THE CRETACEOUS-TERTIARY TRANSITION IN THE ARACHOVA SECTION, THE PARNASSUS-GHIONA ZONE, CENTRAL GREECE

Apostolos Alexopoulos, Nikolaos Solakius and Sophia Gregou

Alexopoulos, A.: Department of Geology, Univeristy of Athens, Panepistimioupoli Zografou, GR-157 71, Athens, Greece.
Solakius, N. & Gregou, S.: Departments of Historical Geology and Paleontology, University of Lund, Sölvegatan 13, S-223 62 Lund, Sweden.

Abstract

The thin-bedded limestones and the overlying argillaceous limestones belong to the late Maastrichtian *Abathomphalus mayaroensis* and *Kassabiana falsocalcarata* Zones as indicated by the presence of planktonic foraminifera. At the end of the Maastrichtian deposition was interrupted owing to a fall in sea level. Duringthe K-T transition and earlier part of the Paleocene, the carbonatic sea floor became subaerially exposed and brecciated. The sea invaded the Arachova area during the *Morozovella pseudobulloides* Zone of the early Paleocene with subsequent deposition of argillaceous carbonatic sediments above the brecciated Maastrichtian pavement. Sediments from *Globigerina cretacea*, *Globigerina fringa* and *Globigerina eugubina* Zones of the early Paleocene are lacking in the Arachova section as also seen when compared with the type section of the K-T boundary at El Kef. During the transition from the Maastrichtian to Paleocene the interruption was shorter in the Arachova area than in the central Parnassus platform.

Introduction

The transition from the Maastrichtian to the Paleocene in the arnassus-Ghiona Zone is characterized by an interruption in deposition owing to the fall in sea level which is believed to have been caused by tectonic movements in combination with the Cretaceous-Tertiary (K-T) boundary event (Solakius et al., 1989; Pomoni Papaioannou & Solakius, 1991; Solakius et al., 1992; Solakius in press; Solakius et al.,1994). In the central parts of the Parnassus-Ghiona Zone, the interruption began during the latest Maastrichtian and continued across the K-T boundary and throughout the earlier Paleocene and giving rise first to the development of hardgrounds at the top of the Maastrichtian carbonate pavement, and subsequently to its karstification owing to the subaerial exposure of the platform (Sernikaki, Prossilion, Solakius et al., 1989; Solakius et al., 992).

During the later part of the early Paleocene, shallow water invaded the central Parnassuss area allowing the development of stromatolites above the karstified carbonate substratum (Kalpakis, 1979; Solakius et al., 1989; Pomoni-Papaioannou & Solakius, 1991). These tidal flat conditions continued to appear in extensive areas of the platform throughout the middle Paleocene (Pomoni-Papaioannou & Solakius, 1991; Solakius in press).

Along the margins of the platform, on the other hand, the interruption in deposition during the K-T transition gave rise to the development of a brecciated horizon above the Mastrichtian argillaceous limestone, as previously evidence showed from the Arachova boundary section which was deposited in the northeastern margin of the platform (Combers, 1983; Gregou et al., 1994). Subsequently, argillaceous limestone was deposited above the brecciated horizon during the early Paleocene (Gregou et al., 1994). However, it is not clear when in the late Maastrichtian the interruption began at Arachova and for how long it continued in the early Paleocene. The duration of this interruption can be seen in a high-resolution biostratigraphic scheme (Fig. 2) that is based on the planktonic foraminifera found in the beds and compared with the planktonic foraminiferal biozonation distinguished in the type section of the K-T boundary at El Kef (Brinkhuis & Zachariasse, 1988). The environments of deposition that prevailed during the late Maastrichtian / early Paleocene interval at Arachova have been assessed and compared with the marine conditions described from the

Geol. Soc. Greece, Sp. Publ., No. 4, 1995
Proceedings of the XV Congress of the Carpatho-Balcan Geological Association, September 1995, Athens Greece

Prossilion boundary section in the central Parnassus platform since the latter represents a different depositional environment (Pomoni-Papaioannou, 1994) (Fig.3).

Geological setting and lithology of the Arachova section

The boundary section studied is exposed close to the old bridge at Arachova and represents part of a klippe which appears between the Arachova and Davlia (Fig.1). Combes (1983) interpreted this klippe as being part of the Parnassus platform which was removed from the northeastern marginal areas, transitional to the "Beotian Zone".

The section which represents the transition from the carbonate to the flysch facies and which was described in detail by Gregou et al., (1994) shows the following lithology (from below): (a) the limestone with rudist fragments (b) the pelagic limestone (c) the red argillaceous limestone of Flaserkalke type and the brecciated horizon (Fig.2).

Biostratigraphy
Distribution of planktonic foraminifera and zonation

The foraminiferal assemblages recorded in the thin-bedded pelagic and the overlying argillaceous limestones (Fig. 2) include important planktonic foraminiferal species such as *Globotruncana linneiana* (D'Orbigny), *Globotruncana arca* (Cushman), *Globotruncana insignis* (Gandolfi), *Globotruncanita stuarti* (De Lapparent), *Globotruncanita stuartiformis* (Dalbiez), *Abathomphalus mayaroensis* (Bolli), *Pseudotextularia elegans* (Rzehak), *Rosita contusa* (Cushman), *Globotruncana falsostuarti* (Sigal), *Kassabiana falsocalcarata* (Kerdany & Abdelsalam), *Racemiguembelina fructicosa* (Egger), *Globotruncanella havanensis* (Voorwijk), *Racemiguembelina extulariformis* (White), *Rosita fornicata* (Plummer), *Pseudotextularia deformis* (Kikoine), *Globotruncana conica* (White) and *Racemiguembelina powelli* (Smith & Pessagno). These species indicate that the beds were deposited during the late Maastrichtian. The presence of two important zone markers in the assemblages examined, *Abathomphalus mayaroensis* and *Kassabiana falsocalcarata*, allow us to distinguish the late Maastrichtian *Abathomphalus mayaroensis* and *Kassabiana falsocalcarata* Zones in this part of the Arachova section (Fig. 2). Here, it is of importance to add, that at the top of the Maastrichtian limestone abundant calcispheres and echinoderms were recorded.

The foraminiferal assemblages recorded in the brecciated horizon, on the other hand, consist of late Maastrichtian and early Paleocene planktonic foraminiferal species.

Thus, the foraminiferal species recorded in the nodules which appear together with calcispheres are represented by *Rosita contusa*, *Racemiguembelina fructicosa* and *Kassabiana falsocalcarata* proving that the nodules were of late Maastrichtian age while the presence of small early Danian planktonic foraminifera together with sporadically represented larger morphotypes of *Globigerina trinoculinoides* Plummer and *Morozovella pseudobulloides* (Plummer) found in the matrix of the brecciated horizon indicates that it was deposited during the early Paleocene. The last two species became abundant in the first layers of the argillaceous limestone overlying the brecciated horizon (Fig. 2). Using the stratigraphical range of *Morozovella pseudobulloides*, the *Morozovella pseudobulloides* Zone is distinguished in these beds (Fig. 2). The presence of small Danian foraminifera (not identifiable in thin sections) which appeared in the sea waters at the beginning of the *Morozovella pseudobulloides* Zone or probably earlier (Brinkhuis & Zachariasse, 1988), together with the zone marker of this zone indicates that the first Paleocene sediments were deposited at Arachova in the *Morozovella pseudobulloides* Zone.

The interruption in deposition during the Cretaceous-Tertiary transition

The above evidence shows that an interruption in deposition took place during the terminal Maastrichtian and earliest Paleocene intervals. The correlation with the El Kef section, Tunisia, indicates that sediments representing the uppermost part of the *Abathomphalus mayaroensis* Zone, in which the planktonic foraminifera are rare (Fig. 3), are not present in Arachova since in the top layers of argillaceous limestone and the nodules of the overlying brecciated horizon the late Maastrichtian planktonic foraminifera are common. They included, however, *Kassabiana falsocalcarata*, a planktonic foraminiferal species which lived during the late Maastrichtian (upper part of the *A. mayaroensis* Zone) becoming extinct at the top of the Maastrichtian (Solakius, 1983). This species is also found in the K-T boundary section at Poty quarry, Brazil, where it became

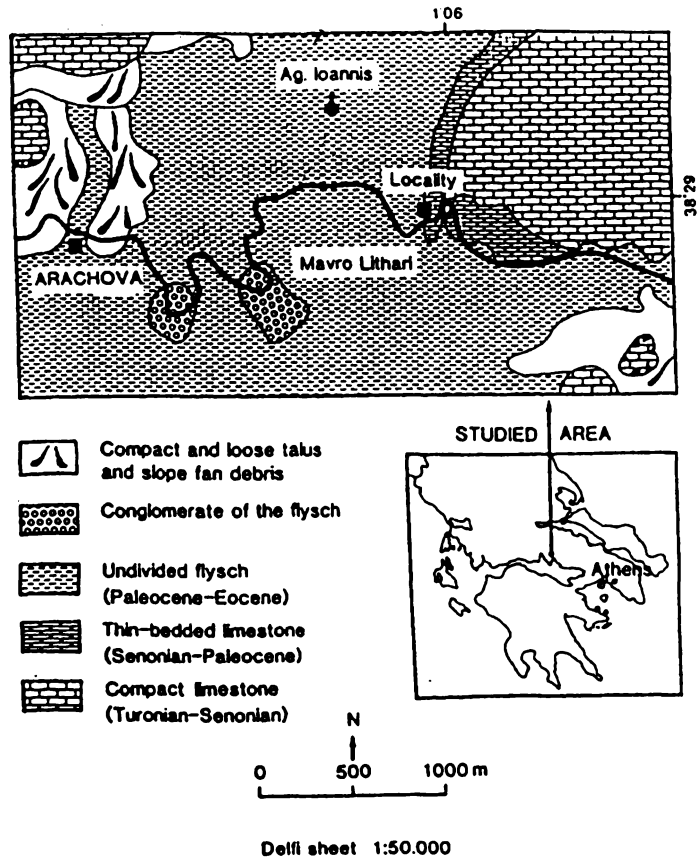


Fig. 1. Geological map showing the location of the section studied

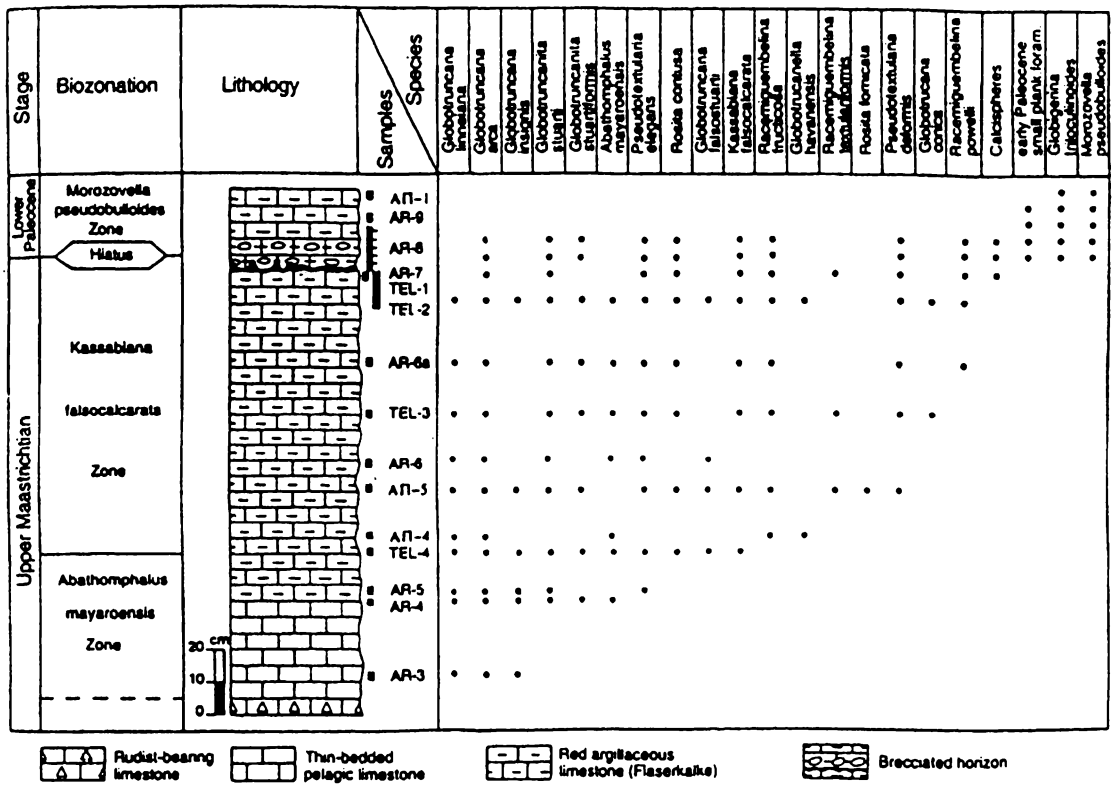


Fig. 2. Lithology and biostratigraphy of the section examined.

extinct at the K-T boundary (Albertao et al., 1994). This indicates that the deposition at Arachova continued almost to the end of the Maastrichtian when it was interrupted immediately before the K-T boundary. Also the sediments from the *Globigerina cretacea*, *Globigerina fringa* and *Globigerina eugubina* Zones are lacking in the Arachova section, a fact which together with the evidence presented that the brecciated horizon represents a paleosol profile (in Gregou et al., 1994) suggest that the Arachova area was subaerially exposed during this interval.

The late Maastrichtian world wide regression (Haq et al., 1987), also caused a fall in sea level in the Arachova area. During the latest Maastrichtian, the sea was shallow in the Arachova where echinoderms colonized the sea floor while in the water column planktonic foraminifera and small calcispheres appeared (Fig. 3). The sea level continued to fall causing an interruption in deposition close to the end of the Maastrichtian which led to the development of a hardground at the top of the argillaceous limestone through mineralization and lithification of the carbonate layers. The rapid fall in sea level during the K-T transition led to subaerial exposure of the carbonate substratum, its subsequent karstification and brecciation through soil-forming processes (Fig. 3). The invasion of the sea water which covered the karstified pavement, due to Paleocene transgression, may have taken place no later than the earliest Paleocene when the small planktonic foraminifera colonized the marine environments together with large morphotypes of *Globigerina triloculinoides* and *Morozovella pseudobulloides*. The Maastrichtian brecciated substratum became reworked and carbonate sediments with periodic clastic influx were deposited above it.

Comparison with the Prossilion section

The conditions of deposition that prevailed during the transition from the Maastrichtian to the Paleocene at Arachova differed from those in the central Parnassus platform (Solakius et al., 1989: Solakius et al., 1992). Thus, in the Prossilion area the open marine conditions which prevailed during the Maastrichtian and where pelagic limestone beds were deposited, interrupted during the latest Maastrichtian (upper part of the K. falsocalcarata Zone, Fig.3) due to fall of the sea level and gave rise to the development of hardgrounds at the top of the Maastrichtian limestone (Pomoni Papaioannou & Solakius, 1991). The continued retreat of the sea led to the exposure and karstification of the Maastrichtian carbonatic sea floor. The subsequent Paleocene transgression reached the Prossilion area during the later part of the early Paleocene (upper part of M. Pseudobulloides Zone), inducing tidal-flat conditions in which stromatolites developed.

If the Arachova and Prossilions sections are compared it is evident that the break in deposition began earlier in the Prossilion area than in the Arachova area since the sediments with calcispheres and planktonic foraminifera recorded in the top layers of the argillaceous limestone and in the nodules of the brecciated horizon at Arachova (uppermost part of the K. falsocalcarata Zone, Fig. 3) are lacking in the Prossilion section as well as in other parts of the central Parnassus platform (Solakius et al., 1989; Solakius et al., 1992).

The Prossilion area was also exposed for a longer period than the Arachova area since the sea water covered the Arachova area in the beginning of *Morozovella pseudobulloides* Zone or earlier while the transgression reached the Prossilion area during the later part of the *Morozovella pseudobulloides* Zone (Fig. 3).

The pelagic conditions which appeared during the Maastrichtian at Prossilion was replaced during the Paleocene by shallow-water (tidal flat conditions), while in the Arachova area the late Maastrichtian open marine conditions continued during the Paleocene. These changes in environments prove that the Arachova area continued to subside also through the Paleocene, while at Prossilion and other areas of central Parnassus platform, the Maastrictian subsidence ceased during the K-T transition (Solakius & Pomoni-Papaioannou, in press).

Summary

The thin-bedded limestones and the overlying argillaceous limestones of the Arachova section investigated, were deposited during the late Maastrichtian interval as shown by the presence of the planktonic foraminifera assemblages recorded. On the basis of two important index species found in these assembages, *the Abathomhalus mayaroensis* and *Kassabiana falsocalcarata* Zone were distinguished in these beds. The fall in sea level which began during the latest Maastrichtian led to an interruption in deposition which continued into the earlier part of the Paleocene. During this period the sea floor at Arachova became exposed, karstified and brecciated. The Paleocene transgression reached the Arachova area during the early Paleocene when the large-sized *Morozovella pseudobulloides* and *Globigerina triloculinoides* appeared in the

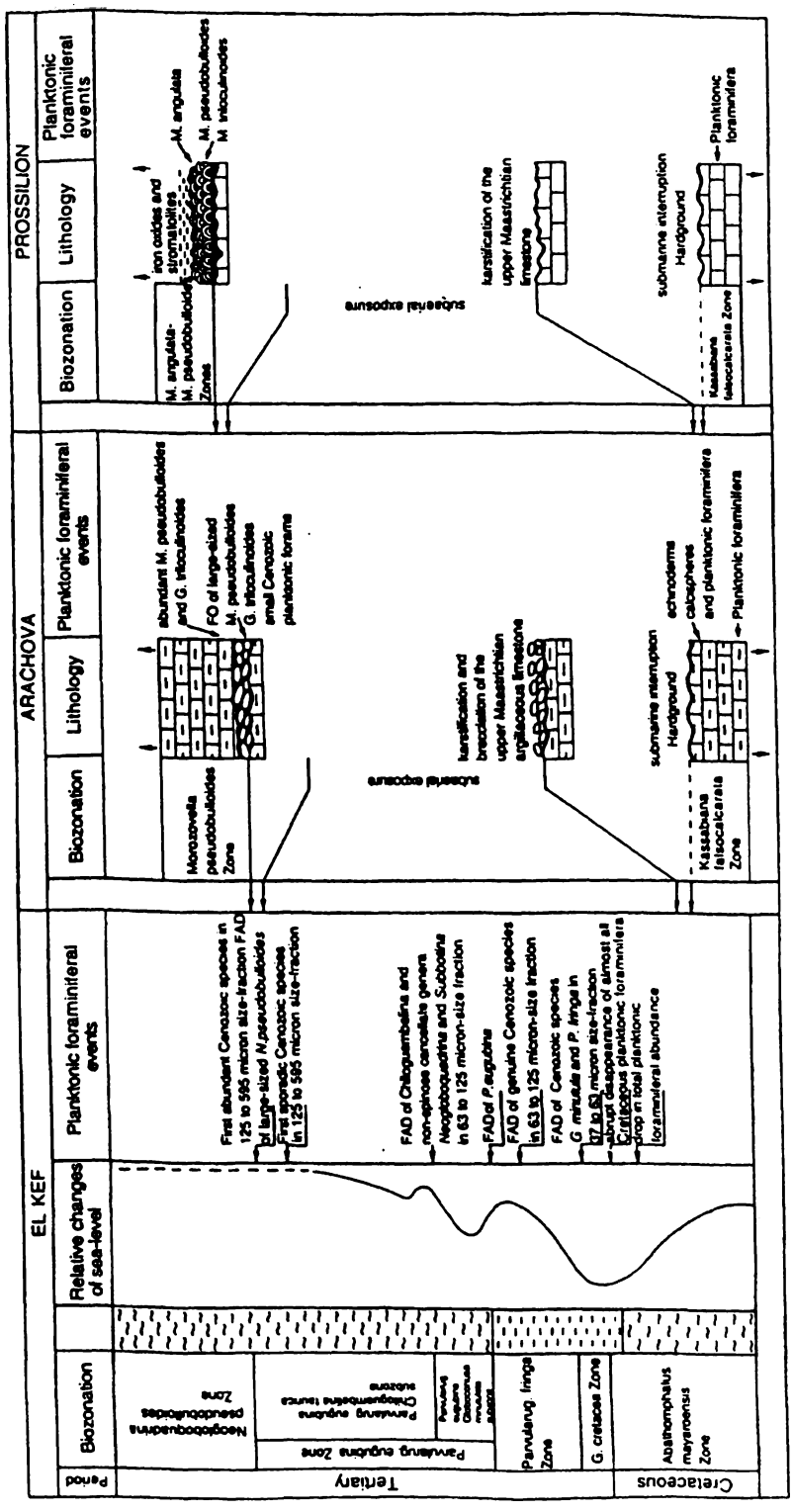


Fig. 3. Comparison of the Arachova section with the type section of the K-T boundary at El Kef and with the Prossilion boundary section from central Parnassus platform.

sea. Thus sediments from the terminal Maastrichtian and from *Globigerina cretacea*, *Globigerina fringa* and *Globigerina eugubina* Zones of the earlier part of the Paleocene are lacking in the Arachova section, and the first sediments deposited in the area during the Paleocene (argillaceous limestones) belong to *Morozovella pseudobulloides* Zone. The coparison with the

Prossilion boundary section shows that the interruption of deposition was shorter in the Arachova area than in the Prossilion area since the subsidence continued also during the Paleocene. At Prossilion and other parts of central Parnassus platform on the other hand subsidence ceased leading to shallow marine conditions throught the later part of the early Paleocene and middle Paleocene.

Acknowledgements

The authors wish to thank Margaret Greenwood-Petersson for the linguistic revision of the manuscript.

References

ALBERTAO, G.A., KOUTSOUKOS, E.A.M., REGALI, M.P.S., ATTREP, M.Jr., MARTINS, P.P.Jr. The Cretaceous-Teriary boundary in southern low-latitude regions: preleminary study in Pernambuco, northeastern Brazil. *Terra Nova*, 6, 366-375

BRINKHUIS, H. & ZACHARIASSE, W.J. (1988). Dinoflagelate cysts, sea level changes and planktonic foraminifers across the Cretaceous-Tertiary boundary at El Haria, northwestern Tunisia. *Marin. Micropal.*, 13, 153-191.

COMBES, P.J. (1983). Découverte d'une nouvelle nappe d'origine nord-orientale dans la zone du Parnasse Grèce. *C.R. Acad. des Sciences de Paris*, 296 II, 397-400.

GREGOU, S., SOLAKIUS, N. & POMONI-PAPAIOANNOU F. (1994). The carbonate-flysch transition (late Maastrichtian-late Palaeocene) in the Arachova sequence of the Parnassus-Ghiona Zone, central Greece. *Geol. Mag.*, 131, 819-833.

HAQ, B., HARDENBOL, J. & VAIL, P.R. (1987). Chronology of fluctuating sea-levels since the Triassic. *Science*, 235, 1156-1167.

KALPAKIS, G. (1982). Contribution a l'etude sédimentologique de la zone Parnasse-Kiona. Biomicrites, stromatolithes, horizon hard grounds á limite du Cretacé-Paléocéne. PhD Thesis, Univ. Athens, 129pp.

POMONI-PAPAIOANNOU, F. (1994). Palaeoenvironmental recostruction of a condensed hardground-type depositional sequence at the Cretaceous-Tertiary contact in the Parnassus-Ghiona Zone, central Greece. *Sed. Geol.*, 93, 7-24.

POMONI-PAPAIOANNOU, F. & SOLAKIUS, N. (1991). Phosphatic hardgrounds and stromatolites from the limestone/shale boundary section at Prossilion (Maastrichtian-Palaeocene) in the Parnassus-Ghiona Zone, Central Greece. *Palaeo. Paleo. Palaeo.*, 86, 243-254.

SOLAKIUS, N. (1983). Maastrichtian planktonic foraminifera from northeastern Tunisia. *Lund Publ. Geol.*, 22pp.

SOLAKIUS, N. (in press). Depositional changes in the Parnassus-Ghiona Zone, central Greece, during the Paleocene. *Bull. Geol. Soc. Greece.*

SOLAKIUS, N., POMONI-PAPAIOANNOU, F. & MARANGOUDAKIS, N. (1989). Planktic foraminiferal biostratigraphy and sedimentology of the Cretaceous-Tertiary boundary in the Sernikaki section (The Parnassus-Ghiona Zone, central Greece). *Rev. Espan. Micropal.*, 21, 373-389.

SOLAKIUS, N., LARSSON, K. & POMONI-PAPAIOANNOU, F. (1992). Planktic foraminiferal biostratigraphy of the carbonate/flysch transitional beds at Prossilion, in the Parnassus-Ghiona Zone, Central Greece. *Acta Geol. Hungarica*, 35, 441-445.

SOLAKIUS, N., POMONI-PAPAIOANNOU, F. & GREGOU, S. (1994). The Cretaceous-Tertiary boundary at the Parnassus-Ghiona Zone, Central Greece. *12 Colloque Afr. Micropal., 2 Colloque Strat. and Paleogeogr. Atlant. Sud. Angers 1994.* Abstract, p. 135.

SOLAKIUS, N. & POMONI-PAPAIOANNOU, F. (in press). Planktonic foraminiferal biostratigraphy and sequence stratigraphy of the carbonate-flysch sequence at Prossilion in the Parnassus-Ghiona Zone, Central Greece. *Bull. Geol. Soc.Greece.*