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PARNASSUS - PELAGONIAN TRANSITIONAL FACIES RECORDED IN THE CRETACEOUS PALEOKASTRON SECTION (W. BEOTIA, CENTRAL GREECE)

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ABSTRACT

A middle to Late Cretaceous section exposed at the Paleokastron Hill in Western Beotia revealed facies patterns which are transitional between those of the Parnassus and Pelagonian zones. Late Albian to Early Cenomanian limestones are followed by Santonian - Campanian terrigenous deposits which contain a diverse, reworked rudist assemblage. Calcareous sedimentation recurred in the Late Campanian and lasted as long as until the Late Paleocene. The observed facies trends are compared with carbon and oxygen isotopic compositions of limestones and discussed in respect to their palaeogeographic significance.

INTRODUCTION

Because of its important bauxite deposits, the Mesozoic rocks of the Parnassus Massif have been the subject of numerous stratigraphic investigations and palaeogeographic discussions (e.g. PAPASTAMATIOU 1960, CELET 1962, COMBES 1977, COMBES et al. 1981, CAMINITI 1985). In this paper, a Cretaceous section exposed at the Paleokastron Hill at the eastern foothills of the Parnassus is described in detail. It earns considerable interest because of its transitional facies when compared to those of the Pelagonian and Parnassus zones, its remarkably diverse Santonian - Campanian rudist - bivalve association, and its tectonic position.

The section is exposed 17km to the west of Levadia (22°44'05''E, 38°28'35''N), 500m to the North of the highway Levadia - Delphi (Fig.1). The base level consists of reddish to light brown flysch - type deposits. They are surmounted by 35m thick, thin bedded micritic limestones with frequent chert nodules in the lower part. It follows a 20m thick horizon of marls, sandstones and conglomerates. Components are redeposited laterites, radiolarites, serpentinites, and weathered ophioliotic volcanics. Scatterd within these terrigenous sediments are numerous hippuritid shells. Massive and thick bedded, light grey limestones rest on the clastic deposits and form the summit of Paleokastron Hill (506m NN). From their lower base, neptunian dikes reach up 15m above the sedimentary discontinuity into gastropod - bearing limestones. The section ends at the northern slope of Paleokastron Hill with thick bedded, brown, impure limestones. They contain corals, orbitolinid foraminifera, and gastropods.

From these field observations - and especially from neptunian dikes in

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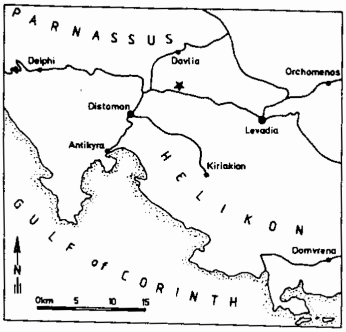

Fig.1: Location map.

an upside - down disposition - it is obvious that the described section was tilted over. This tectonic setting is not restricted to the Paleokastron Hill. Intersected by a North - South trending valley, the stratigraphic units can be traced for more than 2km to the East. To the North, the tilted - over sequence is exposed again, forming the Kokkinos Vrachos Hill.

MICROFACIES AND BIOSTRATIGRAPHY

Stratigraphically oldest massive to thick bedded limestones to the North of the Paleokastron summit are biomicrudites and biomicrosparites. They contain large coral, sponge (*Acanthochaetetes* sp.), and radiolitid fragments as well as intra - and lithoclast. Among abundant orbitolinid foraminifera *Mesorbitolina aperta* (ERMAN) 1854 and *Mesorbitolina subconcava* (LEYMERIE) 1878 indicate a Late Albian age. Other benthic foraminifera are *Cuneolina* sp., *Lenticulina* sp., *Placopsilina* sp., *Pseudocyclammina* sp., and *Tritaxia* sp. Calcareous algae comprise *Bouenia* sp., *Lithocodium aggregatum* ELLIOTT 1956, *Pycnoporidium* sp. and dasycladaceae. Biofacies, ruditic texture, and massive to thick bedding suggest their deposition in the fore - slope talus of a carbonate platform. Microfacies changes 40m above the base to biomicrites with fine grained shell debris and planktonic foraminifera (*Praeglobotruncana* sp., *Rotalipora ticinensis* (GANDOLFI) 1942, *Ticinella roberti* (GANDOLFI) 1942) of Middle Albian to Early Cenomanian age. Among rare benthos *Pseudolituonella reicheli* MARIE 1954 and *Tritaxia* sp. have been recognized. However, this calm open marine sedimentation was sporadically interrupted by coarse - grained debris from the adjacent carbonate shelf, indicated by intercalated fossiliferous rudstones.

The depositional environment then continuously shallowed. Well sorted grainstones with bio - and intraclasts dominate the upper part of the middle Cretaceous limestone sequence. Terrestrial proximity is indicated by an increased amount of lithoclasts. Redeposited volcanic and lateritic components attain diameters of several cm in a level 25m below the emersion surface (Fig.2). The topmost 15m of middle Cretaceous limestones are intersected by neptunian dikes which are filled with red - coloured wacke - and packstones. Their components are angular lithoclasts of serpentinised volcanics and redeposited laterites. In some fissures bioclast were cemented by an isopacheous rim of freshwater calcite spar. The remaining voids were filled with red - coloured micrite.

Gravel to sand sized components of the following 20m thick polymict clastic horizon are predominantly redeposited laterites, radiolarites and serpentinised volcanics. This fanglomerate was obviously not the habitat of rudists and corals which are dispersed throughout these deposits. At the Kokkinos Vrachos Hill, however, radiolitids are preserved in life position in a sandy, impure limestone 10cm below banked Late Cretaceous limestones. Although predominantly redeposited, rudist shells are generally well preserved. Clusters of up to eight individuals grown in intimate shell contact have been found which did not suffer destruction during sedimentary transport. The following species have been identified (Fig.3, plate):

Hippurites cf. canaliculatus ROLLAND DU ROQUAN 1841

Hippurites colliciatus WOODWARD 1855
Hippurites cf. turgidus ROLLAND DU ROQUAN 1841
Vaccinites boehmi (DOUVILLE) 1897
Vaccinites giganteus (D'HOMBRE - FIRMAS) 1838
Vaccinites inaequicostatus (MUENSTER) 1840
Vaccinites praesulcatus (DOUVILLE) 1897
Vaccinites sulcatus (DEFRANCE) 1821
Vaccinites vredenburgi (KUEHN) 1932
Mitrocaprina bayani (DOUVILLE) 1888
Radiolites angeiodes (LAPEIROUSE) 1781

This remarkably diverse fauna indicates a Santonian - Campanian age. Only *V. giganteus* is usually considered to be indicative of the Coniacian. However, this species has recently been described as *V. vredenburgi* from the Campanian of Apulia (LAVIANO & GALLO - MARESCA 1992). Similar associations have been reported from the Vermion Mts. (MITZOPOULOS 1959, KOLLMANN et al. 1985) and Argolis Peninsula (MERMIGHIS 1989, MERMIGHIS et al. 1991). They differ, however, completely from Late Santonian - Campanmian rudist associations of the Parnassus zone (CAMINITI 1985) and the Pelagonian zone in Beotia (STEUBER 1993, STEUBER et al. 1993). Both the latter have close affinities to typical eastern mediterranean faunal assemblages (eg. *Gorjanovicia* POLSAK, *Milovanovicia* POLSAK), while the palaeogeographic distribution of rudist species found at Paleokastron and Kokkinos Vrachos was more widespread throughout the Late Cretaceous Tethys (PONS & SIRNA 1992).

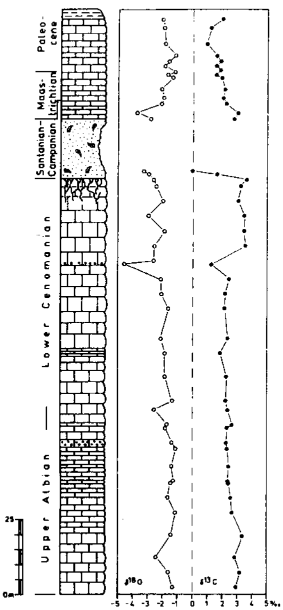

Fig.2: Columnar section and isotopic composition ($\delta^{13}C$, $\delta^{18}O$) of calcareous deposits.

At the top of the siliciclastic deposits the lithofacies changes abruptly to grey, thick bedded limestones. Lateritic lithoclasts are frequent within the lower 20cm of this calcareous sequence. At the base it consists of packstones with Late Campanian larger benthic foraminifera (*Lepidorbitoides* sp., *Pseudosiderolites* sp.), radiolitid and red algae bioclasts, and intraclasts. Deepening of depositional environments is then recorded in biomicrites with abundant planktonic foraminifera of Early to Middle Maastrichtian age: *Gansserina* cf. *gansseri* (BOLLI) 1951, *Globotruncana arca* (CUSHMAN) 1926, *Globotruncana linneiana* (D'ORBIGNY) 1839, *Globotruncana* cf. *ventricosa* WHITE 1928, *Globotruncanita* cf. *stuartiformis* (DALBIEZ) 1955, and *Rosita fornicata* (PLUMMER) 1931.

Biomicrites with Late Paleocene planktonic foraminifera were found 14m above the base level of the Late Campanian - Maastrichtian limestones. They contain *Morozovella* sp., *Planorotalites chapmani* (PARR) 1938, and *Planorotalites* cf. *pseudomenardii* (BOLLI) 1957.

Intraclasts with Cretaceous microfossils (*Globotruncana* cf. *linneiana* (D'ORBIGNY) 1839 and *Rosita* cf. *fornicata* (PLUMMER) 1931) have been observed 5m higher in the section. They float in a micritic matrix with Tertiary planktonic foraminifera. Upper horizons of the sequence comprise

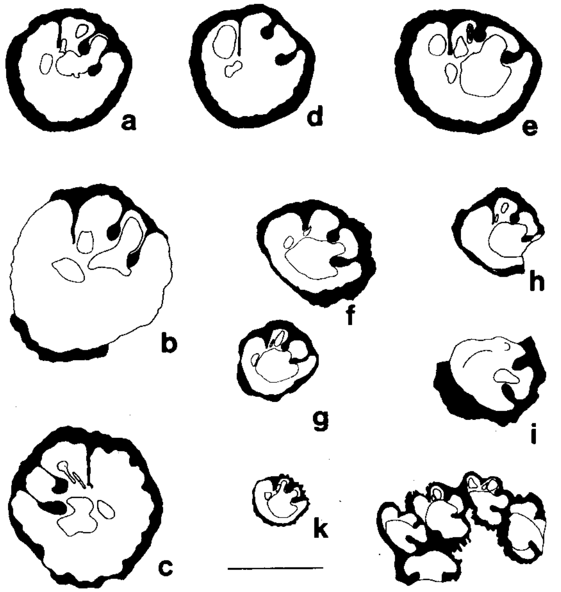

Fig.3: Transverse sections (right valves) of Late Santonian - Campanian hippuritids from Paleokastron; a: *Vaccinites giganteus* (D'HOMBRE - FIRMAS) 1838, b - c: *V. vredenburgi* (KUEHN) 1932, d - e: *V. inaequicostatus* (MUENSTER) 1840, f - g: *V. praesulcatus* (DOUVILLE 1897, h: *V. boehmi* (DOUVILLE) 1897, i: *Hippurites colliciatus* WOODWARD 1855, j: *H.* cf. *canaliculatus* ROLLAND DU ROQUAN 1841, k: *V. sulcatus* (DEFRANCE) 1821. Scale bar is 30mm for figs a - h, k and 15mm for i,j.

thin bedded, light red limestones with chert nodules. These limestones are predominantly biomicrites with Tertiary planktonic foraminifera such as *Morozovella aequa* (CUSHMAN & RENZ) 1942, *Morozovella* cf. *angulata* (WHITE) 1928, *Morozovella* cf. *velascoensis* (CUSHMAN) 1925, *Planorotalites chapmani* (PARR) 1938, *Planorotalites* cf. *pseudomenardii* (BOLLI) 1957. Intercalated are packstones with bioclasts from more shallow - marine environments, which do not include rudist shell debris any more.

The contact to the following flysch - type marls and sandstones is tectonically disturbed.

ISOTOPIC COMPOSITION ($\delta^{13}C$, $\delta^{18}O$) OF LIMESTONES

Different depositional environments which have been briefly delineated by microfacies analyses, should also be expressed in the carbon and oxygen isotopic composition of whole rock samples Fig.2). In the lower part of the Upper Albian to Lower Cenomanian limestone sequence $^{13}C/^{12}C$ and $^{18}O/^{16}O$ ratios show little variation within a range of +2,5 to +1,0^{o}/oo $\delta^{13}C$ and - 3,5 to - 2,0^{o}/oo $\delta^{18}O$. This indicates normal marine conditions of these basal fore - slope deposits and - of course - of the pelagic wackestone intercalations. Several negative excursions of $\delta^{18}O$ correspond to increased amounts of lithoclast. This is particularly evident at the level with cm - sized lateritic lithoclast, were isotopic compositions drop to 1,2^{o}/oo $\delta^{13}C$ and - 4,5^{o}/oo $\delta^{18}O$ which suggests the precipitation of calcareous components in marginal marine environments with reduced salinities. The following shallow - marine grain - and packstones yielded slightly lower $\delta^{18}O$ when compared to the basal fore - slope deposits. This can be explained by higher palaeotemperatures on the shallow carbonate platform. Comparably "heavy" $\delta^{13}C$ in this part of the section is not easily explained but might trace back to biotic fractionations. A considerable fresh water influx is evident in the sharp drop of $\delta^{13}C$ and $\delta^{18}O$ at the base level of the siliciclastic horizon. As whole rock samples were processed, large parts of the analysed carbonates of this carbonate - poor sediment are, of course, diagenetic cements of possible meteoric origin.

Maastrichtian to Paleocene limestones exhibit a significant isotopic pattern. $\delta^{13}C$ shifts gradually from 3^{o}/oo at the base to 1^{o}/oo near the top. Numerous investigations dealt with isotopic investigations of Cretaceous - Tertiary boundary sections, revealing different isotopic patterns and thus leading to controversal discussions (eg. BARRERA 1990, MAGARITZ 1991). An evaluation of carbon isotopic shifts observed at Paleokastron should be discussed in more detail, when further micropaleontological studies have confirmed the precise level of the C/T - boundary and proved the completeness of the stratigraphic record. However, increasing .18O can be explained by the change from shallow - marine platform deposits to pelagic mudstones, implying a drop in palaeotemperatures which lead to increasing $^{18}O/^{16}O$ ratios of the limestones. Shifts in $\delta^{13}C$ might refer to changes in the oceanic circulation which are indicated by a long - lived sedimentary hiatus across the C/T - boundary in Beotia and on the Parnassus Platform.

PALAEOGEOGRAPHIC CONSIDERATIONS

Deposits of the Palekastron section combine facies characteristics which are considered typical for both the Pelagonian and Parnassus zones. In Beotia, Cretaceous transgressions encroached the Pelagonian contineta1 fragment (MOUNTRAKIS 1986) from the Pindos Ocean since the Aptian (CLEMENT & FERRIERE 1973, STEUBER et al. 1993). Lower Cretaceous and Cenomanian sediments are predominantly siliciclastic and were derived from the erosion of ophiolithic nappes which where obducted on the Pelagonian during the eohellenian orogeny (ophiolitic conglomerates; BRUNNER & KOLLMANN 1983). Calcareous sediments only accumulated in areas protected from the influx of siliciclastic deposits and form small limestone bodies or patch reefs. On the Parnassus zone, thick limestone sequences were deposited during this time. Middle Cretaceous emersion and karstification of the Parnassus Platform was diachronous (CELET 1962, COMBES et al. 1981), but limestones younger than of Cenomanian age have not definitely been dated in the footwalls of Cretaceous bauxite deposits. In South Beotia marine sedimentation prior to emersion and bauxite deposition continued until the Coniacian (STEUBER 1993). Thus, middle Cretaceous facies of the Paleokastron section is essentially the same as on the Parnassus Platform.

The hanging wall of Parnassus bauxite deposits is of Santonian - Campanian age (CAMINITI 1985) as indicated by abundant rudists, which occur several meters above the bauxites. The Paleokastron section differs, as no lateritic ores were deposited but instead siliciclastic sediments with, however, a large amount of impure, redeposited lateritic components. This transgressive sequence is similar to Late Santonian - Campanian onlapping deposits described from northern Beotia, were redeposited laterites, sandstones and finally limestones unconformably follow over ophiolithic volcanics or Triassic - Jurassic limestone (STEUBER 1993, STEUBER et al. 1993).

Late Santonian - Campanian rudist associations found along the Pelagonian margin in Beotia (STEUBER et al. 1993) and at Paleokastron differ completely. In fact, not a single species was apparently present in both palaeogeographic settings. This is probably due to the adaption of the relevant species to different shallow - marine environments. However, as hippuritids at Paleokastron have not been preserved in life position, this possible explanation remains to be substantiated.

Another important characteristic of the described section is the facies development during the Cretaceous - Tertiary transition. In the Parnassus zone, pelagic limestone sedimentation is known to have lasted from Campanian until Maastrichtian times (RICHTER & MARIOLAKOS 1974, KEUPP 1976, RICHTER

& RISCH 1981, CAMINITI 1985, SOLAKIUS & POMONI - PAPAIOANNOU 1992). The C/T boundary is marked by a change in lithofacies both in South Beotia and the Parnassus zone: red pelagic shales of Late Paleocene age conformably follow over Maastrichtian limestones. A hiatus is often marked by ferrophosphatic stromatolithic crusts (KALPAKIS 1979) and comprises the Late Maastrichtian and Early Paleocene (SOLAKIUS & POMONI - PAPAIOANNOU 1989). The onset of flysch - type deposition has been dated to occur during the Late Paleocene in North Beotia (GOTZES 1993) and during the Early Eocene in the Parnassus zone (RICHTER & RISCH 1981). Paleocene deposits at the Paleokastron differ from this regional pattern. Early to Middle Maastrichtian pelagic limestones are overlain by at least 15m of Tertiary limestones without any change in lithofacies.

From the observed facies distribution it can be concluded that the Paleokastron sequence was deposited in a palaeogeographic position marginal both to the Pelagonian continental fragment and the Parnassus Platform. Late Cretaceous sedimentation following Cenomanian emersion evidently started during the Late Santonian - Campanian, as indicated by rudist bivalves which were reworked by fanglomerates. These terrigenous deposits indicate proximity to obducted ophiolites, which remained emerged on the Pelagonian until the Late Santonian - Campanian (STEUBER et al. 1993). The palaeogeographic position between the rigid blocks of the Pelagonian and the Parnassus Platform also explains the tilted over tectonic displacement of the sedimentary sequence, as they acted as counterforts during Tertiary deformations.

There is no field evidence about the basement of the described deposits bacause Paleocene flysch - type sediments are thrusted over Late Albian limestones which are the tectonically highest units of the Cretaceous sequence. As detachment of the Paleokastron limestones from the Parnassus carbonate platform is rather unlikely, they were most probably accumulated on top of the Early Cretaceous Beotian flysch. This palaeogeograpical setting accords well with the observed facies patterns.

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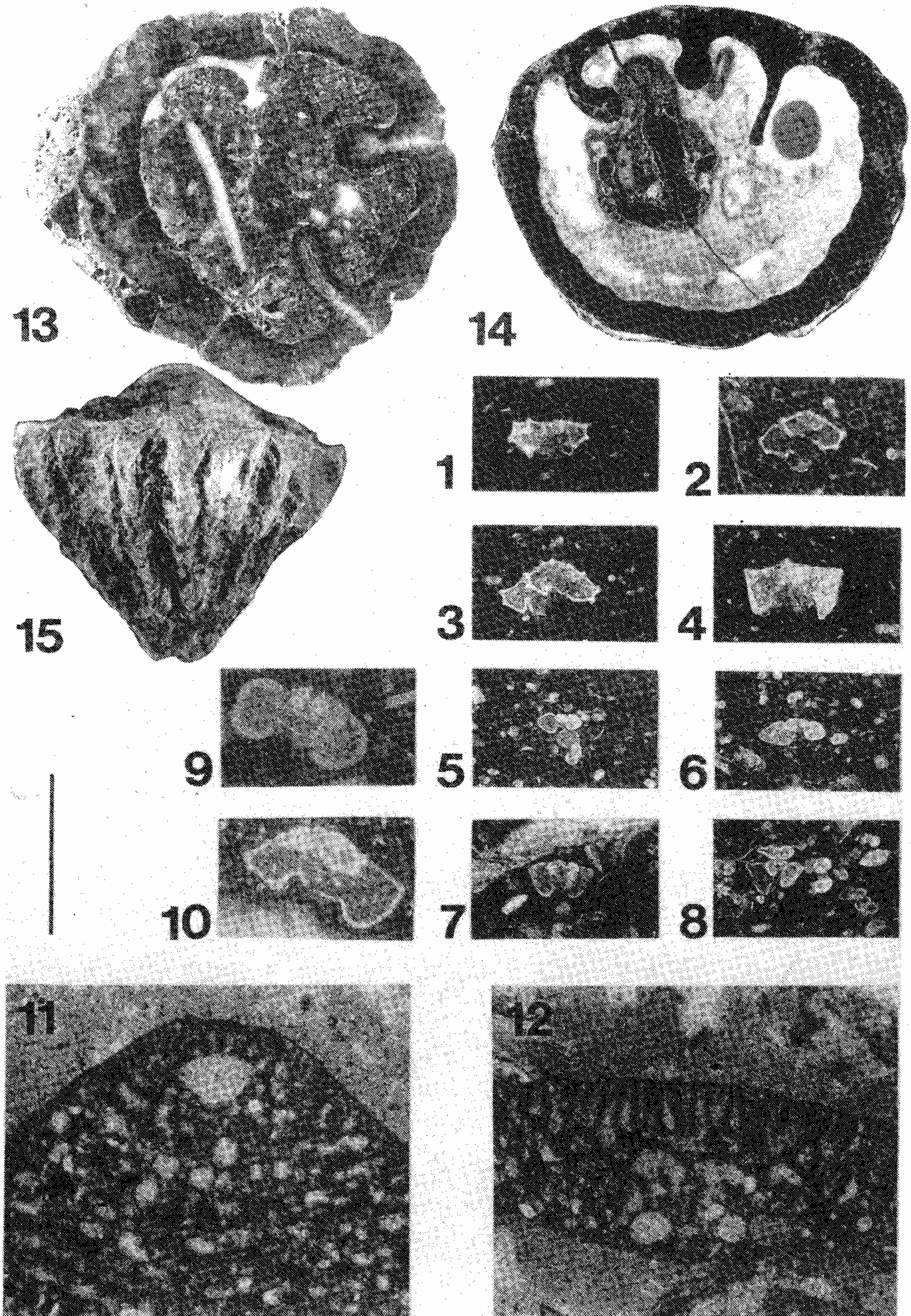
Plate: Fig.1. Globotruncana linneiana (d'Orbigny) 1839; Fig.2. Globotruncana arca (Cushman) 1926; Fig.3. Rosita fornicata (Plummer) 1931; Fig.4. Gansserina cf. gansseri (Bolli) 1951; Fig.5. Planorotalites chapmani (Parr) 1938; Fig.6. Planorotalites cf. pseudomenardii (Bolli) 1957; Fig.7. Morozovella cf. angulata (White) 1928; Fig.8. Morozovella cf. aequa (Cushman & Renz) 1942; Fig.9. Ticinella roberti (Gandolfi) 1942; Fig.10. Rotalipora ticinensis (Gandolfi) 1942; Fig.11. Mesorbitolina subconcava (Leymerie) 1878; Fig.12. Mesorbitolina aperta (Erman) 1854; Fig.11 and Fig.12 showing embryonic chamber and both supra - and subembryonic zone Fig.13. Hippurites cf. turgidus Rolland du Roquan 1841, cross section of right valve; Fig.14. Vaccinites inaequicostatus (Muenster) 1840, cross section of right valve; Fig.15. Radiolites angeiodes (Lapeirouse) 1781. Scale bar is 0,78mm for Figs.1 - 8, 0,64mm for Figs. 9 - 12, 15mm for Fig.13, and 30mm for Figs.14 and 15.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