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TRIASSIC STRATIGRAPHY IN THE ISLAND OF HYDRA (GREECE)

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Riassunto. La successione sedimentaria di età triassica, che affiora sull'isola di Hydra, è costituita alla base da pochi metri di quarzareniti (Formazione di Aghios Nikolaos, Scitico), che passano gradualmente verso l'alto ad un'unità carbonatica molto spessa e ben diversificata, suddivisa in un membro e tre litozone (Calcare di Eros, Scitico-Pelsonico inf.).

Durante il Pelsonico la piattaforma del Calcare di Eros annega ed inizia la deposizione di una successione pelagica di età Pelsonico-Triassico sup., costituita da calcari nodulari (Calcare di Han Bulog) con tufiti verdi e da calcari con selce (Calcare di Adhami). Nella parte orientale dell'isola si sviluppa invece una spessa piattaforma carbonatica (Calcare di Pantokrator) di età Illirico-Triassico sup. La sovrastante successione pelagica, di età giurassica, segna il definitivo annegamento delle piattaforme triassiche e l'instaurarsi di condizioni bacinali. La successione triassica di Hydra rappresenta quindi una tipica successione di margine continentale passivo e suggerisce l'appartenenza di Hydra al dominio Subpelagoniano, nell'accezione di margine passivo occidentale della microplacca Pelagoniana.

Abstract. The Triassic sedimentary succession, cropping out in the island of Hydra, starts with a few metres of quartzarenites (Aghios Nikolaos Fm., Scythian) vertically making transition to a thick carbonate unit (Eros Lmst., Spathian-Pelsonian) subdivided into three lithozones and one member. During Pelsonian an extensional tectonic phase dissects the Eros carbonate platform. Its consequent downwarping results in the deposition of a pelagic sequence spanning the Pelsonian-Late Triassic time interval. This succession generally consists of few metres of nodular limestones (Han Bulog Lmst., Late Pelsonian-Early Ladinian) associated with green tuffs, followed by few hundred metres of cherty limestones (Adhami Lmst.). In the eastern part of the island a thick carbonate bank (Pantokrator Lmst.) develops, spanning the Illyrian to Late Triassic time interval. An overlying pelagic sequence, Jurassic in age, marks the downwarping of the Pantokrator carbonate platform. A typical passive continental margin succession is thus recorded in the Triassic of Hydra, suggesting its affinity with the Subpelagonian domain.

Introduction.

The island of Hydra emerges from the Aegean Sea a few miles south of the Argolis Peninsula (Fig. 1). Its sedimentary succession, spanning the Permian to Jurassic time interval, is considered very significant for unravelling the geologic history of this

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- The geographical names are reported in greek language: O. = Oros = Mountain; N. = Nesos = Island; O. = Ormos = Bay; K. = Kap = Cap; Ag. = Aghios/Aghia = Saint.

part of the Hellenides. For many authors (see fig. 7, 40 in Jacobshagen, 1986) the island of Hydra belongs to the Pelagonian zone which consists of rocks of continental assemblage lying on a prealpine metamorphic basement. This zone is considered a south tethydean microplate differentiated in consequence of a Triassic rifting (Channel & Horvath, 1976; Dixon & Robertson, 1984; Mountrakis et al., 1987). Conversely

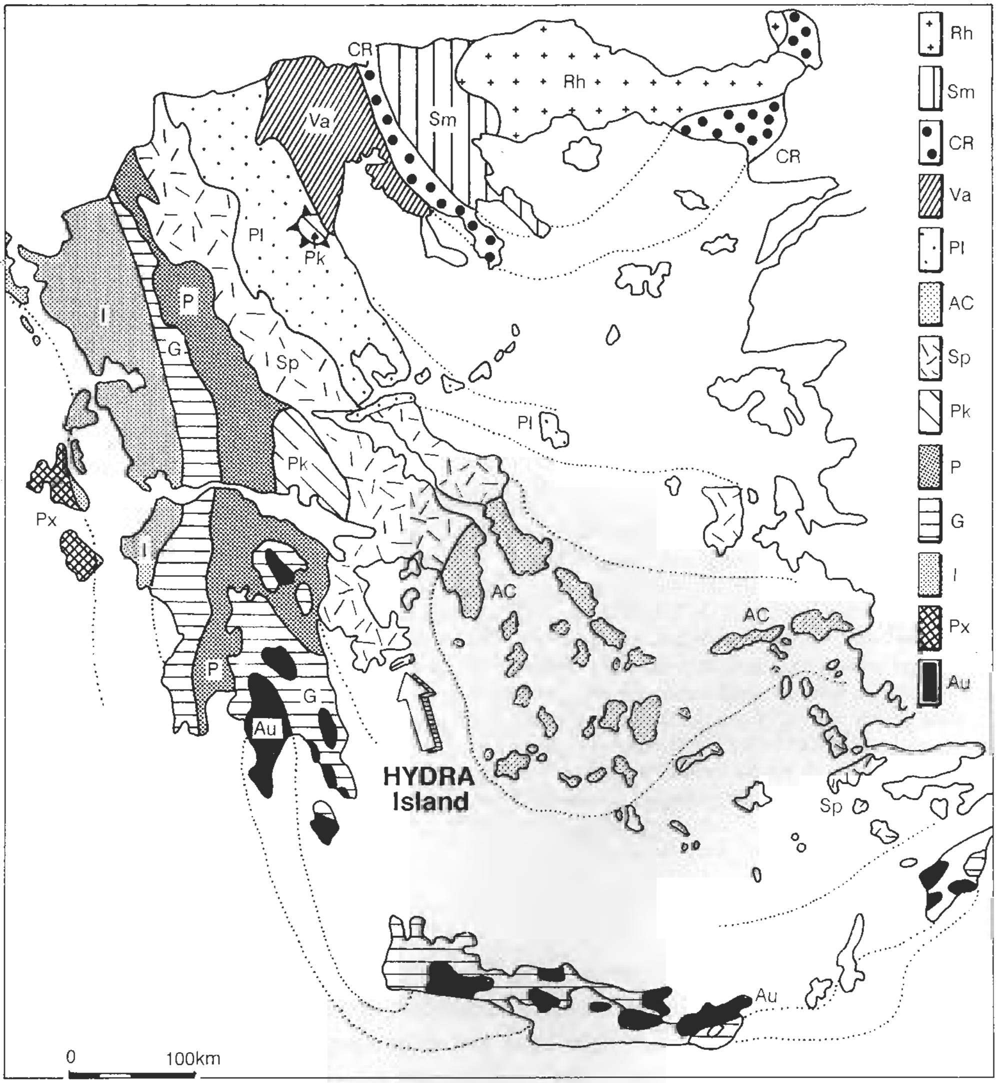


Fig. 1 - Structural zones of the Hellenides modified after Mountrakis et al. (1987). Rh) Rhodope; Sm) Serbomacedonian; CR) Circum Rhodope; Va) Vardar; Pl) Pelagonian; AC) Attico-cycladic; Sp) Subpelagonian; Pk) Parnasos; P) Pindos; G) Gavrovo Tripolis; I) Ionian; Px) Paxos; Au) Plattenkalk-Talea Ori.

Bender et al. (1960), Bannert & Bender (1968), Römermann (1968) locate the island of Hydra in the Subpelagonian zone. The latter, a zone placed to the west of the Pelagonian and striking parallel to it, is characterized by ophiolitic slices cropping out widely in the Argolis Peninsula. Finally, Jacobshagen (1977; 1989 pers. comm.) postulates that Hydra belongs to the Subpelagonian zone, considering it as a passive continental margin succession, deposited on the western part of the Pelagonian terrane. According to this interpretation the ophiolitic bodies are considered as allochthonous (Baumgartner, 1985).

The present paper provides an analysis of the Triassic succession of Hydra, depicts its geological history and gives further evidence to the interpretation of its affinity with the Subpelagonian domain in the sense of Jacobshagen, i.e. as a sedimentary succession of a passive continental margin.

A schematic geological map (scale 1:25.000) of Hydra is also included. The map is the result of the diploma thesis field work of L. Angiolini, L. Dragonetti and G. Muttoni during summers 1988 and 1990, with the supervision of M. Gaetani and A. Nicora.

Previous works.

The island of Hydra was mentioned for the first time in the reports of the "Expédition scientifique de Morée" (1834, 2:159) for its analogies with the Tripolitza series. In 1892 Philippson proposed a Cretaceous age for the rocks of Hydra.

From 1906 to 1955 Renz tried to reconstruct the stratigraphy of the island and published a map (1955). Particularly he studied the microfaunal associations (fusulinids, small foraminifers, Algae) as in also the brachiopods of Permian rocks outcropping along the southern coast of Hydra. In 1940, Okonomidis presented a geological map (1:100.000) of Hydra, essentially based on the studies of Renz. Haralambous (1963) described the Carboniferous-Triassic succession along a profile striking from the Gulf of Palamida to the southern coast of the island (see Fig. 3).

Römermann and Jacobshagen studied Hydra from 1961 to 1965 and in 1981 they published a geological map (IGME 1:50.000) and they recognized a Carboniferous-Jurassic sequence. In 1972 Grant studied the brachiopods of the Upper Permian limestones, demonstrating the correlation between the *Lyttonia* Limestone of Hydra and the *Productus* Limestone of Khisor Range and Salt Range (Pakistan).

In 1973 Wendt published a work on the Hallstatt (Bulog) Limestone of Jugoslavia and Greece. In Hydra he distinguished two different facies deposited in zones with different rate of subsidence during middle Anisian to Ladinian:

- the Aghia Marina Zone (south of Hydra), probably in temporary emergence during this time, as indicated by evidence of subaerial weathering at the top of Eros Limestone and by the local absence of the overlying Bulog Limestone;

- the Aghia Triada zone (north of Hydra), a faster subsiding basin characterized by a thicker and more continuous Bulog Limestone and by the presence of gravity

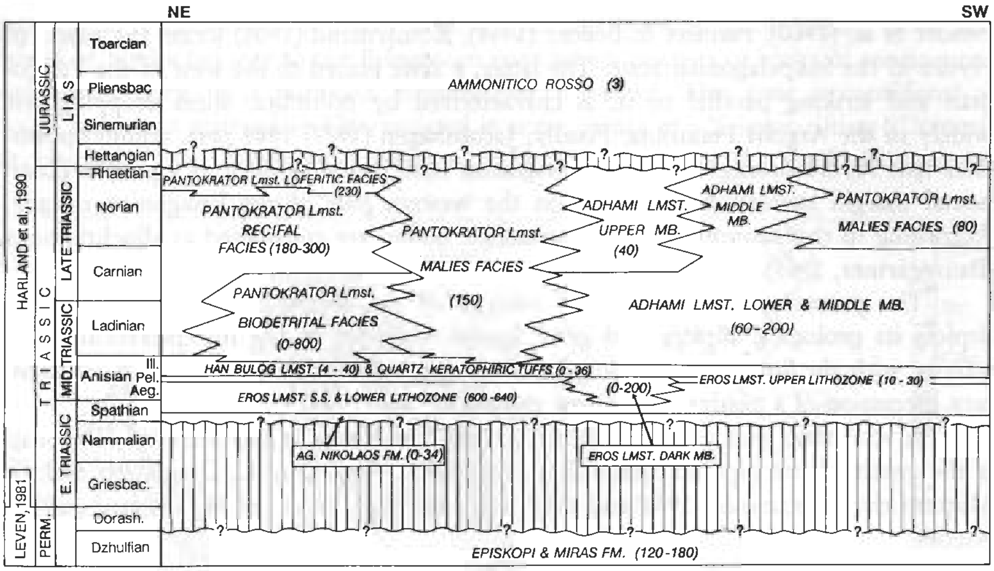


Fig. 2 - Stratigraphic scheme of Hydra.

flows coming from the Ag. Marina zone. During the Ladinian an environmental shift occurred, associated with emergence of the Ag. Triada zone and establishment of deep marine condition in Ag. Marina zone.

In 1984 Schäfer and Senowbari-Daryan studied the Upper Triassic sequence of Hydra. They identified three different facies within the carbonate platform of the Pantokrator Limestone. They also proposed a Late Triassic to Liassic age for this limestone, which prograded southward over the basinal succession of the Horsteinplattenkalk.

In 1986, Durkoop et al. published a report on Triassic red limestones of Argolis and Hydra. They pointed out that the Permian carbonate platform collapsed during Early Triassic with deposition of sandy gravity flows containing Permian and Schythian-Anisian calcareous blocks (Richter & Fuchtbauer, 1981). Near Episkopi, these gravity flows are thought to pass to red micritic sediments with an upper Scythian-lower Anisian conodont fauna.

In 1987, Nestell and Wardlaw worked out the conodont fauna of Upper Permian rocks of Hydra; they reported only lower Dzhulfian associations. The Permian sequence of Hydra has been recently studied in great detail by Baud et al. (1991) and by Grant et al. (1991).

Geological setting.

The sedimentary sequence of Hydra (Fig. 2) spans the Permian to Jurassic time interval. The northward homoclinal dip brings the Permian to crop out in the south-

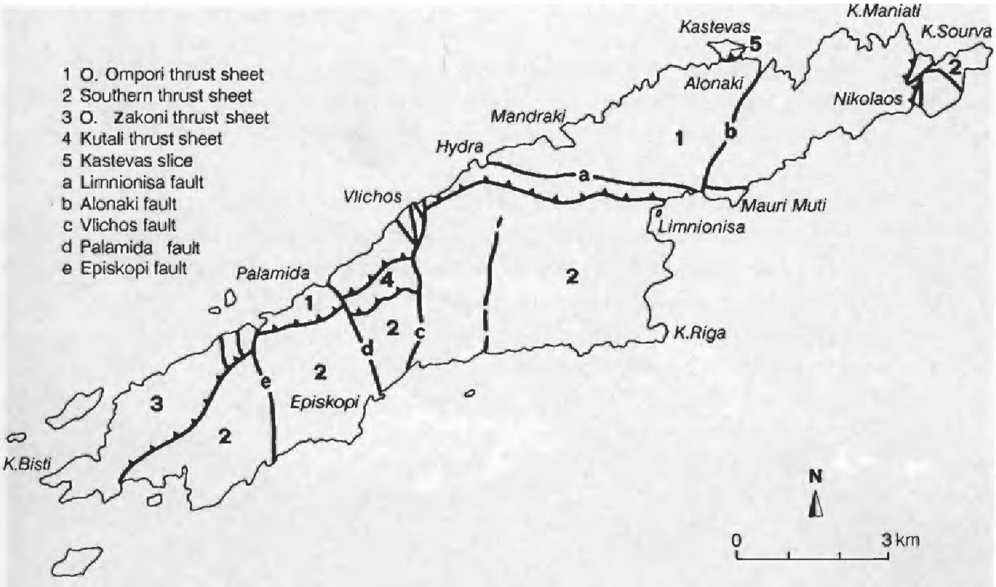


Fig. 3 - Tectonic map of Hydra showing the position of the principal thrust sheets and faults.

ern coast of the island and the Jurassic along the northern. The sequence is arranged in four major thrust sheets (Fig. 3 and the included geological map) and it is affected by folds and kinks. Other minor slices may also be distinguished. These thrust sheets are dislocated by transcurrent faults (lateral ramps), which may have a regional significance.

The northern or upper thrust sheets (O. Ompori, O. Zakoni and Kutali thrust sheets) (Fig. 4) contain mainly Triassic shallow water sediments and the Jurassic pelagic formations, whereas the southern or lower sheet contains Permian to Pelsonian shallow water sediments overlain by a Pelsonian to Jurassic pelagic succession. As already pointed out by Römermann (1968) and Durkoop et al. (1986), differences along an east-west transect exist too, with more pelagic successions outcropping westward.

The sedimentary succession

This paper focuses essentially on the Triassic succession. The units that were investigated include (Fig. 2): the uppermost Permian, the Triassic Aghios Nikolaos Formation, Eros Limestone, Han Bulog Limestone, Quartz keratophyric tuffs, Adhami Limestone, Pantokrator Limestone, and briefly the Jurassic formations.

Fig. 4 - Photo from Gherakina to the East. From N to S: O. Ompori (C), Kutali (B) and southern thrust sheet (A).

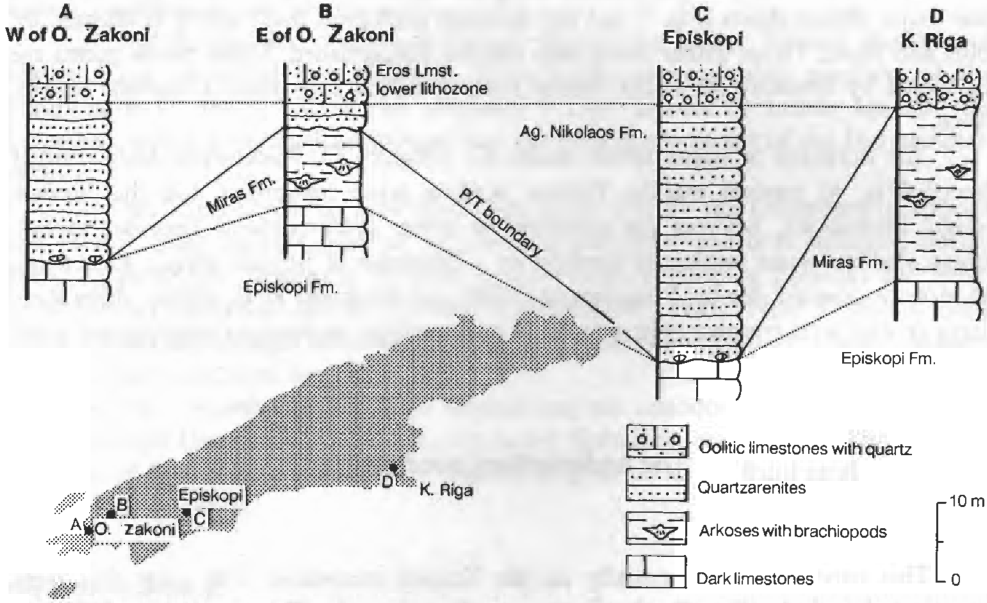


Fig. 5 - Stratigraphy of Permian-Triassic boundary and distribution of Miras and Ag. Nikolaos Formations.

Uppermost Permian succession.

The Triassic succession overlies a Permian carbonate and terrigenous succession, which forms the oldest outcrops of the island and consists of three groups (from the base: Thikia Group, Klimaki Group and Barmari Group; nomenclature after Baud et al., 1991; Grant et al., 1991).

The youngest part of the Permian (Barmari Group of Baud et al., 1991, with minor change) is represented by Episkopi Formation consisting of dark packstones with fusulinids, small foraminifers, echinoderms, brachiopods, gastropods, bivalves, Algae and corals. In some places, it is overlain by the Miras Formation. This formation consists of fine arkoses with abundant feldspars (40-50% of the bulk composition), which are now weathered to fine grained micas and very few epimatrix, pseudomatrix and carbonate cement (5-6% of the bulk composition). Bioclastic limestone lenses with brachiopods, foraminifers and conodonts are also present, 600 m west of Gherakina,

Fig. 6 - Photo shot on the south-western slope of O. Zakoni showing limestone clasts at the base of Ag. Nikolaos Fm.

along the path to Kap Bisti, 200 m a.s.l. The brachiopods are chiefly represented by *Dictyoclostidae* (*Tyloplecta* sp.) and *Linoproductidae*. The petrography of the Miras Fm. is very similar to that of the other Permian terrigenous formations. In fact the Nisisa Fm. (Thikia Group of Baud et al., 1991) chiefly consists of arkoses and the Kap Bisti group p.p. consists of lithic greywackes. Instead there is a great difference in petrography between the Permian terrigenous and the Lower Triassic Ag. Nikolaos Fm., which consists of quartzarenites.

Fusulinid and small foraminifer associations indicate a Dzhulfian age for the Episkopi Formation. Furthermore the Dzhulfian conodont *Hindeodus julfensis* (Sweet) has been identified in the Miras Formation in the locality 600 m west of Gherakina.

The relationships between the formations at the Permian-Triassic boundary are very complicated because of lateral discontinuity of the Lower Triassic Ag. Nikolaos Fm. and of the Upper Permian Miras Fm. The contact is displayed at several localities (Fig. 5); from west to east:

- on the south-western slope of O. Zakoni, 220 m a.s.l., the boundary between the two sequences corresponds to an erosional surface developed between the Episkopi Fm. and the Ag. Nikolaos Fm., the latter containing clasts of the former at its base (Fig. 6);
- on the south-eastern slope of O. Zakoni a few metres of Ag. Nikolaos Fm. overlies the Miras Fm.;
- at Episkopi the contact is similar to that of the south-western slope of O. Zakoni;
- just behind the small house, at 140 m of altitude above K. Riga the boundary is located between the Eros Limestone (lower lithozone) and the Miras Fm. It is often sheared by faults.

Owing to the great differences in the petrography of Miras and of Ag. Nikolaos Fms. and to the presence of eroded clasts at the base of the latter, we can infer that there is a disconformity with a hiatus between the top of the Permian and the base of the Triassic sequences. This gap between Episkopi Fm. and Miras Fm. is not evident at the outcrop scale.

Aghios Nikolaos Formation.

The Ag. Nikolaos Fm., proposed in the present paper for the first time, was previously mapped as Permo-Triassic succession (Römermann et al., 1981) or included in the Miras Fm. (Baud et al., 1991). The appropriate name of this formation should have been Episkopi Fm. (from the type-section in Episkopi), but this name has been used by Baud et al. (1991) and Grant et al. (1991) to indicate a Late Permian formation. The name Ag. Nikolaos derives from a small bay on the north-western coast of the island, where the two lithologies, which characterize the formation, crop out.

The Ag.Nikolaos Formation chiefly consists of quartzarenites pinching out laterally in yellow siltstones, which belong to a distinct member mapped as Silty Member.

The maximum thickness of the Ag. Nikolaos Formation is 34 m at Episkopi, where the unit is exclusively sandy. The Silty Member, which crops out in the westernmost part of the island, is up to 30 m-thick.

This formation lies either above the Episkopi Formation or on the Miras Formation, whereas its top is delimited by the lower lithozone of the Eros Limestone. This contact is gradual with a progressive increase in oolites in the quartzarenites.

Lithology and petrography. The lithology of the Ag. Nikolaos Formation consists of well cemented, white to brown colored quartzarenites arranged in dm to m-thick beds, locally with cross laminations.

The petrographical analysis classifies the arenites as quartzwackes (QFR diagram). The main mineralogical component is polycrystalline and monocrystalline quartz (95%-99% of the grains), in subrounded grains occasionally showing undulose extinction. Phyllosilicates, Fe oxides and igneous rock fragments are also present. The matrix (30% of the bulk composition) consists of calcium carbonate cement, epimatrix and detritic matrix. These data point to high mineralogical and low textural maturities. Consequently these sandstones may be easily distinguished from the arkose of the Miras Fm.

The type-section was measured 500 m east of Episkopi at 200 m a.s.l. It consists of 30 cm to 1 m-thick strata of coarse sandstones yellow to white in coulor, with planar and cross laminations. In the first 2 m of the section light grey limestone clasts are included in the sandstones. The total thickness of the formation is 34 m.

The type-locality for the Silty Member is Kap Bisti.

Age. Owing to the lack of fossils, the age of this formation can be inferred only on the base of the stratigraphic position. The presence of local erosions at the contact between the Permian sequence and the Ag. Nikolaos Fm., the great difference in petrography from the Miras Fm. and its continuity with the overlying Eros Lmst. suggest that the Ag. Nikolaos is a transgressive detrital body at the base of the Triassic cycle.

Depositional environment. The sedimentary structures, i.e. cross laminations at low angle and pinching out of the sandy bodies in the siltstones, suggest that the depositional environment of this formation is probably a terrigenous marine flat affected by waves and/or by current action.

In fact the waves rework the detrital grains giving origin to litoral sand bars, whereas in the western part of Hydra an alluvional mud flat developes (Silty Mb.).

Eros Limestone (Römermann, 1968).

The Eros Limestone constitutes a huge carbonate bank, named after the highest mountain of Hydra by Römermann (1968). In this paper, for the first time, the Eros Lmst. has been subdivided and mapped into four subunits, whose rank was stated on lithology and paleoenvironmental considerations. From bottom to top they are as follow:

a) Eros Limestone, lower lithozone: consisting of gray oolitic limestone with detrital quartz grains and with interbedded silty beds (basal silty beds).

b) Eros Limestone sensu stricto: thick bedded gray oolitic and bioclastic limestone with cements.

c) Eros Limestone, Dark Member: thin bedded dark limestone, locally brecciated.

d) Eros Limestone, upper lithozone: red matrix bearing limestones breccias.

We suggest an informal subdivision in four subunits, without setting up a formal classification. In any case this subdivision was really useful both during the field work and during the elaboration of data.

Eros Limestone, lower lithozone.

The thickness of this lithozone varies from 25 up to 100 m. It is bounded at the top by the Eros Lmst. s.s. or by the Dark Member. The contact with the Eros Lmst. s.s. is marked by the disappearance of quartz grains.

Lithology. The lower lithozone consists of 0.5 to 1 m-thick beds of gray oolitic limestones with various contents in quartz grains of metamorphic and intrusive origin. Minor lithologic differences have been detected in the different tectonic units.

In the northern thrust sheets the lower lithozone is characterized by an oolites/quartz grains ratio abruptly varying from 18:1 to 1:5, forming distinct, tens of metres thick cycles. In the area between Kap Bisti and Ormos Molos, along the southern slope of O. Zakoni, interbeds of yellow to green silty beds with Spathian bivalves, laterally very continuous, are present and are mapped as Eros Lmst. basal silty beds in the geological map. In the first valley west of Vlichos, 1 km south of the coast at 100 m a. s.l., a few metres of red nodular limestones, with bivalves and quartz grains, have also been detected (Fig. 7).

In the southern thrust sheet, the lower lithozone consists of graded limestones with oolites, oncolites, intraclasts, gastropods and bivalves. These structures were observed near the village of Episkopi. Minor amounts of quartz grains and less variable oolites/quartz grains ratio with respect to the other lithofacies have been detected. Stylolite sutures with red matrix impart a nodular aspect to the beds.

Microfacies. Microfacies have been subdivided according to their occurrence in the northern or southern thrust sheets. Generally, the microfacies consist of oolitic grainstones and packstones with monocrystalline and polycrystalline quartz grains. The presence of lumps, intraclasts, bivalves, crinoids, gastropods, dasyclad Algae and foraminifers have been detected. Among the foraminifers *Meandrospira pusilla* (Ho), *Glomospirella shengi* Ho, *Ophthalmidium ? chialingchiangense* (Ho) are present. The microfacies of the northern thrust sheets is characterized by smaller oolites, more homogeneous in sorting and by a major and more variable amount of quartz grains with respect to the microfacies of the southern thrust sheet (Tab. 1). In the silty beds bivalves such as *Unionites* sp. and *Eumorphotis* sp. occur (det. R. Posenato).

Age. The presence of species of the genera *Unionites* and *Eumorphotis* similar to Lower Triassic species (Posenato, 1989 pers. comm.) suggests a late Early Triassic age for the lower lithozone, in agreement with the occurrence of *M. pusilla.* Durkoop et al. (1986) reported the occurrence of red micritic sediment with an Upper Scythian-Lower Anisian conodont fauna in the lower lithozone near Episkopi. We have sampled more than 20 kilos of red nodular limestone at Episkopi and near Vlichos in the same stratigraphic position, but unfortunately no conodonts were found.

Depositional environment. The lower lithozone represents the beginning of carbonate sedimentation in the Early Triassic. The depositional environment of this lithozone is interpreted as an oolitic bars field growing on a terrigenous flat (Ag. Nikolaos Fm.). The quartz input continues during bars growth. The microfacies of the

Fig. 7 - Nodular limestone in the lower lithozone of Eros Lmst. (first valley west of Vlichos).

northern thrust sheets suggests deposition in a quiet environment; lower energy is confirmed by the presence of interbedded silty horizons. The major amount of quartz grains is probably due to the proximity to the area of erosion. Conversely in the southern thrust sheet the presence of oolites of different size and graded beds suggest an higher energy medium characterized by wave and\or currents. The growing and moving of the oolitic bars prevent the life of benthic organisms.

	Algae	Echinoderms	Gastropods	Bivalves	*M.pusilla*	*G.shengi*	*M.dinarica*	*P.densa*	*E.wirzi*	*P.judicariensis*	Duostominidae	*G.grandis*	*P.globosa*	Peloids	Problematica	Small Oolites	Large Oolites	More quartz	Less quartz
EROS LMST. s.s. Microfacies D2	X	X					X	X	X		X				X				
EROS LMST. s.s. Microfacies A1, B3, C3, C4, D1	X	X	X	X			X	X	X	X	X	X	X	X	X				
EROS LMST. s.s. Microfacies B2		X												X		X			
EROS LMST. s.s. Microfacies B1, C1, C2		X		X	X										X	X			
EROS LMST. lower lithoz. Northern thrust sheets	X	X	X	X	X	X										X		X	
EROS LMST. lower lithoz. Southern thrust sheet	X	X	X	X													X		X

Tab. 1 - Bioclastic, oolitic and detritic content detected in Eros Lmst. Among bioclasts the most significative foraminifers are listed.

Eros Limestone sensu stricto.

The Eros Lmst. s.s. is widely distributed in the island (Fig. 8 and geological map), outcropping from Kap Bisti to Molos in O. Zakoni thrust sheet and between the Palamida and Vlichos faults in the Kutali thrust sheet (Fig. 3). Moreover it constitutes the backbone of the southern thrust sheet. The maximum thickness of Eros Limestone s.s. varies from 500 to 600 m. It is overlain by the upper lithozone and passes laterally into the Dark Member.

Lithology and microfacies. The lithology is represented by massive beds of oolitic and bioclastic limestone. Fibrous cement has been mainly observed in the medium and upper portion of the Eros Lmst. s.s. The lithology has been fully studied along four north-south sections with the help of microfacies analysis (Fig. 8); from west to east they are as follow:

A) section south of Gherakina (samples H50-68). This section is located on the plateau immediately south of Gherakina, from 240 m a. s.l. to the houses of the small

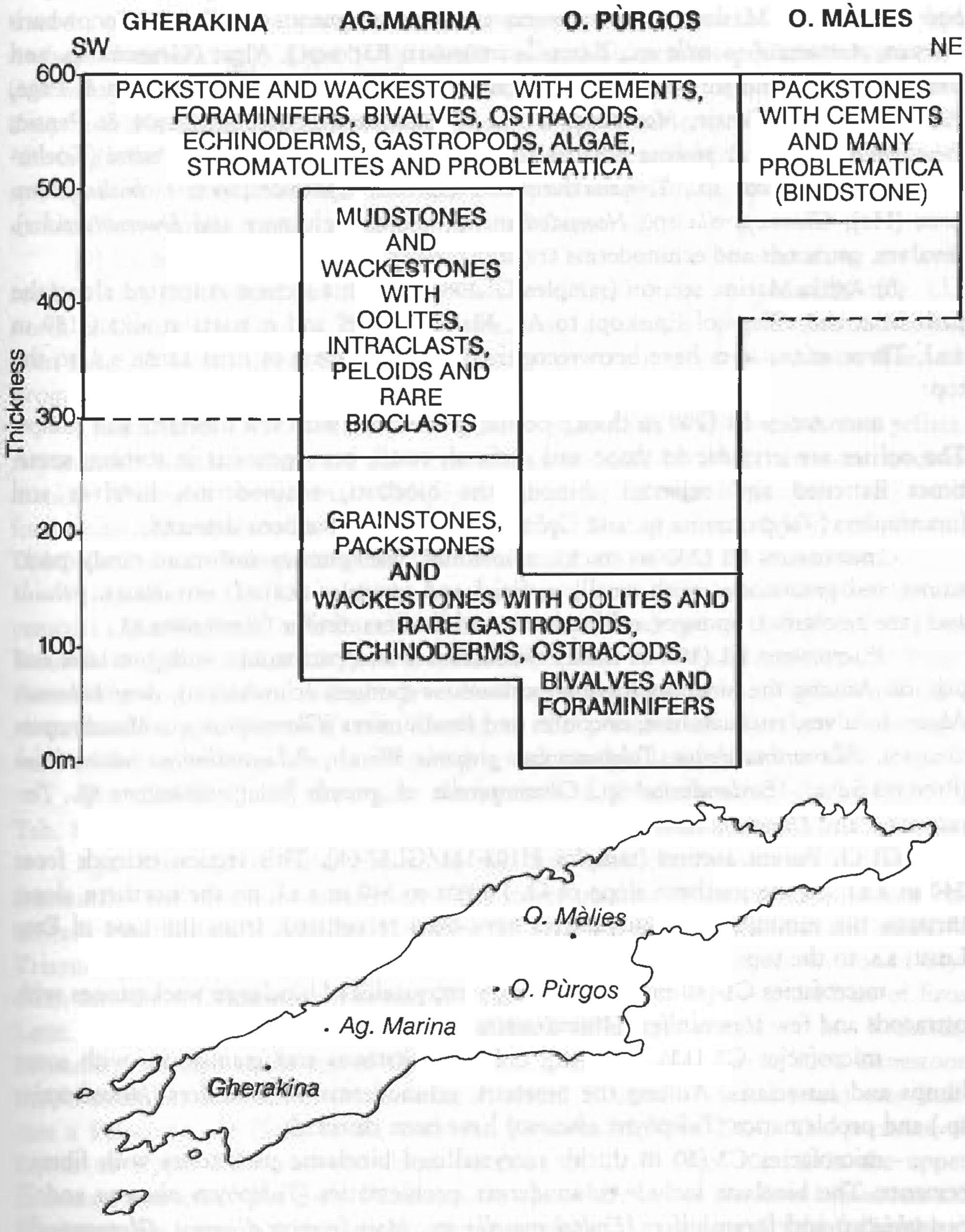


Fig. 8 - Internal subdivisions of Eros Lmst. s.s.: areal distribution and thickness of the microfacies.

village. The base of this section has not been sampled. Samples coming from the upper 300 m of the Eros Lmst. s.s. chiefly consist of recrystallized bioclastic packstones with fibrous cements (microfacies A1). Among the bioclasts there are proble-matica [*Tubiphytes obscurus* Maslov, *T. carinthiacus* (Flügel), *T. gracilis* Schäfer & Senowbari-Daryan, *Archaeolithoporella* sp., *Bacinella irregularis* Radoicic], Algae (*Cayeuxia* sp. and some dasyclads) and foraminifers [*Trochammina* sp., *T. jaunensis* Brönnimann & Page, *Pilammina densa* Pantic, *Meandrospira* sp., *M. dinarica* Kochansky-Devidé & Pantic, *Pseudobolivina* sp., *P. globosa* Kristan-Tollmann, *Endothyranella* sp., *E. wirzi* (Koehn-Zaninetti), *Tetrataxis* sp., *T. nana* Kristan-Tollmann, *Ophthalmidium* ? *chialingchiangense* (Ho), *Glomospirella* sp., *Neoendothyra* cf. *reicheli* Reitlinger and *Duostominidae*]. Bivalves, ostracods and echinoderms are also present.

B) Aghia Marina section (samples GL309-346). This section is located along the path from the village of Episkopi to Ag. Marina chapel and it starts at about 180 m a.s.l. Three microfacies have been recognized, from the base of Eros Lmst. s.s. to the top:

- microfacies B1 (200 m thick): oolitic grainstones with few bioclasts and lumps. The oolites are irregular in shape and surficial, small, homogeneous in sorting, sometimes flattened and oriented. Among the bioclasts, echinoderms, bivalves and foraminifers (*Tolypammina* sp. and *Ophthalmidium* sp.) have been detected;
- microfacies B2 (230 m thick): mudstones, wackestones and more rarely packstones and grainstones with small, surficial and irregular oolites, intraclasts, peloids and rare bioclasts as sponges, echinoderms and the foraminifer *Glomospira* sp.;
- microfacies B3 (100 m thick): wackestones and packstones with bioclasts and peloids. Among the bioclasts there are calcareous sponges, echinoderms, dasycladacean Algae, bivalves, stromatolites, oncolites and foraminifers [*Glomospira* sp., *Meandrospira dinarica*, *Pilammina densa*, *Tolypammina gregaria* Wendt, *Palaeomiliolina judicariensis* (Premoli Silva), "*Earlandinita*" sp., *Glomospirella* cf. *grandis* (Salaj), *Endothyra* sp., *Textulariidae* and *Duostominidae*].

C) O. Purgos section (samples H102-131/GL57-68). This section extends from 240 m a.s.l. on the southern slope of O. Purgos to 340 m a.s.l. on the northern slope, through the summit. Four microfacies have been recognized, from the base of Eros Lmst. s.s. to the top:

- microfacies C1 (40 m thick): strongly recrystallized bioclastic wackestones with ostracods and few foraminifers (*Meandrospira pusilla*);
- microfacies C2 (135 m thick): oolitic packstones and grainstones with some lumps and intraclasts. Among the bioclasts, echinoderms, foraminifers (*Meandrospira* sp.) and problematica (*Tubiphytes obscurus*) have been detected;
- microfacies C3 (50 m thick): recrystallized bioclastic packstones with fibrous cements. The bioclasts include echinoderms, problematica (*Tubiphytes obscurus* and *T. carinthiacus*) and foraminifers (*Endothyranella* sp., *Meandrospira dinarica*, *Glomospirella grandis*);

- microfacies C4 (more than 300 m thick): packstones and more rarely wackestones with bioclasts and peloids. Macroscopic, fibrous and palisade cements arranged in concentric bands are also present. The bioclasts include bivalves, echinoderms, ostracods, gastropods, rare problematica (*Tubiphytes obscurus*, *Bacinella irregularis* and *Archaeolithoporella* sp.), Algae (*Oligoporella* sp. and *Solenopora* sp.) and foraminifers (*Meandrospira dinarica*, *M. deformata* Salaj, *Endothyranella* sp., *E. wirzi*, *Meandrospiranella samueli* Salaj, *Pilammina densa*, *Tolypammina gregaria*, *Tetrataxis nana*, "*Earlandinita*" sp., *Involutina* sp., *Calcitornella* sp., *Ammobaculites* sp., *Pseudobolivina* sp., *Trochammina* sp., *Neoendothyra* sp., *Turrispirillina prealpina* Zaninetti & Brönnimann, *Glomospirella grandis*, *Duostominidae* and *Lagenidae*).

D) O. Malies section (samples H167-184). This section is located along the new road striking from about 150 m of altitude above Kap Riga to the pass (200 m a. s.l.) north of Limnionisa Ormos. The base of the Eros Lmst. s.s. along this section has not been sampled. In the upper 200 m of the platform two microfacies have been detected. From bottom to top:

- microfacies D1 (90 m thick): bioclastic packstones with cements and pellets. Among the bioclasts there are echinoderms, gastropods, bivalves, ostracods, problematica (*Bacinella irregularis*, *Tubiphytes obscurus*, *Archaeolithoporella* sp.) and foraminifers (*Ammobaculites* sp., *Trochammina* sp., *Endothyra* sp., *Endothyranella* sp., *Ophthalmidium ? chialingchiangense*, *Neoendothyra* cf. *reicheli* and *Duostominidae*);

- microfacies D2 (120 m thick): bioclastic packstones with very abundant fibrous cements. The bioclasts include echinoderms, ostracods, abundant *Tubiphytes obscurus*, *Bacinella irregularis*, *Cayeuxia* sp. and foraminifers such as *Endothyranella* sp., *E. wirzi*, *Neoendothyra* cf. *reicheli*, *Meandrospira dinarica*, *Pilammina densa*, *Trochammina* sp., *Ammobaculites* sp., *Duostominidae*. Owing to the presence of abundant *T. obscurus* with evident encrusting fibrous cement, this rock can be classified as a bindstone.

The distribution of the major components of these microfacies is reported in Tab. 1.

Age. The age of Eros Limestone s.s. has been determined on the base of foraminifer and conodont associations. The lower portion of the platform lacks a significant foraminifers association. However the presence of *M. pusilla* indicates an Early Triassic age (Salaj et al., 1983 and Oravecz-Scheffer, 1987). Moreover we found Scythian conodonts [*Neospathodus homeri* (Bender)] at about 310 m above the base of Eros Lmst. s.s. on the eastern slope of O. Zakoni (MR 225 sample of M. Richards, Lausanne, collected at the top of the Dark Mb.). In the upper part of Eros Limestone the foraminifers association (*M. dinarica*, *P. densa*, *E. wirzi*, *P. iudicariensis*) may indicate a Pelsonian age (Salaj et al., 1983 and Oravecz-Scheffer, 1987). The presence of Lower to Upper Pelsonian conodonts (sections A, C, F) (Fig. 10, 11) in the upper lithozone restricts to the Early Pelsonian the age of the top of the Eros Limestone s.s. So almost the lower 300 m of the platform deposited during Late Scythian (Spathian) and only the upper part is Anisian (up to Early Pelsonian).

Depositional environment. The depositional environment of the lower 200 m of the Eros Limestone (microfacies B1 and C2) is interpreted as migrating oolitic bar fields, probably affected by current winnowing, as shown by the homogeneity in sorting of the oolites. Higher in the sections, the oolitic fields are replaced by a lower energy environment, represented by bioclastic packstones with abundant foraminifers and cements (microfacies A1, B3, C3, C4, D1). At Ag. Marina, no foraminifers occur in the lower 200 m (microfacies B2) that represent lower energy environment. In the easternmost section (O. Malies), the foraminifer-bearing packstones are bound by very abundant *Tubiphytes* and algal crusts and encrusted by fibrous and palisade cements (microfacies D2). This suggests the existence of a hard, although poorly developed organic rim in the eastern part of the island. So during Scythian-Early Anisian a thick carbonate platform developes, consisting of oolitic bars at the base and open lagoon facies towards the top. The margin of the platform is probably located in the east, where bindstones are detected. Moreover this bank is dissected by intraplatform troughs, in which the Dark Mb. of the Eros Lmst. deposits.

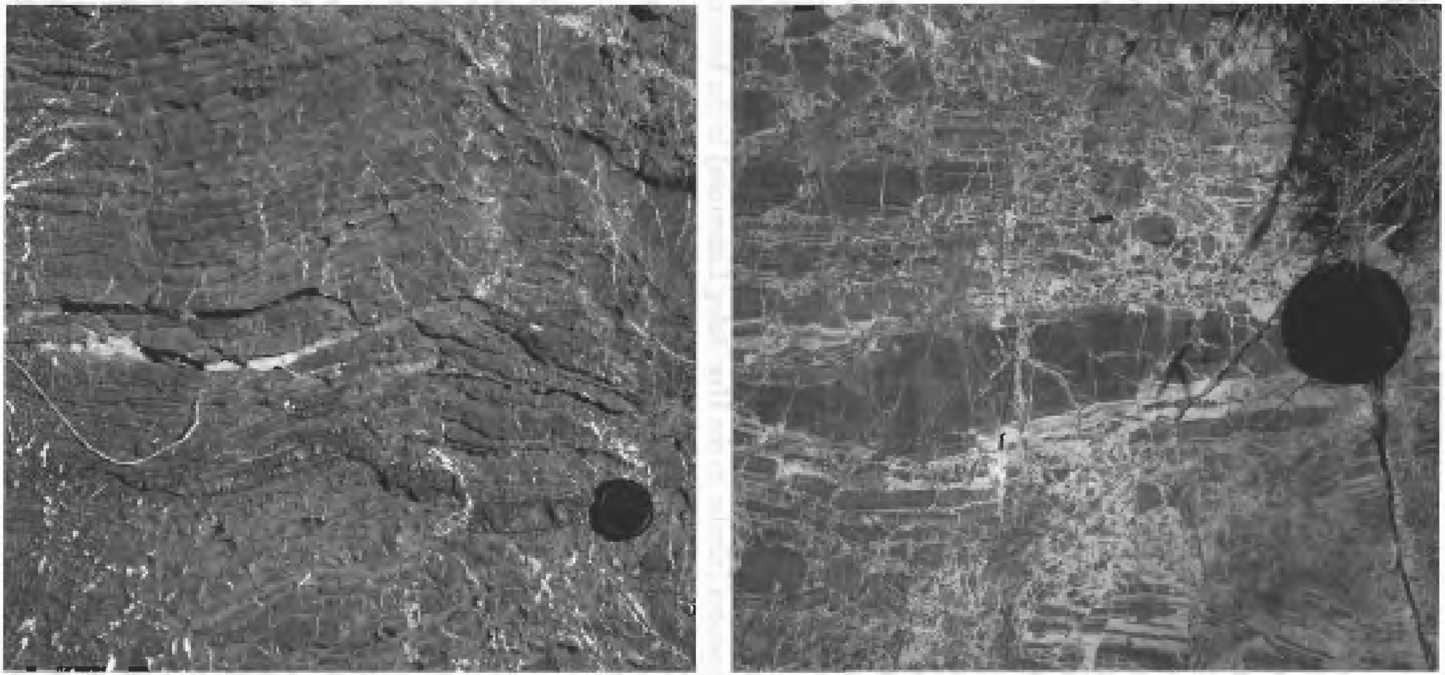
Eros Limestone, Dark Member.

The Dark Member outcrops from Kap Bisti to Ormos Ag. Nikolaos, around the summit of O. Zakoni and east of the large valley west of Ormos Molos in O. Zakoni thrust sheet. It also constitutes the Kutali thrust sheet and it outcrops east of Ormos Limnioniza in the southern thrust sheet (see geological map). The thickness of this member varies widely, because of its interfingering to the Eros Limestone s.s. The maximum thickness measured is 200 m. The Dark Member is overlain either by the Eros Limestone s.s. or by the Han Bulog Limestone in the area north of O. Zakoni. Laterally the Dark Member makes a gradual transition to the platform. The transitional facies consists of massive, dark, sometimes brecciated limestones with few oolites and oncolites. The lithology and microfacies of the Dark Mb. have been studied in particular on the southern slope of O. Zakoni, in the valley west of Ormos Molos, in the first valley west of Vlichos and near Ormos Limnioniza.

Lithology. The lithology of the Dark Member consists of centimetric to decimetric laminated planar beds of dark limestone with chert in nodules and bands (Fig. 9a). Massive beds of intraformational breccias are also present. A later dolomitization replaced the primary laminated limestone and constitutes also the cement of the breccias (Fig. 9b).

Microfacies. The microfacies of the Dark Member chiefly consists of a thin alternation of mudstones and bioclastic wackestones with rare oolites and peloids. The bioclasts include pelagic bivalves, radiolarians, sponges spicules, rare echinoderms and foraminifers (*Glomospirella* sp., *Pilammina inconstans* Michalik, Jendrejakova & Borza, *Rectocornuspira kalhori* Brönnimann, Zaninetti & Bozorgnia, *Glomospirella triphonensis* Baud, Zaninetti & Brönnimann).

Age. The age of the Dark Member ranges from Spathian to Early Pelsonian according to the occurrence of *R. kalhori* in its lower part, of Spathian conodonts *(N.*



a b

Fig. 9a, b -Photo of the Dark Member of Eros Lmst. (first valley west of Vlichos). 9a) Chert lenses; 9b) dolomitic intraformational breccias.

homeri) and of Pelsonian-Illyrian conodonts in the overlying Han Bulog Limestone (sections A, B, C, F, G, H) (Fig.10, 11) and to the relationship with the Eros Lmst. s.s.

Depositional environment. Owing to its discontinuous distribution, to its peculiar lithology and to the clear relation of interfingering with the Eros Lmst. s.s., the depositional environment of the Dark Member can be interpreted as intraplatform troughs. These troughs, anoxic but probably not very deep, developed in different sites either at the base of the platform, or in the middle, or from a hundred of metres over the base to the top of the Eros Lmst. s.s. The presence of both platform clasts (oolites and benthic foraminifers) and pelagic bioclasts (radiolarians and filaments), in the same discrete levels in the Dark Mb., indicates an episodic influx of open marine waters that sweept the platform and resedimented material into the basins. The abundance of intraformational breccias may suggest block-faulting activating the basins.

Eros Limestone, upper lithozone.

The thickness of this lithozone varies from 10 up to 30 m. In the northern thrust sheets the upper lithozone is overlain by the Han Bulog Limestone and locally by the Quartz-keratophyric tuffs. In the southern thrust sheet, the upper lithozone is overlain either by the Han Bulog Limestone, by the Quartz-keratophyric tuffs or by the Adhami Limestone, lower member. The breccias of the upper lithozone pass progressively upward into the Han Bulog Limestone. This is indicated by the occurrence of nodular limestones (similar to the Han Bulog Limestone) in the breccias.

Lithology. The lithology of this member consists of red matrix-bearing calcareous breccias with centimetric to decimetric gray oolitic clasts and pink clasts with crinoids. In the uppermost portion of this lithozone, the clasts are locally coated with cherty crusts.

Microfacies. The microfacies of the clasts consist of packstones and wackestones with peloids and bioclasts such as echinoderms, sponges, dasyclad Algae, ostracods, pelagic bivalves and foraminifers (*Meandrospira dinarica, Pilammina densa, Endothyranella* sp., *E. wirzi, Ammobaculites* sp., *Trochammina* sp., *T. almtalensis* Köhen-Zaninetti, *Endothyra* sp., *Tetrataxis nana, Permodiscus* sp., *Duostominidae*). The red matrix contains ostracods and pelagic bivalves.

Age. A rich conodont fauna has been found in this lithozone in the stratigraphic sections A, C, F (Fig. 10, 11 and Tab. 2). The association is mostly dominated by the occurrence of *Gondolella bulgarica* (Budurov & Stefanov), *G. bifurcata bifurcata* (Budurov & Stefanov), *G. bifurcata hanbulogi* (Sudar & Budurov) and *Gladigondolella tethydis* (Huckriede). In the lower part (sect. C, samples GL85-87) *G. bulgarica* and *G. b. bifurcata* prevail, whereas *G. b. hanbulogi* becomes more frequent higher up (sect. C, samples GL88-91). Based upon these considerations this lithozone seems to cover the whole Pelsonian time interval.

Depositional environment. The breccias of the upper lithozone record the downwarping of the Eros Lmst. platform, which is also suggested by the presence of

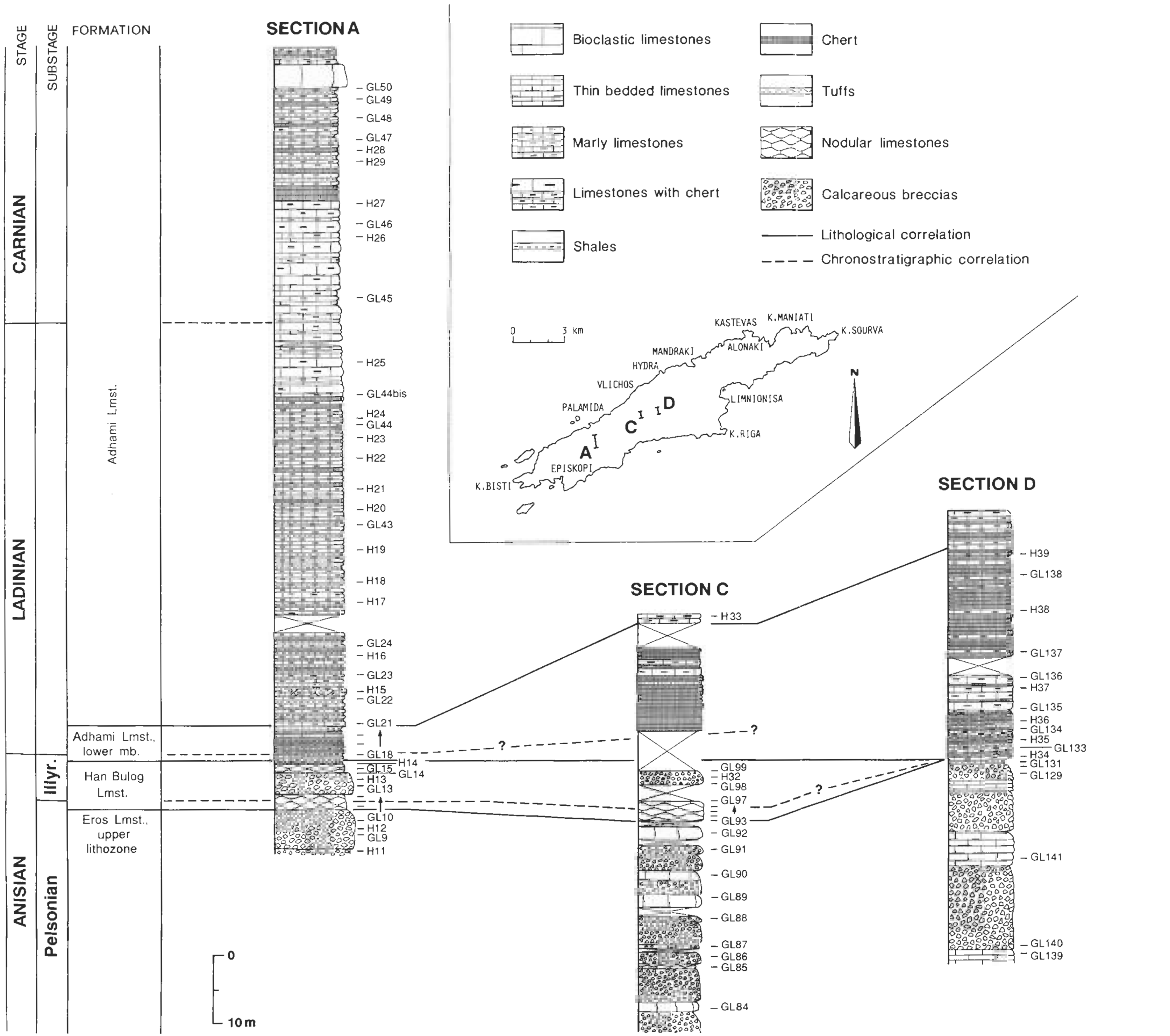
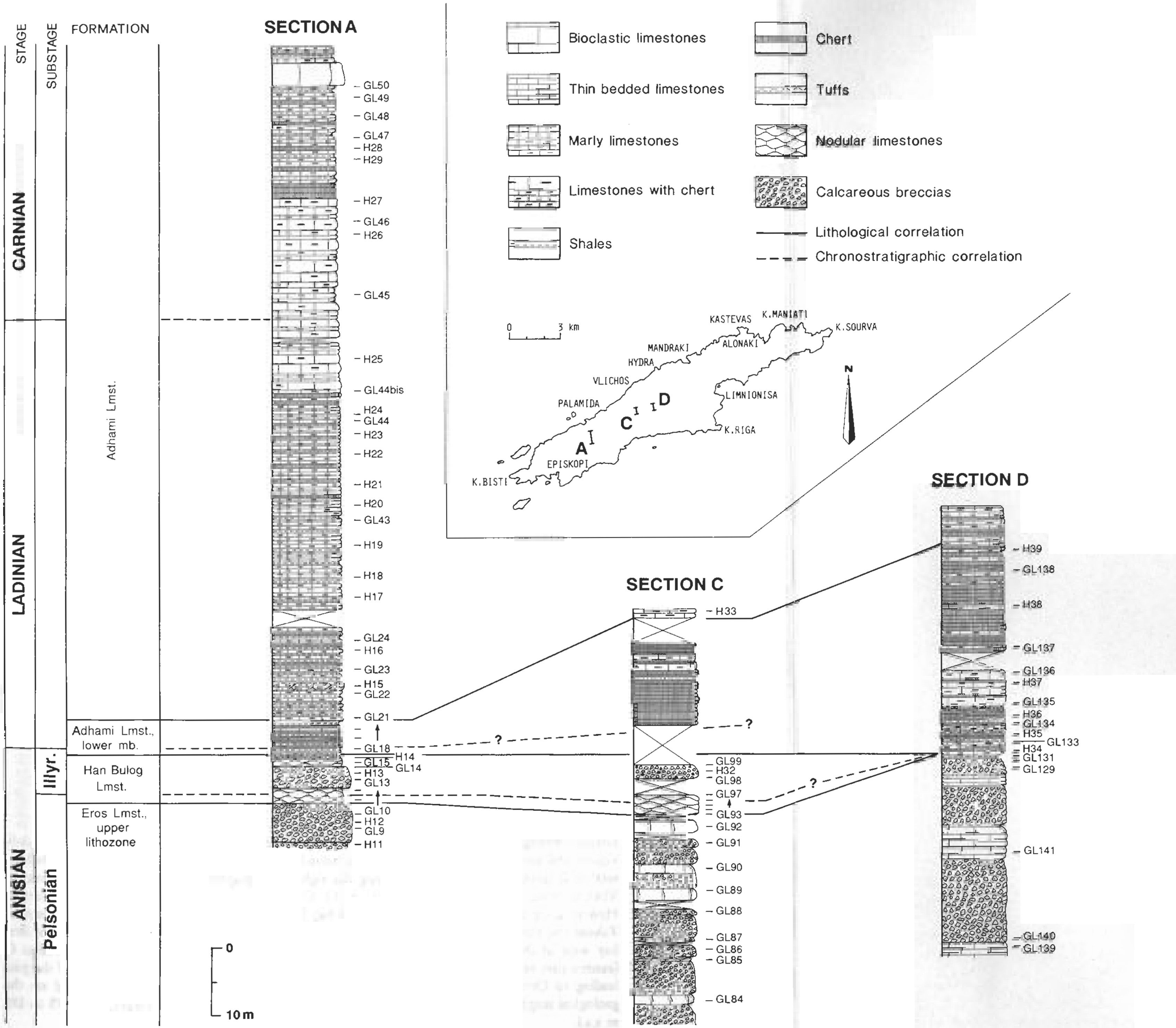


Fig. 10 - Detailed stratigraphic sections measured in the southern thrust sheet. Chronostratigraphic subdivisions and correlations based on conodont zonation. The locations of the sections are as follow: section A (central part of Hydra), from Ag. Marina chapel (180 m a.s.l.) northward for 200 m along the path to Ormos Palamida; section C (central part of Hydra), at 270 m a.s.l. on the ideal (by air) link between O. Eros and Vlichos; section D (central part of Hydra), at 240 m a.s.l. on the ideal (by air) link between O. Eros and Kamini, WNW of Pr. Ilia.



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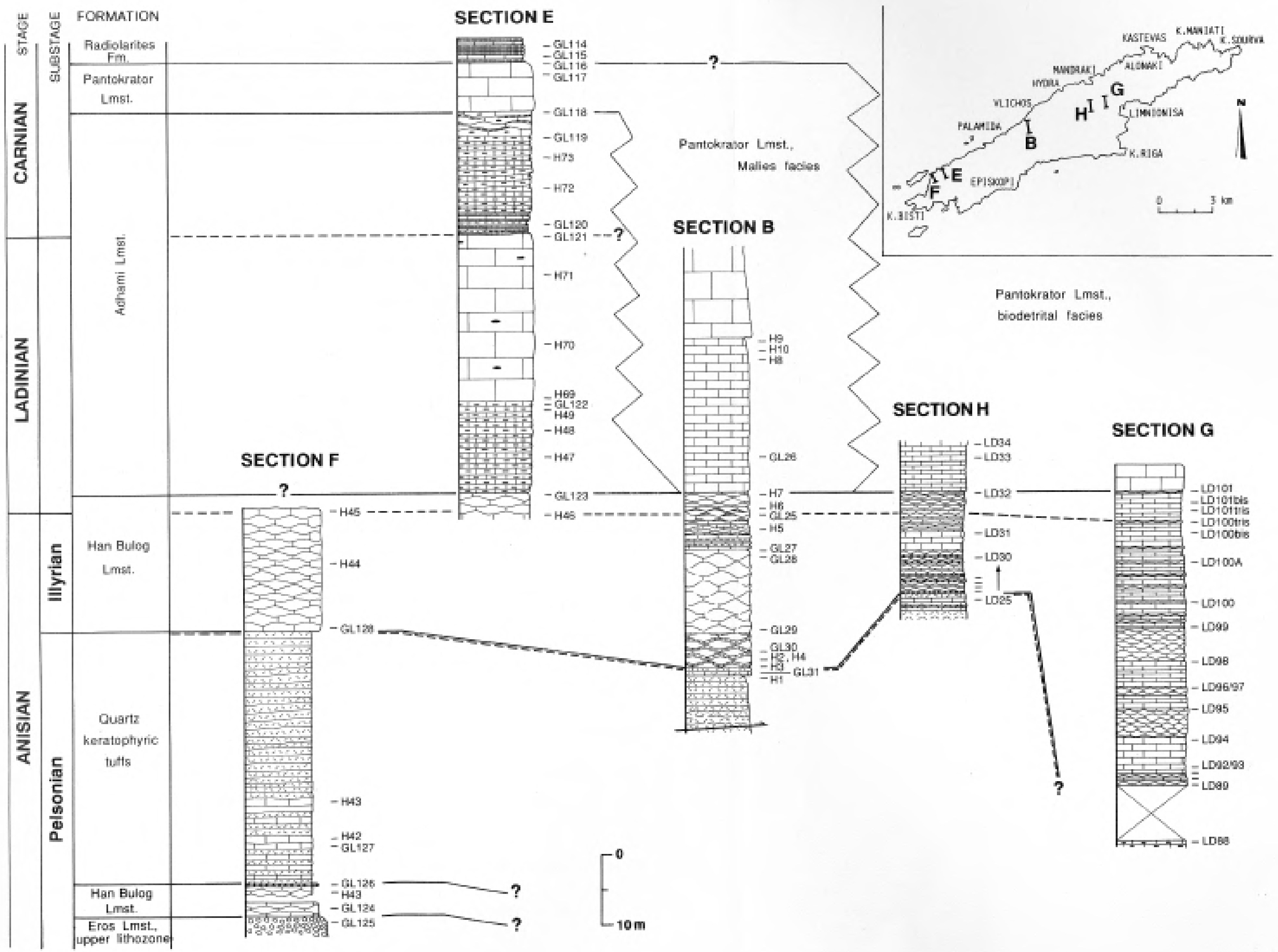

Fig. 11 - Detailed stratigraphic sections measured in the northern thrust sheets. Chronostratigraphic subdivisions and correlations based on conodont zonation. The locations of the sections are as follow: section B (central part of Hydra), along the right hydrographic side of the first valley west of Vlichos, from 40 m to 100 m a.s.l. in the O. Ompori thrust sheet; section E (western part of Hydra), along the western side of the second bay located east of the ideal (by air) link between O. Zakoni and the easternmost tip of Petasi Island; section F (western part of Hydra), along the first bay west of the ideal link between O. Zakoni and the easternmost tip of N. Petasi; section G (eastern part of Hydra), about 10 m south of the monastery located on the eastern side of the pass leading to Ormos Limnionisa from 240 to 250 m a.s.l. (the monastery is not located on the geological map); section H (eastern part of Hydra), 250 m WNW of Ag. Triados, from 175 to 180 m a.s.l.