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LATE CRETACEOUS TO EARLY PALEOCENE PLANKTONIC FORAMINIFERAL STRATIGRAPHY OF THE AGIOS NIKOLAOS SEQUENCE, THE PARNASSUS-GHIONA ZONE, CENTRAL GREECE

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ABSTRACT

The planktonic foraminiferal assemblages of the Agios Nikolaos carbonate-flysch sequence show that after the late Campanian subsidence the previously shallow marine carbonate conditions were replaced by a pelagic environment in which limestone beds were deposited, except for an interruption in deposition during the early Maastrichtian and early part of the late Maastrichtian owing to the lowering of the sea level; deposition was resumed during the late Maastrichtian. During the K-T transition deposition ceased as a result of the K-T boundary event during which a brecciated horizon was formed at the top of the pelagic limestone. Marine conditions again prevailed during the early Paleocene with resulting to the deposition of pelagic carbonates followed by flysch deposition at the end of the Paleocene and in the early Eocene. The Agios Nikolaos area thus constituted part of the northeastern marginal areas of the Parnassus-Ghiona Zone which subsided during the late Campanian-Paleocene interval into a basin that developed in the Beotian domains, bordered by Parnassus to the west and the Pelagonian Zone to the east.

KEY WORDS: Late Cretaceous-early Paleocene planktonic foraminifera, Stratigraphy, Parnassus-Ghiona Zone, Hellenides, Greece.

1. INTRODUCTION

The klippe extending from the Arachova to Davlia forms part of a thrust sheet that advanced from the northeastern margin of the Parnassus platform south of Tithorea (Combes, 1983). This part of the margin was pushed into the Parnassian substrate when the Pelagonian nappe overthrusted, but only after the Beotian nappe was formed. Combes's (1983) hypothesis that the carbonatic formations of the Arachova klippe originated from the northeastern margins of the Parnassus platform, is based mainly on the absence of bauxite horizons (except at Kouvelos) in the Cretaceous successions found in the klippe. Gregou et al. (1994) indicated that the Arachova area, which makes up part of the klippe, originated from the northeastern marginal areas of Parnassus transitional to the Beotian basin since they found that the transitional beds (the pre-flysch deposits according to Gregou & Solakius, 1997) between the carbonate and flysch facies in the Arachova sequence had been deposited during the late Maastrichtian-Paleocene under pelagic carbonate conditions with the periodical influx of clastic material. The results of Alexopoulos et al. (1995) support this theory. They compared the upper Maastrichtian-lower Paleocene strata of the Arachova sequence with those of the Prossilion sequence from western-central Parnassus and

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found that in the Arachova area the late Maastrichtian pelagic sedimentation continued (except for a short interruption across the K-T boundary) throughout the Paleocene. On the other hand at Prossilion tidal flat conditions prevailed throughout the late early and middle Paleocene (Solakius et al., 1992).

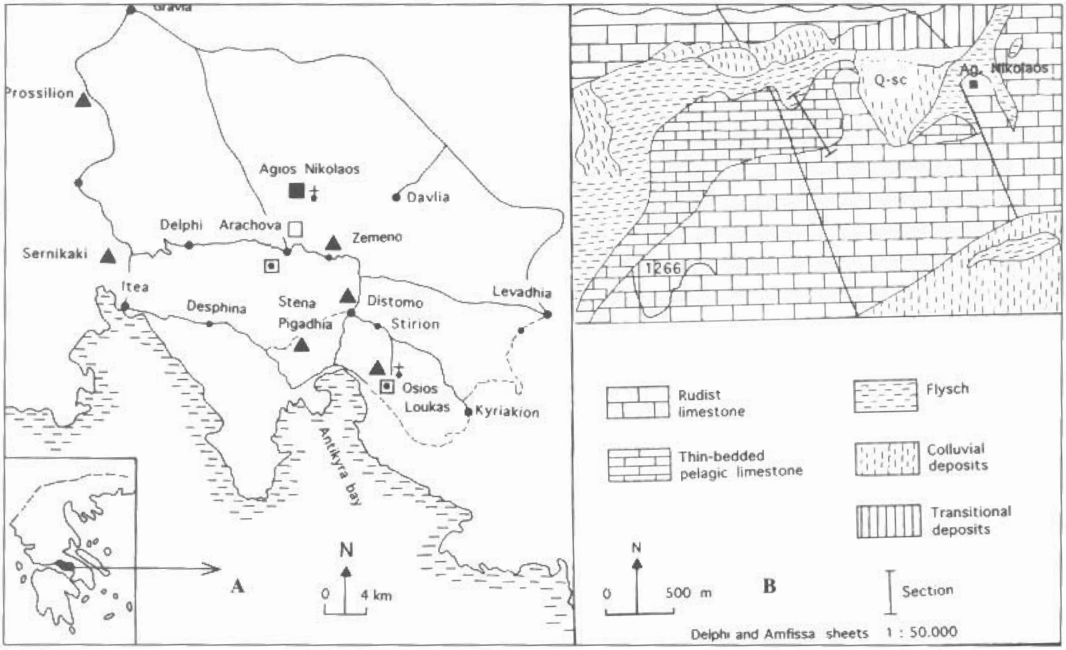

Fig. 1. A: Simplified topographic map showing the position of the areas discussed (from Gregou et al., 1994) and **B:** geological map showing the position the Agios Nikolaos sequence.

The question remains as to whether the other Upper Cretaceous - Paleocene carbonate-flysch sequences recorded in the Arachova klippe were deposited in the marginal areas or in environments resembling those of central Parnassus. We therefore investigated the carbonate-flysch sequence and its planktonic foraminiferal assemblages, in the neighbourhood of the chapel of Agios Nikolaos on the Arachova klippe (Fig. 1). The foraminiferal assemblages recorded in the beds include index species on which biozones have been distinguished in the sequence (Fig. 2). We have also compared the Agios Nikolaos and Arachova sequences with those from central Parnassus to demonstrate the difference in environments of deposition which existed in these areas during the Late Cretaceous-Paleocene interval (Fig. 3).

2. GEOLOGICAL SETTING AND LITHOLOGY OF THE AGIOS NIKOLAOS SEQUENCE

The Agios Nikolaos sequence is exposed close to the Arachova spring and the Agios Nikolaos chapel (Fig. 1) on the Arachova klippe. Combes (1983) described this klippe in detail and found that it comprises of thrust sheets composed mainly of a thick series of carbonates which originated from the northern marginal areas of Parnassus which formed the transition to the Beotian basin to the northeast.

The lithology of the sequence (from below upwards) is as follows (Figs 2, 4): **Rudist limestone** (32 m thick); a thick-bedded, grey, bituminous limestone with rudist shells and rudist and echinoderm fragments.

White-grey pelagic limestone (64 m thick); a thin-bedded pelagic limestone white-grey in colour with chert nodules of varying size; $CaCO_3$ content 80-98 % (Fig. 4).

Brecciated horizon (1.5 m thick); grey to green, overlies the pelagic limestone; includes echinoderms; $CaCO_3$ value 87 % (Fig. 4).

Grey pelagic limestone of Flaserkalke type (0.60 m thick); grey to green, overlies the brecciated horizon; $CaCO_3$ value 87 % (Fig. 4).

Olistostrome (5 m thick); It composes of 1-2 m thick blocks which are overlain the grey pelagic limestone of Flaserkalke type.

Grey pelagic limestone of Flaserkalke type (0,20 m). Above the olistostrome a thin bed of grey pelagic limestone of Flaserkalke occurs; it shows a $CaCO_3$ content of 90% (Fig. 4).

Olistostrome (7 m thick); Another olistostrome unit occurs above the thin bed of the grey pelagic limestone of Flaserkalke type.

Grey pelagic limestone (16 m thick); contains small chert nodules. $CaCO_3$ content 88-98% (Fig. 4).

Green marls (3 m thick); grey to green, pass upwards to flysch deposits. The green marls will be treated in a forthcoming paper.

3. PLANKTONIC FORAMINIFERAL STRATIGRAPHY

There are no planktonic foraminifera in the rudist limestone since it was deposited in very shallow water. In the pelagic limestone beds planktonic foraminifera are abundant and show considerable species diversity. These assemblages included zone markers on the basis of which the following biozones were distinguished (Fig. 2).

Late Cretaceous

In the white-grey pelagic limestone the foraminiferal species recorded are: *Globotruncana arca* (Cushman), *Globotruncanita calcarata* (Cushman), *Rosita fornicata* (Plummer), *Globotruncana linneiana* (D΄Orbigny), *Globotruncana*

bulloides Vogler, *Pseudotextularia elegans* (Rzehak), *Globotruncana arca rugosa*

(Marie), *Globotruncanita elevata* (Brotzen), *Heterohelix* sp.,

Globotruncanella havanensis (Voorwijk), *Rosita patelliformis* (Gandolfi), *Globotruncana ventricosa* White, *Globotruncanita atlantica* Caron, *Globotruncanita stuartiformis* (Dalbiez), *Racemiguembelina textulariformis* (White), *Globotruncana insignis* Gandolfi and *Rugoglobigerina* sp. The total range of *Globotruncanita calcarata* marks the *Globotruncanita calcarata* Zone of the late Campanian (Robaszynski et al., 1979; Caron, 1985) . According to these authors the last occurrence of this species (LO) also marks the Campanian-Maastrichtian boundary. However, the Campanian-Maastrichtian boundary is lacking in the Agios Nikolaos sequence; the foraminiferal assemblages found in the upper part of the white-grey pelagic limestone appeared during the late Maastrichtian and belong to the *Abathomphalus mayaroensis-Kassabiana falsocalcarata* Zones of this interval which were defined on the total ranges of the index species *Abathompahalus mayaroensis* (Bolli) and *Kassabiana falsocalcarata* (Kerdany & Abdelsalam) (Robaszynski et al., 1979; Solakius, 1983; Caron, 1985;). Other species recognized in these assemblages were: *Rosita contusa* (Cushman) , *Rosita plicata* (White), *Globotruncanella havanensis*, *Gansserina gansseri* (Bolli), *Racemiguembelina fructicosa* (Egger), *Racemiguembelina powelli* Smith & Pessagno, *Globotruncanita stuarti* (De Lapparent), *Globotruncana conica* White, *Globotruncana falsostuarti* Sigal, *Pseudotextularia deformis* (Kikoine) *Plummerita* sp., *Rugoglobigerina* sp. and the late Campanian species *Pseudotextularia elegans*, *Globotruncana arca* , *Rosita fornicata* , *Globotruncana linneiana* , *Globotruncana bulloides* , *Globotruncanita stuartifromis* , *Globotruncana insignis* and *Heterohelix* sp. which also occured during the Maastrichtian.

From this distribution of the planktonic foraminifera it can be seen that an interruption in deposition took place during the early Maastrichtian and earlier part of the late Maastrichtian in the Agios Nikolaos area (Fig. 2).

K-T transition

The foraminiferal species recorded in the brecciated horizon comprise reworked late Maastrichtian planktonic foraminifera, Calcisphaeres and small Paleocene planktonic foraminifera. *Morozovella pseudobulloides* (Plummer) and *Globigerina triloculinoides* Plummer have also been identified, which indicates an interruption in deposition during the K-T transition which is also supported by the lack of *Globigerina eugubina* (Luterbacher & Premoli-Silva), *Globigerina fringa* (Subbotina) and other planktonic foraminiferal species from the K-T transition (Fig. 2).

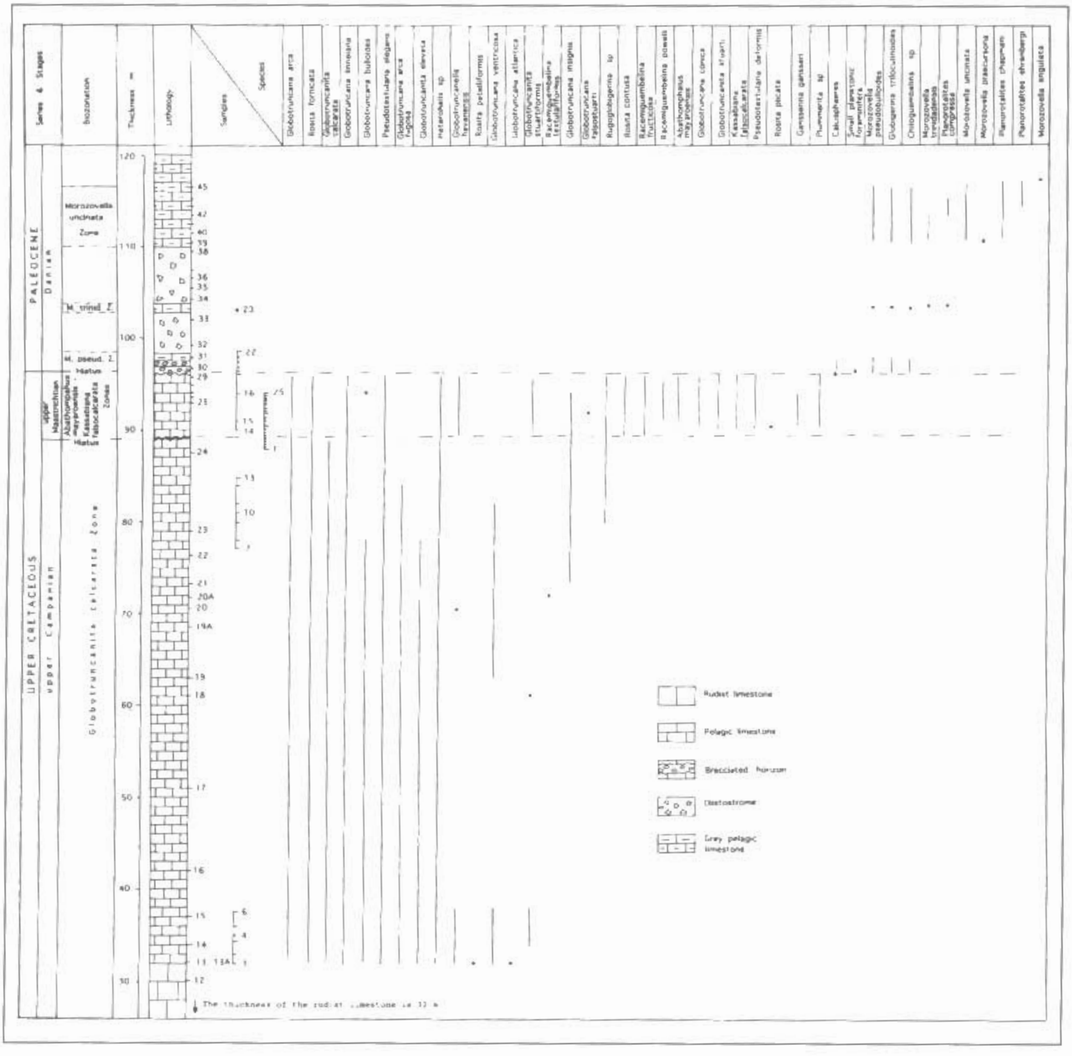

Fig. 2: Biozonation and distribution of the planktonic foraminifera examined.

Early Paleocene

In the grey limestone of Flaserkalke type that overlies the brecciated horizon, the species *Morozovella pseudobulloides*, *Globigerina triloculinoides* appear together with *Chiloguembelina* species (Fig. 2). *Morozovella pseudobulloides* thus defines the *Morozovella pseudobulloides* Zone of the early Paleocene (Toumarkine & Luterbacher, 1985). However, the upper boundary of this zone could not be defined since these limestone beds are overlain by olistostrome.

In the thin bed of the grey limestone of Flaserkalke type found between the olistostrome units (Fig. 2), the early Paleocene planktonic foraminifera *Morozovella pseudobulloides*, *Globigerina triloculinoides*, *Chiloguembelina sp.*, *Morozovella trinidadensis* (Bolli) and *Morozovella compressa* (Plummer) representing the *Morozovella trinidadensis* Zone of the early Paleocene (Toumarkine & Luterbacher, 1985) were defined. Finally, in the grey pelagic limestone, the foraminiferal species, *Morozovella pseudobulloides*, *Globigerina triloculinoides*, *Morozovella trinidadensis*, *Morozovella compressa* and *Chiloguembelina sp.* appear together with *Morozovella uncinata* (Bolli), *Morozovella praecursoria* (Morozova), *Planorotalites champani* (Parr), *Planorotalites ehrenbergi* (Bolli) and *Morozovella angulata* (White). On the basis of the stratigraphical range of the index species *M. uncinata* the *Morozovella uncinata* Zone (Fig. 2) could be defined in the grey limestone (Toumarkine & Luterbacher, 1985).

4. DISCUSSION AND CONCLUSIONS

The above stratigraphical data is evidence that during the early part of the Campanian (and earlier) the Agios Nikolaos area was covered by shallow water which gave rise to the deposition of the limestone with rudists. This facies prevailed over the entire Parnassus platform, the Beotian trough and the Pelagonian Zone which during the early part of the Late Cretaceous together formed a region of carbonatic deposition (Richter et al., 1996) of which the Agios Nikolaos area formed a part.

During the late Campanian pelagic conditions arose in the Agios Nikolaos area as the result of tectonic movements that affected the Parnassus platform giving rise to the development of horsts and grabens (Richter & Mariolakos, 1974b). Thin-bedded, biomicritic, pelagic limestone was deposited in the Agios Nikolaos area as well as in the grabens in the central areas, while on the horsts shallow water deposition prevailed except for the topographic highs which were exposed (Gregou & Solakius, 1997).

The interruption in deposition that took place in the Agios Nikolaos area during the early Maastrichtian and early part of the late Maastrichtian was the result of a lowering of the sea level which affected the entire Parnassus platform. In the areas of Parnassus where deposition was not interrupted condensed carbonatic sequences of a few metres in thickness appear e.g. at Prossilion (Solakius & Pomoni-Papaioannou, 1992) (Fig. 3). During the late Maastrichtian pelagic carbonatic deposition was resumed in the Agios Nikolaos area but was interruped during the latest Maastrichtian-earliest Paleocene as a result of the K-T boundary event which gave rise to the development of the brecciated horizon at the top of the white-grey pelagic limestone. During this interval the seafloor in the Arachova area and in some areas of the horsts as in Stena Pigadhia, Zemeno, began to subside and deposition of biomicritic limestones took place. However, in the Arachova area the carbonatic environment received the first fluxes of clastic material indicating that the source was not far distant. Deposition was also interrupted here during the K-T transition due to the fall in sea level over the entire platform (Gregou & Solakius, 1997; Solakius, in press) which caused the development of the brecciated horizon on top of the pelagic limestone, while in the horsts and grabens of central Parnassus phosphatic hardgrounds with iron oxides developed (Pomoni-Papaioannou & Solakius, 1992; Pomoni-Papaioannou, 1994) (Fig. 3)

This sedimentary development of the Agios Nikolaos sequence demonstrates that the shallow water deposition and the subsequent pelagic deposition of carbonates that took place during the Campanian and most of the Maastrichtian resembles the deposition in the grabens and deeper areas of central Parnassus (Fig. 3). The Agios Nikolaos seafloor began to subside during the late Campanian as at Prossilion and Osios Loucas in the central areas (Solakius & Pomoni-Papaioannou, 1992; Gregou & Solakius, 1997) indicating that similar conditions prevailed. The depositional conditions in the Arachova area during the Maastrichtian also resemble those in central Parnassus except for the clastic fluxes that periodically reached the Arachova area during the latest Maastrichtian (Fig. 3).

The difference in deposition in these areas occurred during the K-T transition and during the Paleocene. While the seafloor of central Parnassus became exposed and karstified at the end of the Maastrichtian and in the early Paleocene (or later) because of the fall in sea level (Solakius in press), the

Agios Nikolaos area continued to subside (except for the short interruption in deposition during the K-T transition), during most of the Paleocene which allowed the carbonatic deposition to continue. The Arachova area also continued to subside during the Paleocene except for the short period of exposure during the K-T transition, the area then being situated within the inner shelf. In the central areas, on the other hand, the Paleocene trangression gave rise to shallow-water conditions which allowed stromatolites to develop in the shallow areas while in the deeper water calcarenitic deposition prevailed (Gregou & Solakius, 1997; Solakius in press;) (Fig. 3).

It is thus obvious that the Agios Nikolaos and Arachova areas were situated within the northeastern marginal areas of Parnassus which subsided during the late Campanian-Paleocene into a basin that covered the Beotian domains and was bordered by the Pelagonian Zone to the east. With the shallowing of the Beotian trough and the deposition of carbonates after Santonian times, the sedimentary history of the Beotian Zone came to an end (Richter et al., 1996).

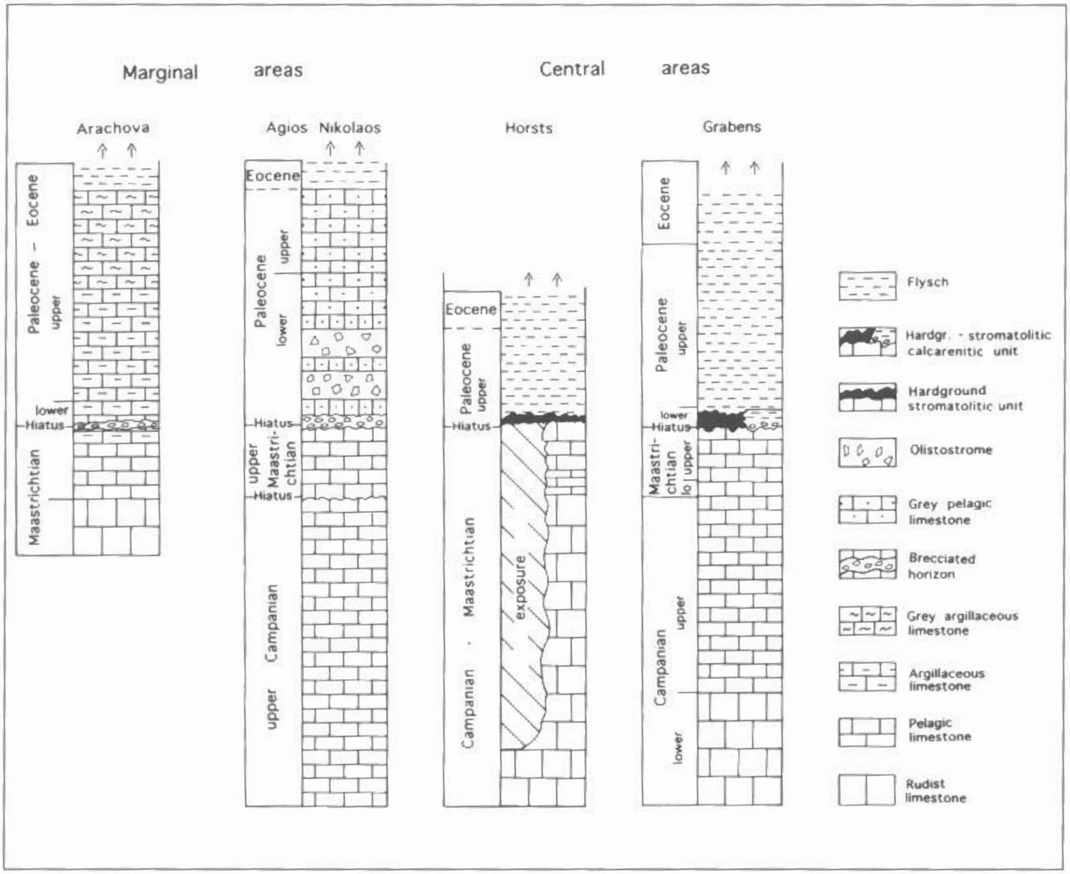

Fig. 3: Comparison of the carbonate-flysch sequence from the central and marginal areas of the Parnassus-Ghiona Zone (sequences not scaled).

Instead a new basin began to develop between Parnassus and the Pelagonian Zone in which carbonates were deposited during the late Campanian - Paleocene and subsequently flysch during the Paleocene-Eocene transition. After the total collapse and subsidence of the tectonically stable Parnassus during the late Paleocene-early Eocene this basin extended westwards to the Vardussia subzone as indicated by the deposition of the red calcareous shales of the flysch which were deposited in a sea extenting from the Beotian domains to the east to the Vardussia subzone to the west (Gregou & Solakius, 1997). The tectonic movements that affected these zones during the early Tertiary when the Beotian sediments overthrusted the Parnassus - Ghiona Zone (Richter et al., 1996), transported the sediments of the marginal areas of Parnassus westwards probably in the manner as suggested by Combes (1983).

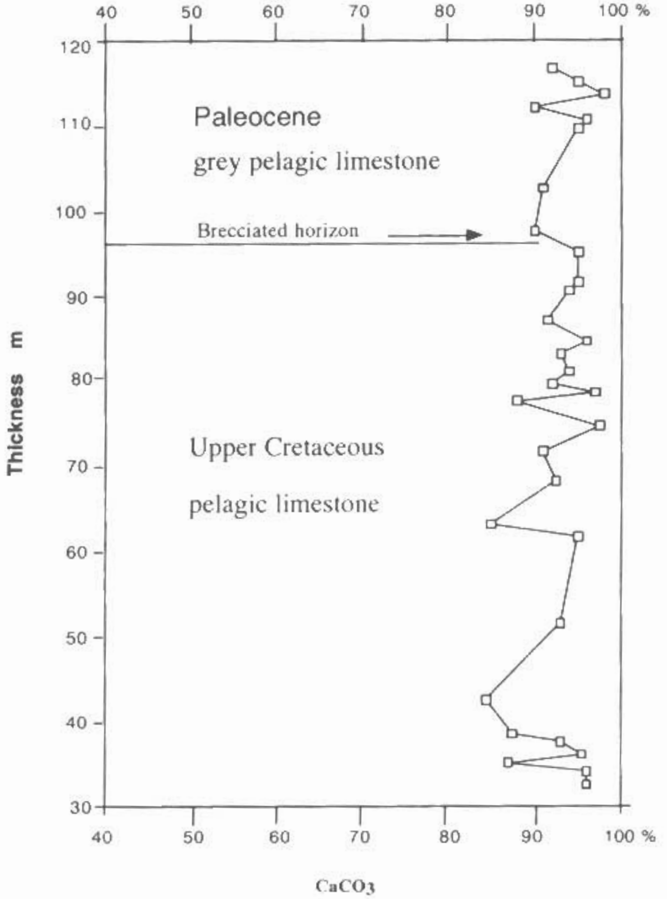

Fig. 4.: The $CaCO_3$ content in the Agios Nikolaos sequence

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