuttgart): 191-213.

Küchler, T., Kutz, A. & Wagreich, M., 2001. The Campanian-Maastrichtian boundary in northern Spain (Navarra province): the Imiscoz and Erro sections. In: Odin, G.S. (Ed.): The Campanian and Maastrichtian Stage Boundary. Characterisation at

- Tercis les Bains (France) and Correlation with Europe and other Continents [Developments in Palaeontology and Stratigraphy, 19]. Elsevier (Amsterdam): 723-744.
- Küchler, T. & Wagreich, M., 1999. Macro- and nannofossil distribution across the Campanian-Maastrichtian boundary interval in Navarra, northern Spain. *In*: Schulp, A., Jagt, J.W.M. & de Graaf, D.T. (Eds): The 150th anniversary of the Maastrichtian Stage: a celebratory conference (abstracts). Natuurhistorisch Museum Maastricht (Maastricht): 41.
- Kutz, A., 1995. Kalk-Mergel-Rhythmite der Oberkreide (Campan und Maastricht) am Massiv von Oroz Betelu (N-Spanien, Provinz Navarra). Ein Exkursionsführer. Berliner geowissenschaftliche Abhandlungen E16 (Gundolf-Ernst-Festschrift): 289-304.
- Monechi, S. & Thierstein, H.R., 1985. Late Cretaceous-Eocene nannofossil and magnetostratigraphic correlations near Gubbio, Italy. *Marine Micropaleontology* 9: 419-440.
- Odin, G.S., 1996 (comp.). Definition of a Global Boundary Stratotype Section and Point for the Campanian/Maastrichtian boundary. *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre* 66 (Supplement): 111-117.
- Odin, G.S., 2001 (Ed.). The Campanian-Maastrichtian Stage Boundary. Characterisation at Tercis les Bains (France) and Correlation with other Continents (Developments in Palaeontology and Stratigraphy, 19). Elsevier (Amsterdam): xxviii + 881 pp.
- Odin, G.S., Courville, P., Machalski, M., Cobban, W.A. & Kennedy, W.J., 2001. The Campanian-Maastrichtian ammonite fauna from Tercis (Landes, France); a synthetic view. *In*: G.S. Odin (Ed.): The Campanian-Maastrichtian Stage Boundary. Characterisation at Tercis les Bains (France) and Correlation with other Continents [Developments in Palaeontology and Stratigraphy, 19]. Elsevier (Amsterdam): 550-567.
- Perch-Nielsen, K., 1985. Mesozoic calcareous nannofossils. *In*: Bolli, H.M., Saunders, J.B. & Perch-Nielsen, K. (Eds): *Plankton stratigraphy*. Cambridge University Press (Cambridge): 329-426.
- Premoli Silva, I. & Sliter, W.V., 1994. Cretaceous planktonic foraminiferal biostratigraphy and evolutionary trends from the Bottaccione section, Gubbio, Italy. *Palaeontologia Italica* 82: 1-89.
- Rawson, P.F., Dhondt, A.V., Hancock, J.M. & Kennedy, W.J., 1996 (Eds). *Proceedings 'Second International Symposium on Cretaceous Stage Boundaries'*, Brussels 8-16 September 1995. *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre* 66 (Supplement): 1-117.
- Robaszynski, F., Bless, M.J.M., Felder, P.J., Foucher, J.-C., Legoux, O., Manivit, H., Meessen, J.P.M.T. & Van Der Tuuk, L.A., 1985. The Campanian-Maastrichtian boundary in the chalky facies close to the type-Maastrichtian area. *Bulletin des Centres de Recherches et d'Exploration-Production Elf-Aquitaine* 9: 1-113.
- Rögl, F., von Salis, K., Preisinger, A., Aslanian, S. & Summesberger, H., 1995. A continuous Cretaceous/Paleogene boundary section near Bjala, Bulgaria. *Newsletter of the International Subcommission on Paleogene Stratigraphy* 5: 11-17.
- Schönfeld, J. & Burnett, J., 1991. Biostratigraphical correlation of the Campanian-Maastrichtian boundary: Lägerdorf-Hemmoor (northwestern Germany), DSDP Sites 548A, 549, and 551 (eastern North Atlantic) with paleobiogeographical and paleoceanographical implications. *Geological Magazine* 128: 479-503.
- Schönfeld, J., Schulz, M.-G., McArthur, J.M., Burnett, J., Gale, A., Hambach, U., Hansen, H.J., Kennedy, W.J., Rasmussen, K.L., Thirlwall, M.F. & Wray, D.S., 1996. New results on biostratigraphy, palaeomagnetism, geochemistry and correlation from the standard section for the Upper Cretaceous white chalk of northern Germany (Lägerdorf-Kronsmoor-Hemmoor). *Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg* 77: 545-575.
- Simmons, M.D., Williams, C.L. & Hancock, J.M., 1996. Planktonic foraminifera across the Campanian/Maastrichtian boundary at Tercis, south-west France. *Newsletters on Stratigraphy* 34: 65-80.
- Sissingh, W., 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie en Mijnbouw* 56: 37-56.
- Wagreich, M., 1987. A contribution to the nannoflora of Nagorany (Ukrainian SSR; Upper Cretaceous). *Beiträge zur Paläontologie von Österreich* 13: 85-86.
- Wagreich, M. & Krenmayr, H.-G., 1993. Nannofossil biostratigraphy of the Late Cretaceous Nierental Formation, Northern Calcareous Alps (Bavaria, Austria). *Zitteliana* 20: 67-77.
- Wagreich, M., Küchler, T. & Summesberger, H., 1998. Integrated nannofossil, planktonic foraminifera and ammonite stratigraphy of some European key sections: Santonian-Campanian and Campanian-Maastrichtian boundaries. *Abstracts of the 16th Congress of the Carpathian-Balkan Geological Association*. Vienna: 632.
- Wagreich, M., Svábénická, L. & Egger, H., 1999. Paleobiogeographic aspects of Late Cretaceous calcareous nannofossil assemblages at a transect from the northern Tethys to the European temperate realm. *Geologica Carpathica* 50: 83-84.