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LATE CRETACEOUS PALEOGEOGRAPHY AND HIPPURITID BIOSTRATIGRAPHY OF BEOTIA(GREECE)

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ABSTRACT

The Late Cretaceous paleogeography in Beotia has been established on the basis of hippuritid biostratigraphy. Hippuritids are abundantly preserved in the sequence of Turonian to Maastrichtian deposits, which are perfectly exposed in the area. They provide in fact reliable index fossils. Several of the recovered species are mentioned for the first time from Beotia.

A strong transgression affected South Beotia during the Aptian-Cenomanian whereas the region north of the Copais depression remained emersed until Santonian-Campanian times. Then, the sea invaded all of Beotia. This transgression postdated a period of emersion and bauxite formation in the Helikon and Paleovouna. The observed changes in sedimentary environments fit well with global fluctuations of sea level.

INTRODUCTION

Rudists have been reported from Beotia since the pioneering investigations of GAUDRY (1867) and BITTNER (1880). As a matter of fact, type localities of several hippuritid species are located in this province. Due to stratigraphic misinterpretations, especially of the Alpine Gosau deposits, their significance as index fossils has long been doubted. However, in the course of more recent investigations (e.g. POLSAK et al. 1982) it became obvious that rudists are probably the best macrofossils available for biostratigraphical dating of Cretaceous shallow water limestones in the Tethyan realm.

As hippuritids are commonly found in Beotia, valuable information concerning the biostratigraphy and paleogeography of the widespread Cretaceous deposits is expected. Quite often they are

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associated with yet incompletely known radiolitids and caprinids, their monographic description being under preparation.

REGIONAL GEOLOGY

In Beotia (fig.1), the Cretaceous transgression buried a pronounced relief, resulting from the closure of the Vardar-Ocean in the course of Eohellenian orogeny during the Early Cretaceous. The early mesozoic record of oceanisation started with the Anisian (STEUBER 1991, 1992) and continued until the Tithonian (SIMON 1987). Lateritic ore deposits formed during periods of emersion not only previous to the Cretaceous transgression, but also during the Jurassic and Late Cretaceous. Although a precise biostratigraphic scheme did not exist for these ore deposits, numerous investigations focused on the paleogeography of their depositional environments (eg. COMBES 1977, VALETON et al. 1987).
The detailed studies of KONERTZ (1987) resulted in a comprehensive description of Cretaceous rocks in the Helikon Mountains. Clastic sediments, previously reported as Paleogene flysch, were discovered to be of Albian to Cenomanian age, transgressively sealing the Eohellenian relief in the Helikon Mountains. This, of course, lead to new structural interpretations (JUX et al. 1987), although an Aptian age of transgressive limestones near Aliartos (fig.2) was already mentioned by CLEMENT (1970).

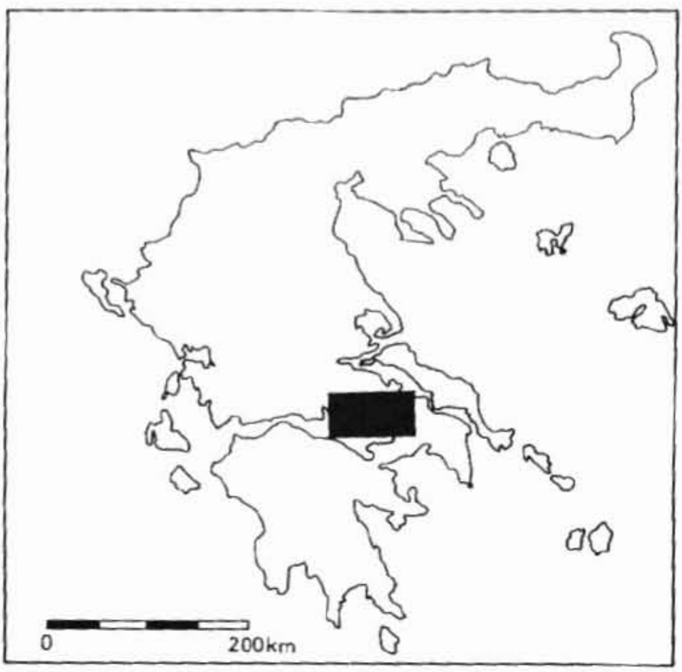

fig.1: area studied.

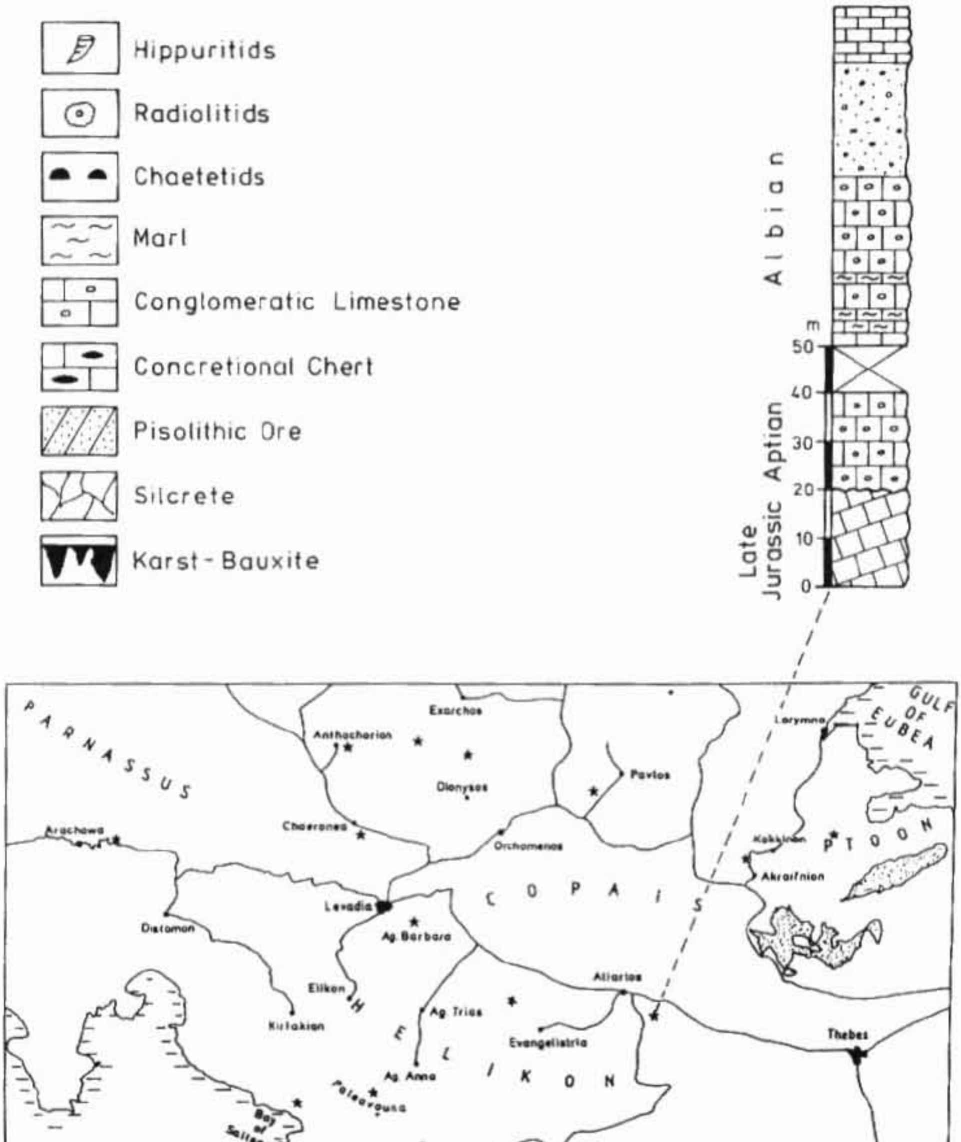

fig.2: location map and standard section of Aptian-Albian deposits from Aliartos (after KONERTZ 1987).

SECTIONS STUDIED

Ptoon Mountains: Lateritic iron and nickel ores mark the base level of the Cretaceous onlap in the Ptoon Mountains. Mining activities provide excellent exposures within the transgressive sediments. The eohellenian basement is composed of Middle to Late Jurassic oolites and limestones with *Cladocoropsis* and, at Kokkinon, Late Triassic *Megalodon*-limestones. Due to the economic potentials of the ore bodies, several investigations were concerned to establish a biostratigraphy of the onlapping deposits. However, little attention was paid to the abundant, well preserved hippuritids. As a matter of fact, the cretaceous trangression was dated as Cenomanian (TATARIS et al. 1970), Turonian (NOETH 1931, JORDAN 1990) and Early Senonian (BIGNOT & GUERNET 1968). The most precise age determination was given by NOETH (1931), who mentioned *Hippurites grossouvrei* DOUVILLE, *Radiolites lusitanicus* (BAYLE) und *Radiolites sauvagesi* (D'HOMBRES-FIRMAS). During recent field campaigns several specimens of

Vaccinites praegiganteus (TOUCAS),
Vaccinites inferus (DOUVILLE),
Radiolites ex gr. *lusitanicus* (BAYLE),
Radiolites ex gr. *praesauvagesi* TOUCAS

have been collected at the northern slope of Tsekoureli, E' of Ag. Ioannis (fig.3). They clearly indicate a late Turonian age. NOETH (1931) hesitated to argue on *H. grossouvrei* DOUVILLE because he only found right valves. As several complete specimens are available now, it is evident that we are dealing not with *H. grossouvrei* but with *V. inferus* (DOUVILLE). Both *V. praegiganteus* and *V. inferus* have scarcely been mentioned since the original descriptions by DOUVILLE (1894) and TOUCAS (1904).

Keratovouno at Chaeronea: The Keratovouno (Hörnerberg) was at first described by GAUDRY (1867). The site is known for a well exposed hippuritid biostrome, the type locality of *Vaccinites gaudryi* (MUNIER-CHALMAS). There are, however, quite contradicting opinions about the local geological setting. Although BITTNER (1880) gave a precise description of the section, KLINGHARDT (1948) mentioned "wild geklüftete Kalke, die, wie gewöhnlich, keine sichere Bankung erkennen lassen". Furthermore he described *Radiolites lusitanicus* (BAYLE) var. *rigida* CHOFFAT, a species which I could not recognized during several visits of the location and which does not agree with the stratigraphic level indicated by the species listed below. Other inconsistencies concern the geological structure of the region. An overthrust of the Late Cretaceous limestones including the underlying bauxitic horizon on Paleogene flysch deposits is indicated by PAPASTAMATIOU et al. (1971). New palynological studies of the

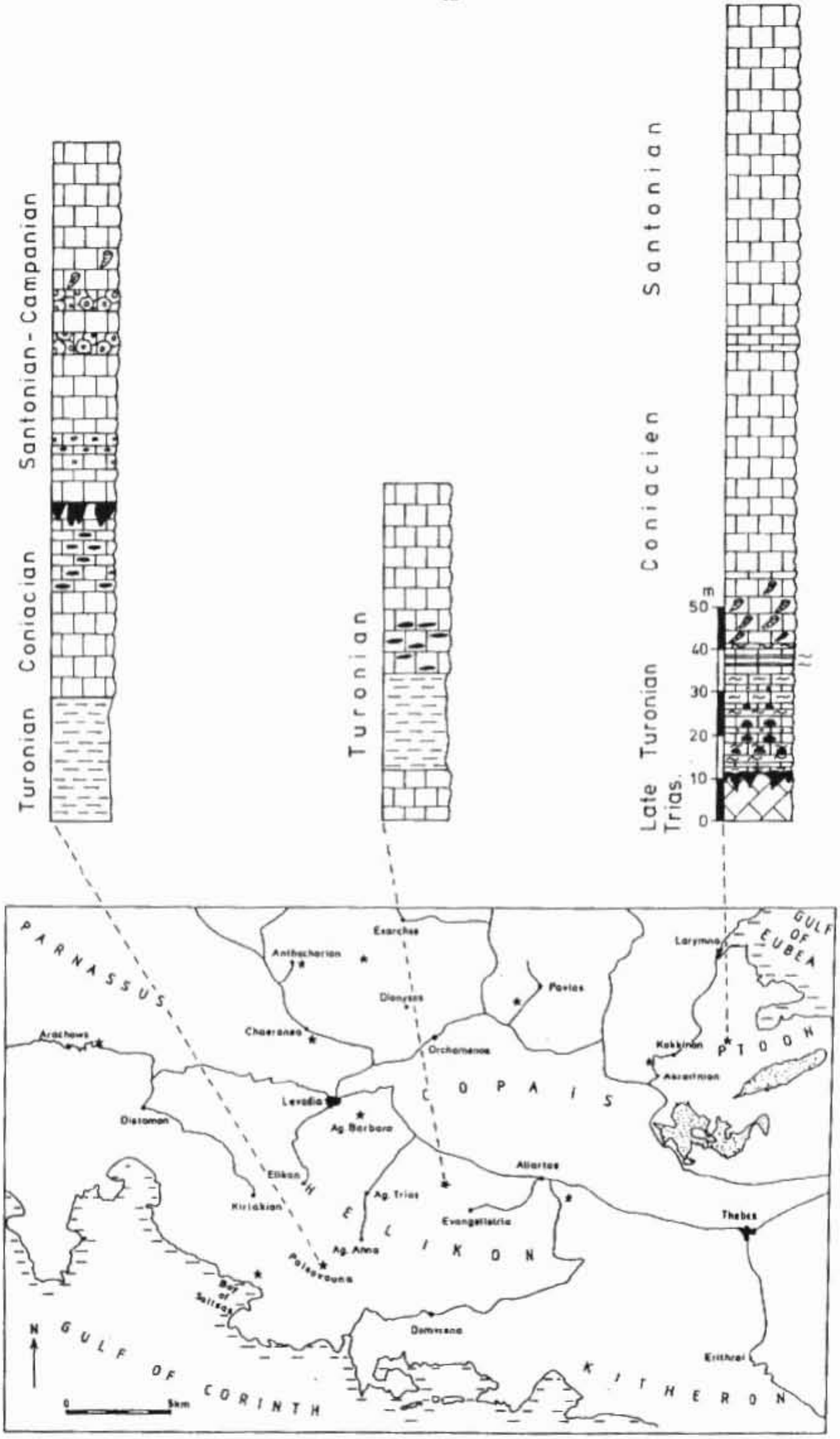

fig.3: location map and standard sections of Turonian deposits from the Koufospithari and Paleovouna Mountains (after KONERTZ 1987) and from Ptoon (after JORDAN 1990).

brown, red and green coloured marls below the lateritic ore revealed a microflora of Barremian age, containing cysts of *Pterodinium premnon* DUXBURY. Thus, the clastic sequence belongs to the stratigraphic unit of the "Beotian flysch".
Subaerial weathering during Early Upper Cretaceous lead to the formation of a silcrete, which is covered by a allochthonous, pisolithic bauxite (fig.4). The marine transgression in this region commenced during Late Santonian/Early Campanian, as indicated by *Vaccinites gaudryi* (MUNIER-CHALMAS), *V. cornuvaccinum* (BRONN) and *Plagioptychus toucasi* MATHERON which were recovered from the reputated rudist beds at the Keratovouno.

Anthochorion: On the NW' slope of the Vetrisa, SE' of Anthochorion, a red coloured silcrete and rudist limestones unconformably rest on Late Jurassic limestones with *Cladocoropsis* (fig.4). While radiolitids are rare and corroded, several well preserved hippuritids have been collected. The dominating species is *Vaccinites alpinus* (DOUVILLE), which was about forgotten after the original description from Gosau in 1897. At Anthochorion the species occurs together with *V. cornuvaccinum* (BRONN), which has been described from Late Santonian and Early Campanian strata (POLSAK et al 1982).

Paleovouna, S' Exarchos: *Vaccinites alpinus* (DOUVILLE) and *V. cornuvaccinum* (BRONN) occur at the northern slope of Paleovouna Mountain, south of Exarchos (fig.4). There, rudist limestones rest unconformably on Late Jurassic/Early Cretaceous radiolarites and ophiolites.

Dionysos: North of Dionysos, a biostrome with well preserved hippuritids and radiolitids is exposed. The fossiliferous beds occur 4m above sepentinized amphibolites and contain *Vaccinites cornuvaccinum* (BRONN), *V. gaudryi* (MUNIER-CHALMAS) and *V. alpinus* (DOUVILLE). They are outnumbered by well preserved radiolitids. Single shells of *Vaccinites* cf. *chaperi* (DOUVILLE) have been collected 20m above this horizon.

Kalamos, SW' Pavlos: A similar sequence is exposed 5km east of Dionysos, near Pavlos (fig.4), where *Vaccinites gaudryi* (MUNIER-CHALMAS) and *V. cornuvaccinum* (BRONN) were found. However, at Pavlos, a 2m thick bed of redeposited lateritic iron ore is intercalated in marls and sandstones (fig.4) which cover serpentinized basalts and hyaloclastics (fig.4).

Paleovouna: Hippuritid limestones are quite common in the Paleovouna massif (fig.4) but well preserved fossils are rare. Near the summit and above the bauxite horizon several beds consist of complete and detritial radiolitids. No fossils were gained

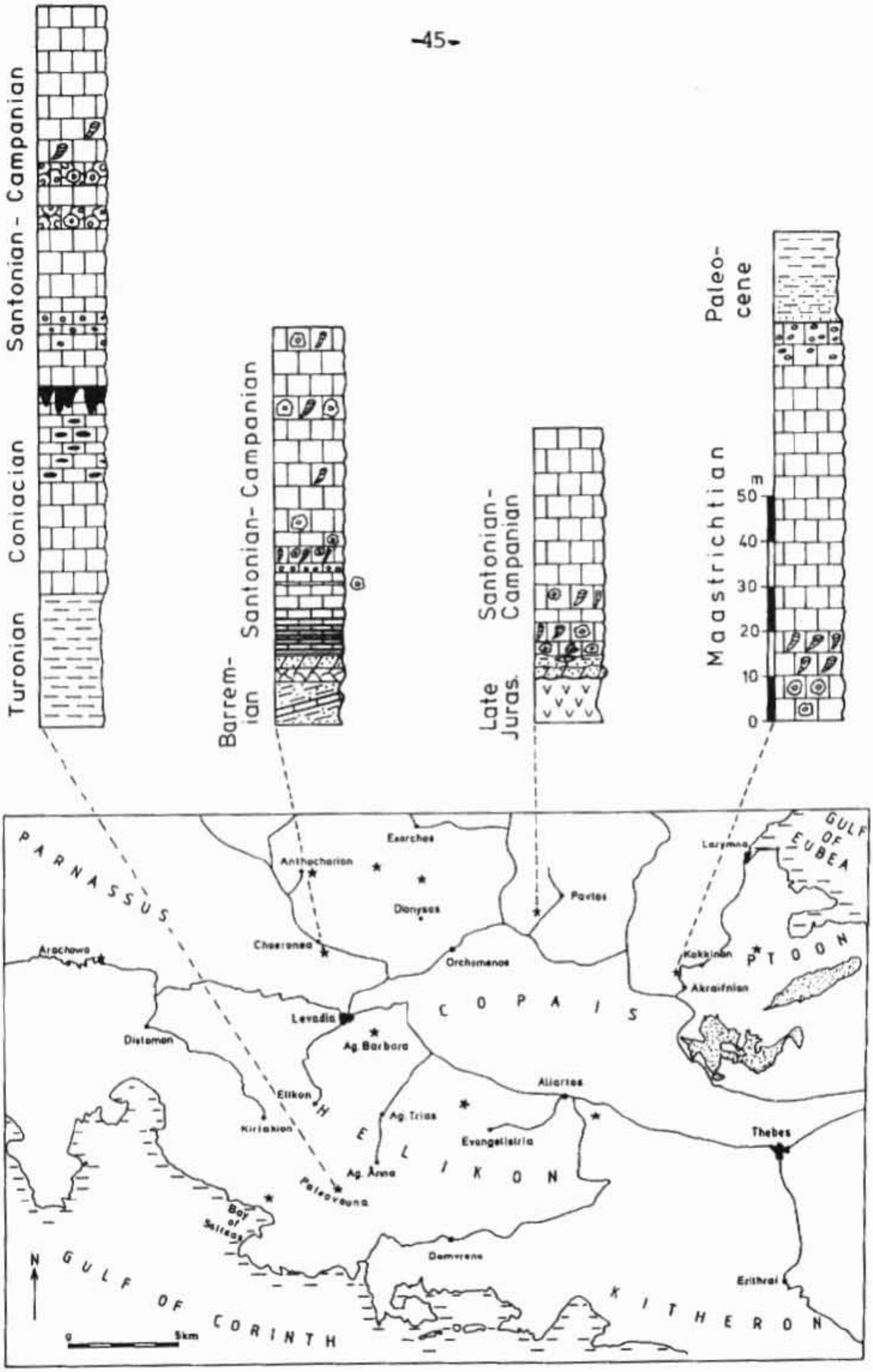

fig.4: location map and standard sections of Santonian/Early Campanian-Maastrichtian deposits from the Paleovouna Mountains and Akraifnion (after KONERTZ 1987) and from Chaeronea and Pavlos.

from the hard limestones. Above this horizon, several cross sections of *Vaccinites atheniensis* (KTENAS) were noted. This species, rather common in Greece (SAKELLARIOU 1961, KUEHN 1948), is obviously restricted to the Late Santonian-Early Maastrichtian (CZABALY 1982). This stratigraphic level fits well with the results of the investigations of KONERTZ 1987 (fig.4).

Bay of Saltsas: A thick sequence of rudist limestones is exposed on the southern slope of Elatos to the Bay of Saltsas. The fossils are scattered in the sediment, which is apparently the debris of an adjacent biostrome. They belong to:
Vaccinites cf. *boehmi* (DOUVILLE),
Vaccinites chalmasi (DOUVILLE),
Hippuritella variabilis (MUNIER-CHALMAS),
Hippurites cf. *socialis* DOUVILLE,
small hippuritids ex gr. *Hippurites canaliculatus* ROLLAND DU ROQUAN
and are of Campanian age.

Ag. Barbara, SE' Levadia: In several quarries near Ag. Barbara the reputated black "Levadia Marble" is broken. The recrystallized limestones contain *Vaccinites atheniensis* (KTENAS) and in stratigraphically higher horizons *Hippurites colliciatus* WOODWARD, the latter indicating an Early Maastrichtian age.
Recrystallized limestones with remnants of rudists similar to those of Ag. Barbara have already been mentioned by BITTNER (1880) from the Herkyna gorge SW' of Levadia. At Ag. Trias, however, dark grey metamorphic limestones crop out, which are transgressively covered by Aptian-Cenomanian clastics (JUX et al. 1987). Similar transgressive deposits were described from Ag. Barbara (BRUNNER & KOLLMANN 1982-1983), but with a different tectonic interpretation. The described section (BRUNNER & KOLLMANN 1982-1983, fig.3) is indicated to rest on an overthrust although any specification is missing.
Apparently, the metamorphic basement of Ag. Trias and Ag. Barbara gradually submerged during the Late Cretaceous. The flanks were buried with Aptian to Cenomanian clastics, whereas on the summits rudists settled not earlier than during the Late Santonian-Early Maastrichtian. This date is indicated by *V. atheniensis* (KTENAS) and *H. colliciatus* WOODWARD. The rudists settled on a substrate composed of reworked marble sands. These rocks may be difficult to distinguish from the metamorphic basement, but lack typical features such as micro-scale folding and lineation.

Arachowa: In a road cut 4,5km E' of Arachowa, a section is exposed which reveals the transition of Late Cretaceous limestones to Paleocene, red coloured flysch deposits of the Parnassus Mountains (RICHTER & MARIOLAKOS 1974). Sections of the Campanian species *V.*

cf. *boehmi* (DOUVILLE) and radiolitids have been recognized 20m below red marls of the Parnassus flysch.

Akraifnion: At Akraifnion (fig.4), the transition of Late Cretaceous limestones to Paleogene flysch deposits is well exposed. The microfacies of this section was described by KONERTZ (1987). Well preserved phytoplancton was used to establish a biostratigraphy of the tertiary marls and sandstones (GOTZES 1991). A single horizon, 70m below the lithological boundary contains *Hippurites lapeirousei* GOLDFUSS and *Hippuritella cornucopiae* (DEFRANCE), previously described from Maastrichtian deposits.

PALEOGEOGRAPHY

The distribution of hippuritids in transgressive deposits of Beotia reveals a stepwise encroachment of the Late Cretaceous sea and gradual coverage of the eohellenian relief. South of the Copais depression, sandstones, marls and limestones with *Orbitolina* unconformably rest either on a metamorphic basement (eg. Ag. Trias, Ag. Barbara) or Late Jurassic limestones (Aliartos, fig.2). During the Late Turonian, Jurassic *Cladocoropsis*-limestones and oolites as well as Late Triassic *Megalodon*-limestones of the Ptoon Mountains were submerged (fig.3). At the same time, a deepening of depositional environments in the Helikon is recorded by red marls with abundant planktonic foraminifera (KONERTZ 1987). Apparently, the Turonian transgression embraced parts of Eubea and Attica as well (BIGNOT et al. 1971, CLEMENT 1976).
During the Santonian, almost whole of Beotia emerged. This emersion was enduring enough to produce a deep karst relief. In the dolines allochtonous bauxites were deposited (Paleovouna). Marine sedimentation seems to have persisted only in the Ptoon Mountains, at least, no hints towards an significant depositional hiatus have been reported from this region. The following Late Santonian-Early Campanian transgression flooded the entire region, including areas north of the Copais, where no Early Upper Cretaceous deposits have been detected (fig.4). Allochthonous bauxites were deposited not only in the Paleovouna region, but as well in the north of the Copais depression (Chaeronea, Pavlos). When stable marine conditions of platform sedimentation were established, rudist biostromes developed in shallow, agitated waters. Their remnants are significant biostratigraphic markers. The calcareous sedimentation persisted until Maastrichtian time, when tectonic movements caused flysch deposition.
This paleogeographic evolution fits well with fluctuations of global sea levels during the Middle and Late Cretaceous (fig.5). Thus, crustal movements have obviously been of minor importance for paleogeographical configurations, although increased subsi-

dence might have prevailed after the Late Santonian-Campanian transgression. The observed stratigraphical pattern and facies developments can be explained by the gradual submersion of the Eohellenian relief.

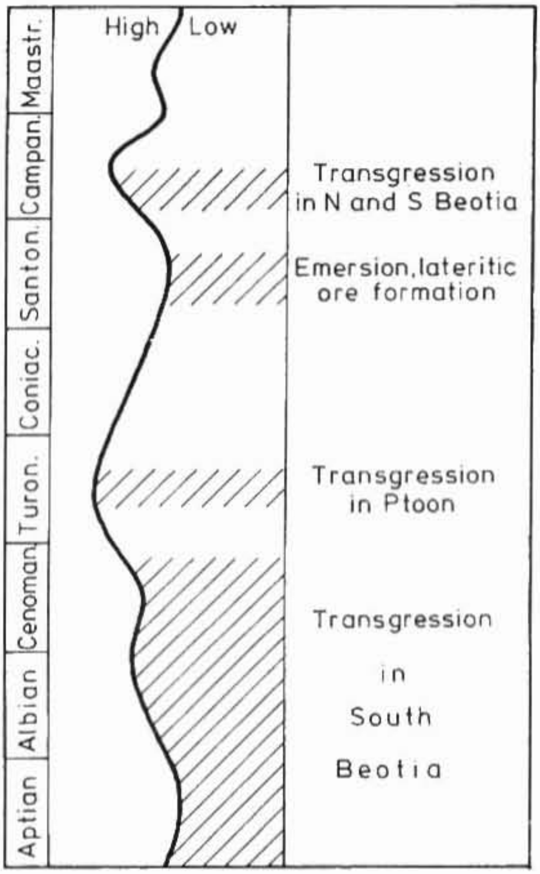

fig.5: fluctuation of global sea levels (after HAQ et al. 1987) and major paleogeographic events during the Middle and Late Cretaceous in Beotia.

REMARKS ON HIPPURITID DISTRIBUTION

Among the previously mentioned hippuritids are several species which have hitherto not been mentioned from Beotia: *Hippuritella cornucopiae* (DEFRANCE), *Hippurites colliciatus* WOODWARD, *H. lapeirousei* GOLDFUSS, *Vaccinites alpinus* (DOUVILLE), *V. chalmasi* (DOUVILLE), *V. praegiganteus* (TOUCAS), *V. inferus* (DOUVILLE), *V.* cf. *boehmi* (DOUVILLE).
However, *Vaccinites boehmi* (DOUVILLE) has recently been recorded from the Argolis Peninsula (MERMIGHIS 1989).

More than one hundred specimens collected at Chaeronea and from locations north of the Copais depression have been ascribed to *Vaccinites cornucaccinum* (BRONN), *V. gaudryi* (MUNIER-CHALMAS) and *V. alpinus* (DOUVILLE). As already mentioned by KUEHN (1948), intermediate forms between *V. cornuvaccinum* and *V. gaudry* are encountered frequently, which lead POLSAK (1959) to regard *V. gaudry* as a subspecies of *V. cornuvaccinum*. Both species are abundantly distributed in the Santonian/Early Campanian of the Eastern Alps, Dinarids and Greece. In Beotia, *V. alpinus* is associated with these species and apparently belongs to the same taxonomic group. As intermediate forms between these three species are quite abundant, a redescription seems to be necessary. The results of an reinvestigation will be published elsewhere.

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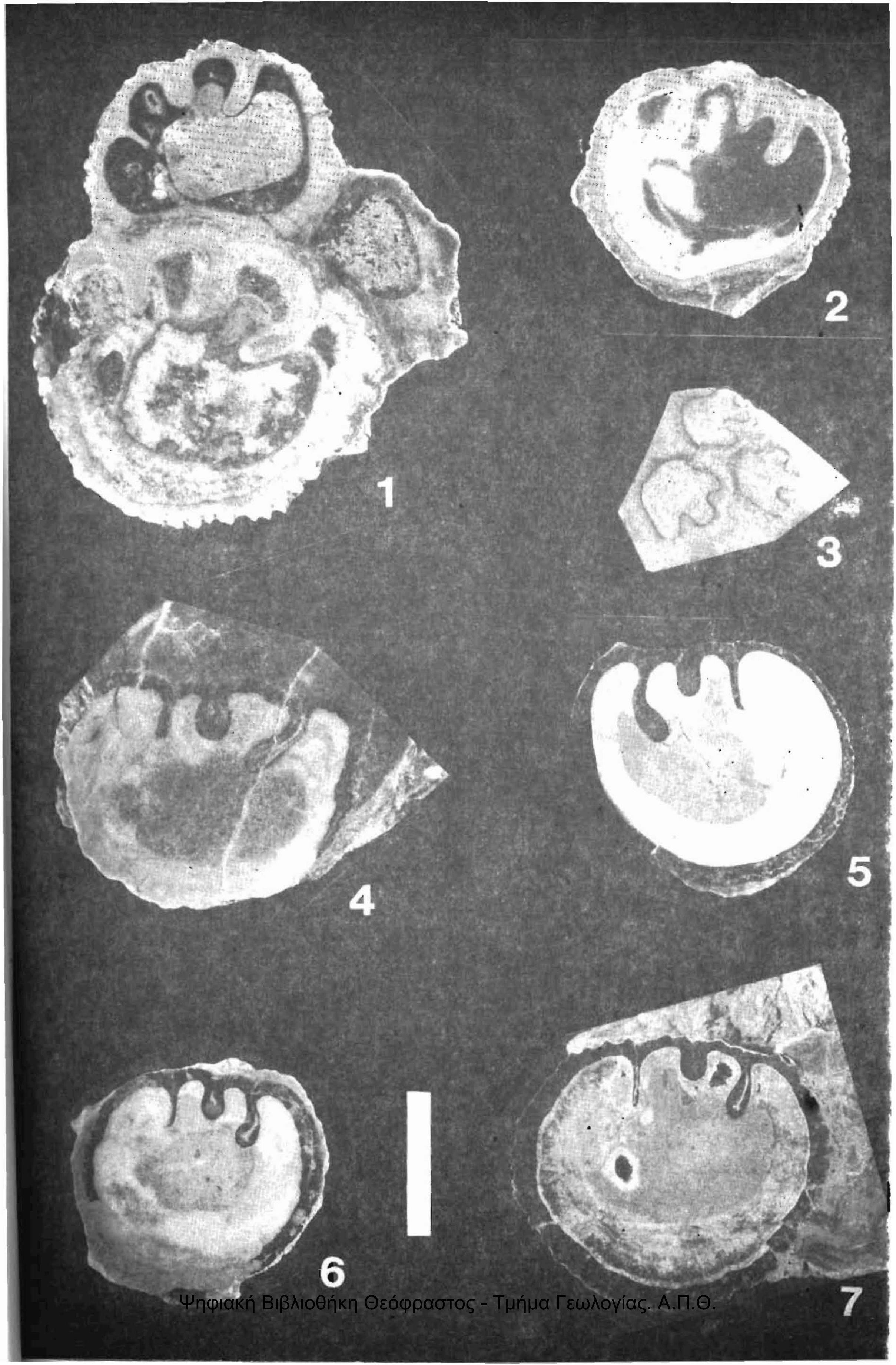
PLATE 1

fig.1: *Vaccinites inferus* (DOUVILLE), Ptoon.
fig.2: *Vaccinites praegiganteus* (TOUCAS), Ptoon.
fig.3: *Hippuritella variabilis* MUNIER-CHALMAS, Bay of Saltsas.
fig.4: *Vaccinites* cf. *boehmi* (DOUVILLE), Bay of Saltsas.
fig.5: *Vaccinites cornuvaccinum* BRONN, Anthochorion.
fig.6: *Vaccinites gaudryi* (MUNIER-CHALMAS), Keratovouno.
fig.7: *Vaccinites alpinus* (DOUVILLE), N'Dionysos.
(scale bar represents 1,5cm in fig.1 and 3cm in figs.2-7)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