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ΝΕΑ ΣΤΡΩΜΑΤΟΓΡΑΦΙΚΑ ΔΕΔΟΜΕΝΑ ΤΩΝ ΠΡΟ-ΙΟΥΡΑΣΙΚΩΝ ΕΝΟΤΗΤΩΝ ΤΗΣ ΠΕΛΑΓΟΝΙΚΗΣ ΣΤΗ ΝΗΣΟ ΕΥΒΟΙΑ

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NEW STRATIGRAPHIC DATA ON THE PELAGONIAN PRE-JURASSIC UNITS OF EVIA ISLAND (GREECE)*

by

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I. INTRODUCTION

The tectonic metamorphic units from Evia and Attica are overthrusted by the non metamorphic units from the Pelagonian zone (formerly called sub- Pelagonian) found in Evia, Attica and Beotia. This cover sequence is composed from top to bottom of:

- Maastrichtian to Danian flysch (72-60 Ma).
- Trangressive late Cretaceous limestones (95-72 Ma)
- Ophiolites (serpentinites, peridotites, diabases) emplaced during the Kimmeridgian (145-135 Ma).
- Neritic limestones and dolomites of Jurassic and late Triassic (230-235 Ma).
- Middle and early Triassic sequences of shallow as well as deep water facies (Hallstatt), together with detritic sediments and volcanic spilitic lavas.
- Late Paleozoic formations (290-250 Ma).

The ophiolites have been obducted on the Jurassic platform, a melange is found between the two sequences representing a former accretionary wedge with deep water facies (e.g. radiolarian cherts).

The lower tectonic units from Evia can be regarded as the basement from the most external Pelagonian tectonic units. They could also represent another more external paleogeographic realm as some sequences are found in both domains but with different stratigraphy and sedimentology.

We shall review this stratigraphy in light of new paleontologic and structural data and see wether these lower units represent a new paleogeographic domain.

II. NORTH EVIA

Several outcrops of basement have been recognized in this region (fig. 1, units Ia, II III and IV), the basement is often covered by detritic continental beds (100 to 200m thick) including some late Permian limestones. These limestones form lenses or boudins due to strong deformation, but detailed mapping has shown that they form continuous

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* Νέα στρωματογραφικά δεδομένα των προ-Ιουρασικών ενοτήτων της Πελαγονικής στη νήσο Εύβοια.

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strata interbedded in the detritic sequence (fig. 2). These sequences are covered by different types of Triassic strata (carbonate platform, volcano-sedimentary). One unit (II) is quite different as a turbitic sequence directly overlies the basement.

– The basement

The basement found in several structural units is of Variscan affinities (STAMPFLI *et al.* 1998). It is the most southerly occurrence of such high grade metamorphic rocks in the Pelagonian domain. It is represented by ortho and paragneisses (fig. 3a & b) (some of the latter resembling Verrucano type detritic sequences, like in unit Ia). The orthogneisses were former intrusives as confirmed by geochemical analyses (fig. 3a & 3b). They are represented by amphibolitic and biotitic gneisses, amphibolites, micaschistes, micro-granites and mylonites in upper green-schist facies presenting several phases of de-formation.

– Synthetic section

Different types of limestone sequences have been identified in this area, they belong to different structural units (fig. 1 & 2) and their age varies from late Permian to middle Triassic.

Some of these sequences are found thrusted or in stratigraphic contact with either a continental detritic sequence or the basement (e.g. in structural unit III). The detritic sequence was deposited on the basement. As it contains a late Permian limestone inter-calation, this sequence was attributed to the Verrucano s.l.. There are no fossils in this sequence, the age of the top of the sequence is constrained by the following fossil occurrences:

- Permian limestones are found within the detritic continental sequence separating it into two stratigraphic units. We found different facies (black reefal limestones, with crinoids and sponges and black micritic limestones) which contain *Lantschichites* and *Sichotenella* (first occurence in Greece) as well as some Nodosariidae and algae or pseudo-algae like *Pseudovermiporella, Tubiphytes* and *Archaeolithoporella*. They can be dated from the Midian to Dorashamien (255-245 Ma). They often follow a quartzitic conglomerate. In one outcrop the conglomerate is followed by a fore-reef type breccia whose elements are light gray limestones containing *Colaniella, Reichelina, Paraglobival-vulina*, as well as corals and sponges and white to pinkish limestones with some cephalopod fragments. These fore-reef deposits grade laterally into reefal or lagoonal facies as described above and crop out near the country road from Polylofos to Aghios north of Valandi. Some samples from a large outcrop of recrystallised limestones at the Lofos hill contain the foraminiferas *Glomospira* ex. gr. *tenuifistula, Endoteba* sp. and *Meandrospira pusilla*, and define a middle Triassic age (Anisian). Similar facies are present also at the Valandi hill.

The limestones west of Edipsos, on the top of Korakolithos hill as well as the outcrop near the chapel of Theotokos have been dated as Murgabian to Dorashamian, contrary to previous interpretation which considered them as Triassic. They contain: *Climacammina, Hemigordius, Neohemigordius, Multidiscus, Colaniella, Paraglobivalvulina, Diplospherina, Globivalvulina, Dagmarita, Staffella, Paleofusulina,* Nodosariidae, *Tubiphytes, Permo-calculus, Gymnocodium* and *Mizzia*. They are thicker than the limestones found east of Edipsos, they are clearly refolded and could be thrusted on the Verrucano or even on the basement. They may represent a slightly different paleogeographic domain.

- a light colored limestone sequence often dolomitic is found overthrusted on the detritic sequence or on the basement, but also locally overlays the Verrucano sequence

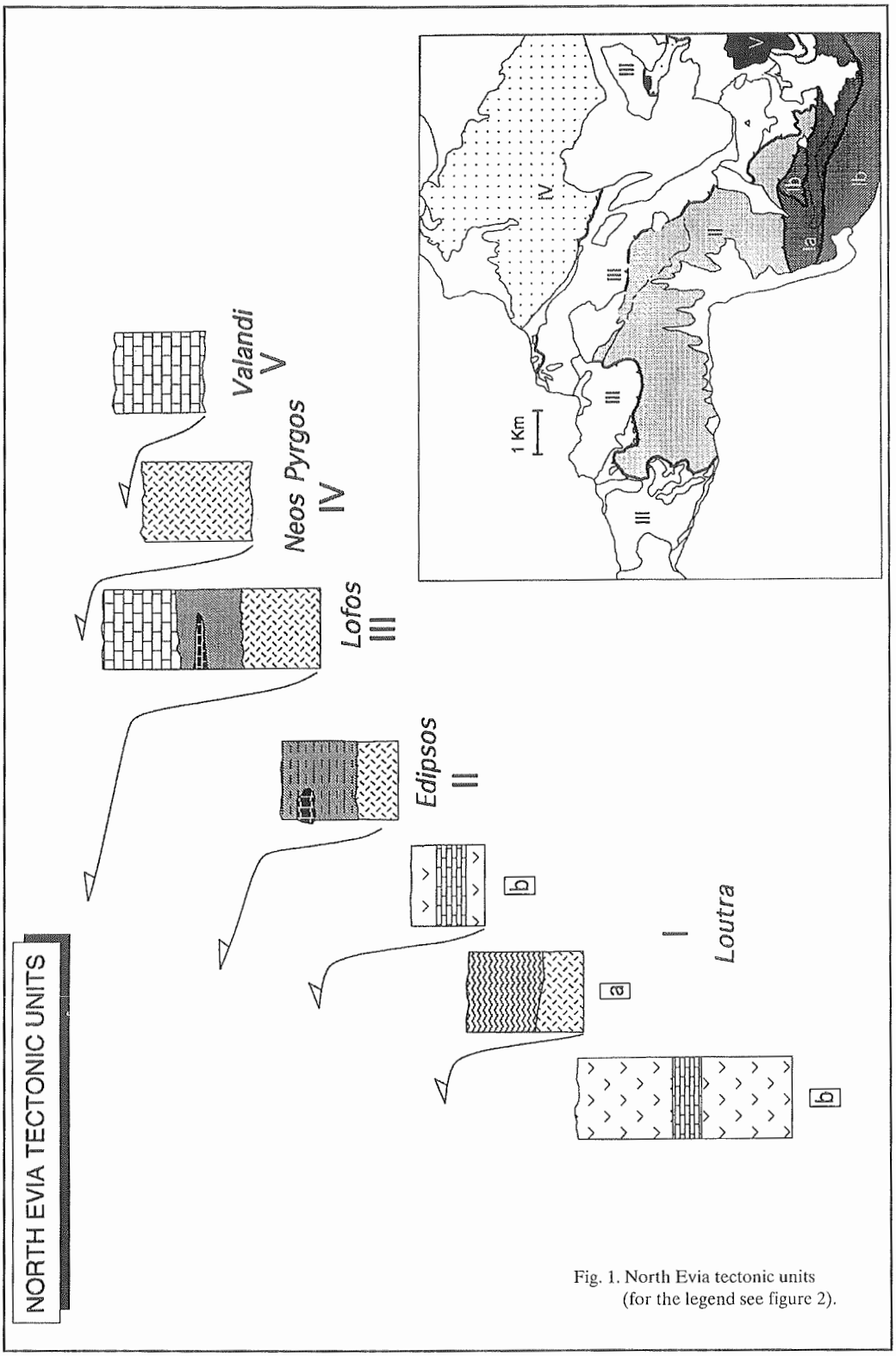


Fig. 1. North Evia tectonic units
(for the legend see figure 2).

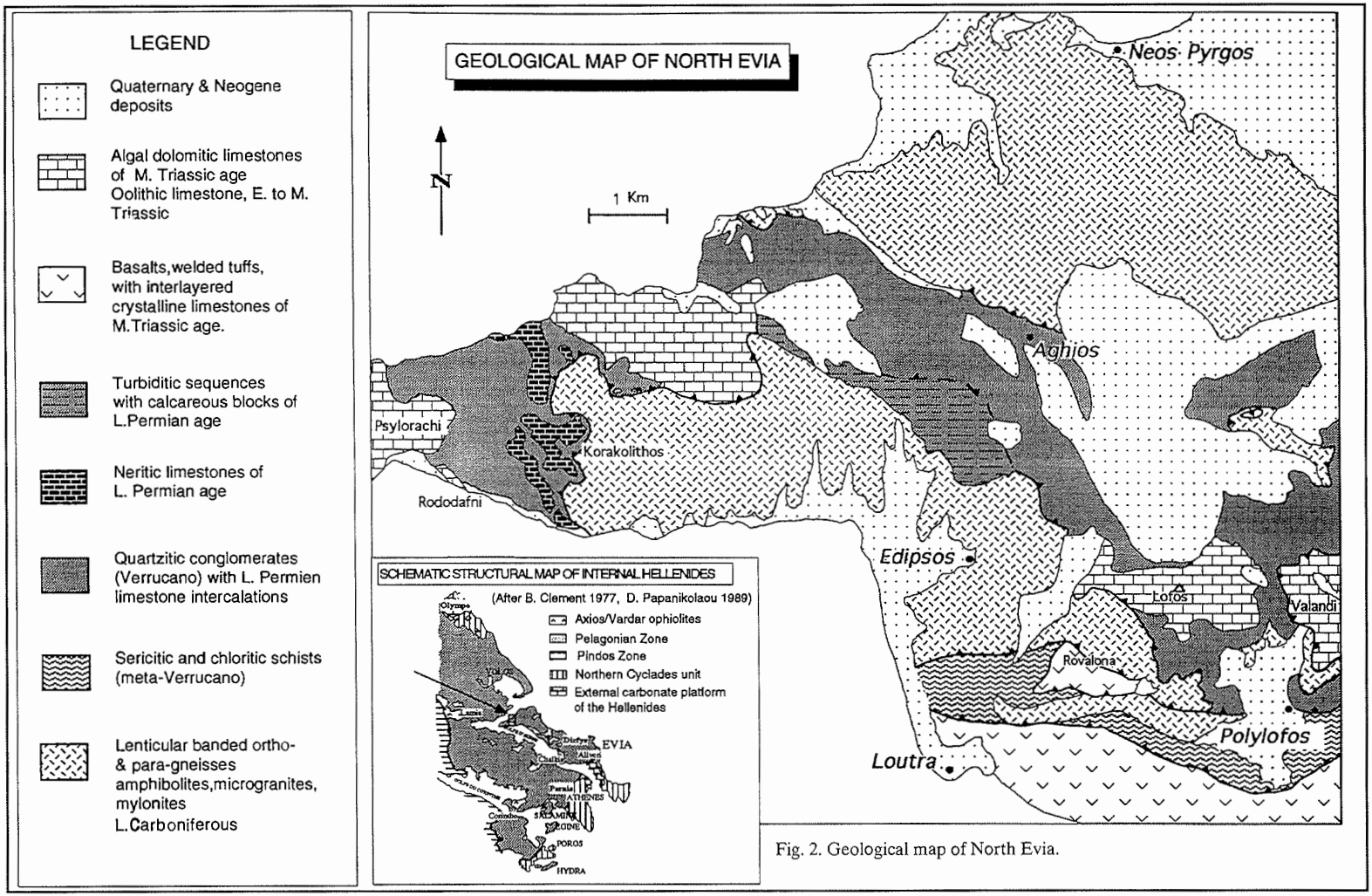
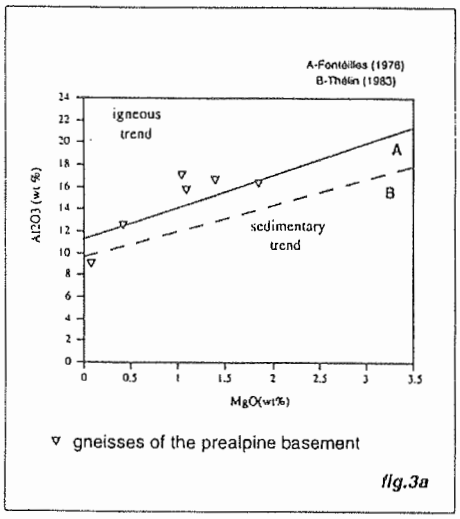
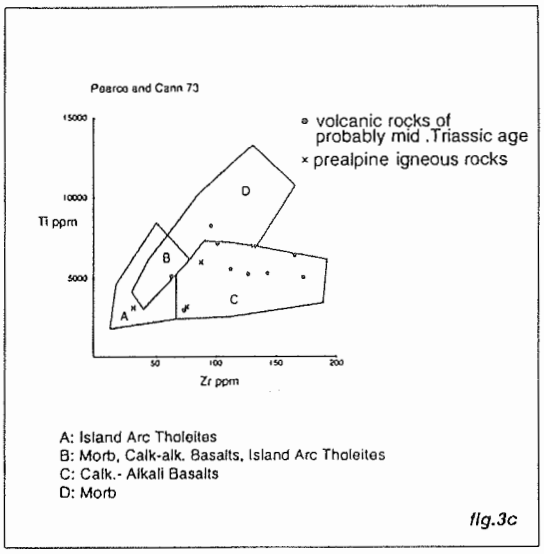
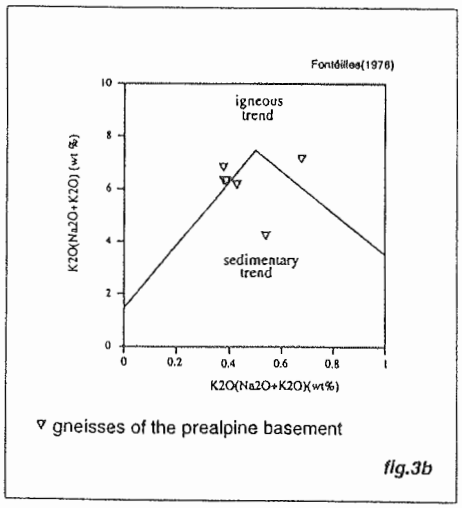


Fig. 2. Geological map of North Evia.

GEOCHEMICAL PRELIMINARY DATA
NORTH EVIA







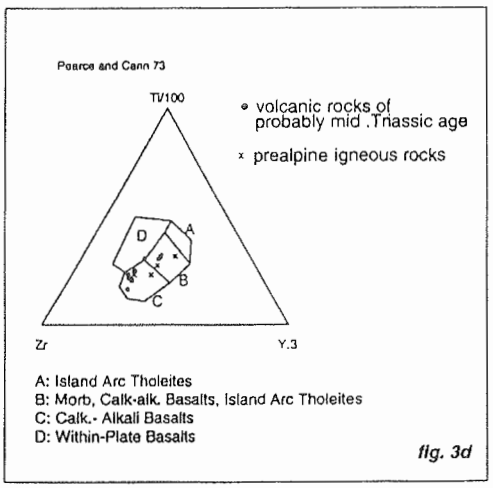


Fig. 3. Geochemistry of North Evia basic rocks and basement gneisses.

with a stratigraphic contact. It contains *Meandrospira dinarica, M. cheni* and *M. deformata, Pilammina praedensa, Agathammina* and *Glomospirella* c.f. *vulgaris*, which suggest to assign an early to middle Triassic age to that sequence. They crop out near Psylorachi hill.

- a dark gray bioturbated and oolitic limestone sequence is also found in stratigraphic contact with the Verrucano west of Edipsos containing *Meandrospira pusilla, Glomospirella, Gandinella*. The age of this sequence ranges from early to middle Triassic.

Structural Unit Ia is a sequence with some basement and metamorphic Verrucano slices. In Unit Ib the dominating types of rocks are volcanoclastics with some intercalations of recrystallised limestones often strongly folded and difficult to date. The presence, for the first time in Evia in these limestones, of *Meandrospira dinarica*, in a few samples collected near Loutra, gives an Anisian age to this formation. This volcanoclastic sequence is known elsewhere in Greece (PE-PIPER *et al.* 1996) and has usually been dated as middle Triassic (PAPANIKOLAOU & ZAMBETAKIS - LEKKAS 1980). The Units Ia and Ib were most likely folded together after a thrusting event.

– **The Triassic volcanism**

The middle Triassic volcanism is represented by a deformed series of lavas (basalts, trachy-basalts, basaltic andesites and basaltic trachy-andesites) tuffites and welded tuffs. Geochemical analyses using K2O-SiO2, N2O+K2O-SiO2, Ti-Zr-Y, Ti-Zr and Spider (rock/MORB, rock/chondrites) diagrams show a volcanism of calc-alkaline to alkaline affinities (fig. 3c & d). This type of volcanism recognised in many other places from northern Italy to Turkey (STAMPFLI 1996), could be related to a setting of arc volcanism possibly grading to a back-arc rifting (PE-PIPER 1982; PE-PIPER & PANAGOS 1989). It is sealed by platform limestone in some areas (central Evia).

– **The turbidite sequence**

Structural Unit II contains another type of detritic sediments represented by a middle to upper fan type turbiditic sequence, containing olistoliths of brecciated Permian limestones. These limestones contain the following foraminifera: *Hemigordius, Reichelina, Baisalina, Staffella*, and some algae: *Mizzia* and *Permocalculus*, giving a Midian to Dorashamian age.

No other fossils have been found so far in this sequence. Its age could be very late Permian or younger. This sequence is not similar to the flyschoid Liri formation from central Evia.

III. CENTRAL EVIA

In central Evia the situation is not as simple as described by the previous authors (GUERNET 1971; ARGYRIADIS 1978; SIDERIS 1986). The principal changes concern the ages of the series and the structural framework. These central Evia series were regarded as a single detrital unit containing blocks of Paleozoic and Triassic limestones. Detailed mapping has shown that we are actually dealing with several tectonic units. The upper unit is made of late Triassic platform limestones thrusted or in sedimentary contact with a volcano-detrital sequence. The next Seta Unit represents continuous sequence similar to that described in northern Evia, with Verrucano facies and late Permian to middle Triassic carbonates. A third Liri Unit is represented by a flysch sequence containing olistoliths.

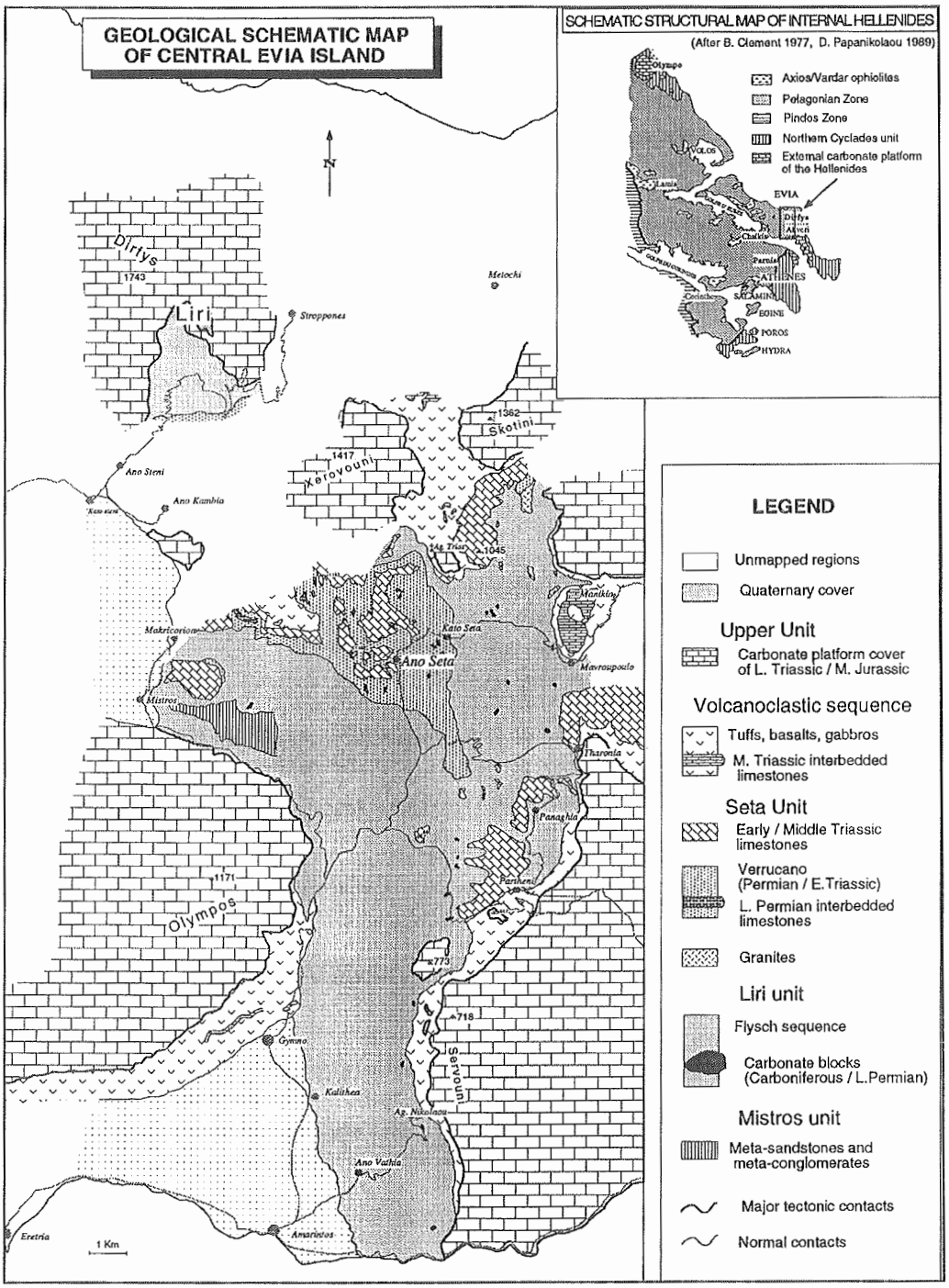


Fig. 4. Geologic map of Central Evia island

– The upper Triassic-Jurassic Unit

This unit represents the Pelagonian zone carbonate platform starting in the late Triassic and grading to deep water facies in the middle to late Jurassic. This platform seals the complicated story which we are presently unravelling. The sequence below this platform has often been grouped into the so-called Pelagonian basement, but as we have seen there is more than only polymetamorphic Variscan basement.

This platform is usually in tectonic contact with the units below (SIDERIS 1986). A stratigraphic contact with the volcano-detrital unit can be observed on the northern side of the Mount Xerovouni (fig. 4). It consists from the base to the top, of late Triassic nodular limestones followed by reefal facies with rare Megalodontidae of latest Triassic age followed by thin bedded Liassic limestone with some Lithiotis and cherty limestone of probable middle Jurassic age. The top of the sequence comprises radiolarian cherts already recognised and dated as late Jurassic in the Achladi region by BAUMGARTNER & BERNOULLI, 1976.

– The volcano sedimentary sequence

This sequence is relatively similar to the one cropping out in northern Evia. It was first described by GUERNET, 1965 a, b, and 1967, then studied by PE-PIPER, 1982, and PE-PIPER & PANAGOS, 1989, from a petrographical-geochemical point of view.

It is mainly composed of tuffites with some basaltic and andesitic flows or pillows and also some gabbros (fig. 5). In the tuffites interbedded limestones, sometimes up to 20 m thick, contain some fauna of Anisian to late Carnian age:

- marly limestones rich in middle Anisian foraminifera such as *Pilammina densa, Pilammminella grandis.*
- Hallstatt type limestone have yielded some ammonites fragments not yet determined
- calciturbidites followed by nodular limestones contain some Norian conodonts (*Paragondonella polygnathiformis).*

Concerning the volcanic series the geochemical study so far confirms the interpretation of the geodynamic back arc rifting environment as already suggested by PE-PIPER et PANAGOS, 1989.

- the gabbros exhibit an alkaline tendency of intraplate affinity
- the basalts are alkaline to subalkaline with an intraplate to arc affinity

– The Seta Unit

Deprat (1904) already used this name to group all the detritic sequences of central Evia. We want to restrict this unit to the relatively continuous sequence found in that region composed of a granitic basement followed by Verrucano type sandstones containing some late Permian limestones as seen in northern Evia, and finishing with a Triassic carbonate platform.

These different lithologies, sometimes in thin layers, are highly folded giving an olistostromic appearance to the unit.

Detailed mapping (1:5.000) has shown that one is dealing with a normal stratigraphic sequence composed of:

- several hundred meter thick lithic-arkosic sandstones at the base
- sometimes conglomerates containing late Permian limestones are found in the top of the sequence, may be marking the Permo-Triassic boundary.

Petrographic analyses of the sandstones indicate a granitic and volcanic source with

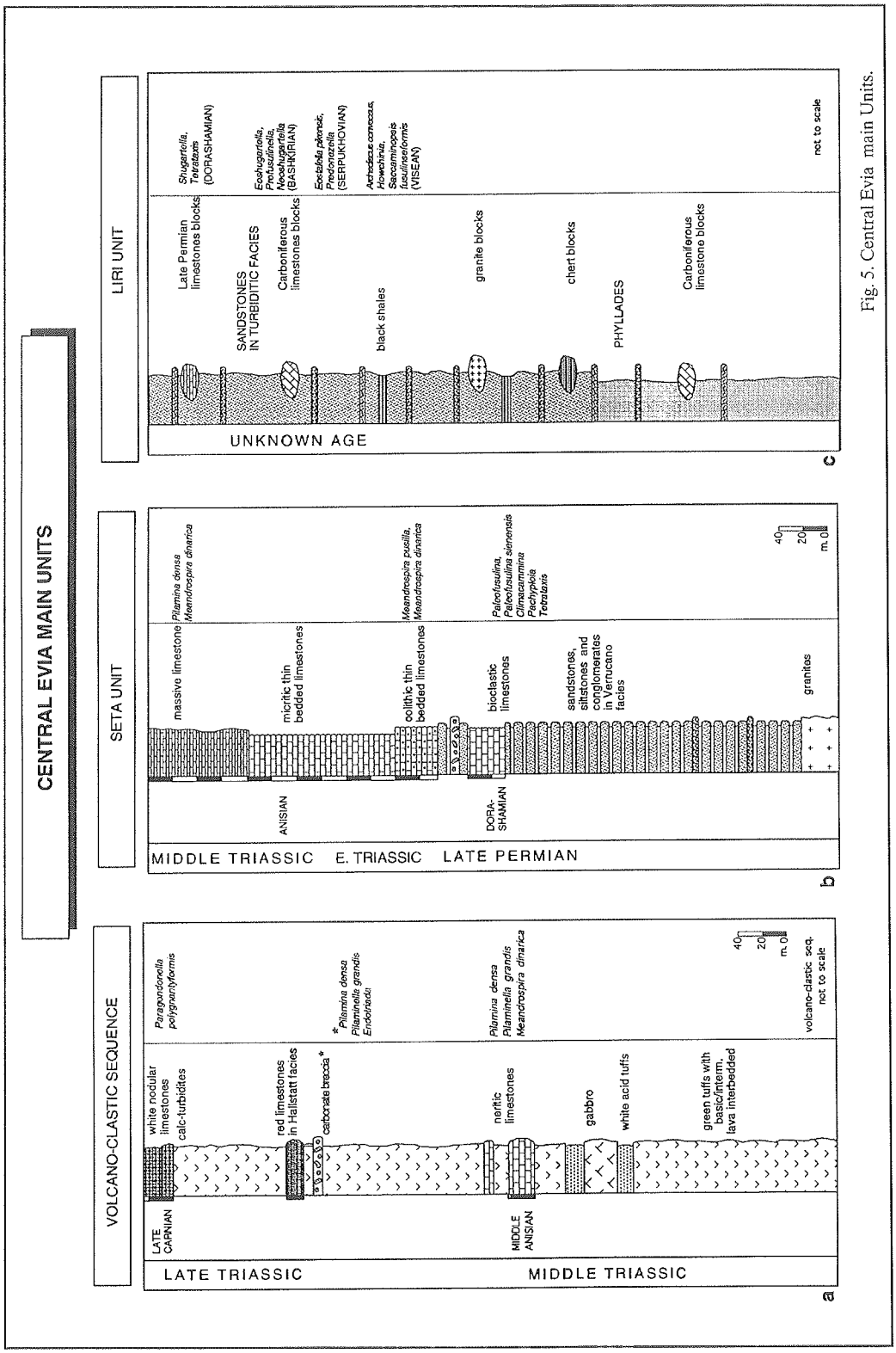


Fig. 5. Central Evia main Units.

some contribution from sedimentary rocks. These deposits correspond to fluviatile environments (flood-plain to subaerial fan).

The detritic sequence contains a late Permian neritic limestone formation (a few meters to 40 m of maximum thickness) whose fauna has already been described (RENZ 1937; RENZ & REICHEL 1945; RENZ 1955; GUERNET 1971; ARGYRIADIS 1978).

Light gray limestones rich in algae, crinoids, sponges and gastropods are associated with darker calcarenites rich in algae and foraminifera of Dorashamian age, (e.g. *Colaniella, Permocalculus, Codonofusiella, Paleofusulina*).

The detritic sequence above the late Permian limestone is similar to that below, so far we still consider it as Verrucano s.l. although there could be a hiatus at the base of this detritic sequence of likely early Triassic age. This sequence passes upwards to limestones of variable thickness (40 to 200m), no complete section has been found so far. It starts with alternating thin beds of calcarenites with a still prominent detrital input and oolitic limestones with rare gastropods and algae (*Diplopora, Oligoporella*). They are followed by thin bedded dark gray micritic limestones, sometimes bioturbated, without microfauna, suggesting a lagoonal setting. They are overlain by massive partly dolomitized and colored limestones with some shell fragments.

The foraminifera give an age between early Triassic and Anisian for the whole sequence (*Meandrospira pusilla, Meandrospira dinarica, Hoyenella, Meandrospiranella).*

– The Liri Unit

We are dealing here with a thick flyschoid sequence containing olistoliths mainly of platform limestones (fig. 5). The matrix as the blocks has been affected by strong deformation and a weak metamorphism. This terrigenous sequence contains the whole spectrum of detritic lithologies, the conglomerates and sandstones displaying typical turbiditic or mass-flow features with granitic boulders interstratified with black shale. A more phyllitic part of the sequence contains thin beds of black cherts completly recrystallized.

The sandstone petrography suggests a source rich in granitic, volcanic and metamorphic rocks and also cherts. This source could be a former orogenic area or a volcanic arc. The heavy mineral content should help us to characterize the provenance of the detritic material.

The olistoliths are mainly limestones, there are also some granitic blocks and rare massive flint blocks. The limestones are black, of shallow marine type, sometimes rich in corals and crinoids. Their age lies between late Visean and early Moscovian. Three typical microfaunal associations are present:

- Bashkirian *(Eostaffella, Profusulinella, Neostaffella)*,
- Serpukhovian *(Eostaffella postikensis, Praedonezella)*,
- Visean *(Archaedischus convexus, Howchinia, Saccamminopsis fusulinaeformis).*

Rare late Permian blocks already described by SIDERIS (1986) are also present and characterized by *Neoendothyra* and *Schubertella*.

The granitoid rocks are hydrothermalized and cataclastic, their mineralogical composition is between granites and granodiorites similar to the boulders found in the mass-flow.

The age of this detritic sequence is younger than late Permian. A preliminary palynological analysis of a few black shale samples gives a Carnian age.

– Metamorphism

All the described units have been affected by weak metamorphism. Illite crystallinity and petrographic analyses have shown that:

- the volcano-sedimentary sequence is of anchizonal facies concerning the limestones, whilst an association with albite-prehnite-epidote characterizes the basic rocks.
- the Seta unit is also anchizonal for the carbonates and anchizonal/epizonal for the Verrucano siltsones.
- the Liri unit displays an epizonal facies both for the blocks and matrix.

In the region of Mistros meta-arkoses and meta-conglomerates have been found together with metabasites in thin layers. This sequence is separated from the overlying Liri unit by a tectonic contact. The metamorphic facies is lower green-schist.

IV. CONCLUSIONS

Detailed field work in northern and central Evia has shown the presence of several tectonic units involving Variscan type basement dominated by intrusives. This basement is followed by an immature detritic sequence of continental facies with a late Permian carbonate marine incursion and grades into an early to middle Triassic carbonate platform very similar to the south Alpine sequence of the same age. In the southern Alps the Verrucano Lombardo (Val Gardena sandstones) is followed by the late Permian Bellerophon limestone, overlain by a new detritic episode (the Werfen formation) grading into the middle Triassic carbonate platform (CASSINIS *et al.* 1979).

Thus we regard the Evia sequence as an equivalent of the south Alpine sequence. The latter is interpreted as a syn- to postrift transitional sequence (MASSARI *et al.* 1994) that we assigned to the opening of the Hallstatt-Meliata back-arc rift during the Permian (STAMPFLI 1996). The late Permian to early Triassic sequences seal the rifting event and would correspond to the onset of sea floor spreading (early Triassic MORB lavas have been reported from Romania) (CIOFLICA *et al.* 1980).

The presence from Italy to Turkey of arc related extrusives of middle to late Triassic age points towards the closure and subduction of the Paleotethys ocean at that time. We could confirm the Anisian to late Carnian age of this sequence in our area as well as its alkaline to calc-alkaline geochemical characteristics.

The fact that this arc related sequence is sealed by a new late Triassic-Jurassic carbonate platform points towards the cessation of subduction which can only be accomplished through a final closure and collision of the Cimmerian terranes with Eurasia (Pelagonia).

The flyschoid sequence of Liri of Triassic age, could correspond to a flysch marking the final closure of Paleotethys in the area (STAMPFLI *et al.* 1995). The melanges related to the Paleotethys active margin have already been described in the Chios island (PAPANIKOLAOU & SIDERIS 1983b; BAUD *et al.* 1990), where it seems that the active margin deformation cease in late Permian in the allochthonous unit, and in early Triassic in the para-autochthonous unit.

The only sequence in Evia which can be considered as a sedimentary melange could be the olitostromic part of the Liri sequence. The Verrucano s.l. and the volcano-sedimentary sequences, often described as melanges, or even as a single tectono-sedimentary unit (together with the Liri unit), are actually continuous sedimentary sequences in which the limestone horizons are sometimes disrupted by interfering Alpine folding phases. We

believe that such disrupted sequences are quite widespread in the pre-Jurassic units of Greece.

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ABSTRACT

A new tectonic and stratigraphic subdivision of the pre-Jurassic Pelagonian Units is presented. Two key areas are investigated in the northern and central Evia island.

The northern part is characterized by rather large outcrops of Variscan basement forming several tectonic units. The sedimentary cover consists of detritic beds of Verrucano type, with some late Permian marine incursions, followed by early to middle Triassic platform carbonates. The middle Triassic is also represented by a volcano-clastic sequence.

In one tectonic unit, the metamorphic basement is directly overlain by a turbiditic sequence comprising only late Permian carbonate olistoliths.

In the central Evia three main units have been distinguished on the base of new paleontological data and field observations: (1) the Seta Unit, (2) the volcano sedimentary sequence and (3) the Liri Unit.

The Seta Unit presents small outcrops of granitic basement followed by a sedimentary cover of Permian to middle Triassic in age similar to the northern Evia sequence. That sequence may be regarded as synrift deposit of the future Hallstatt-Meliata marginal ocean.

The volcano sedimentary sequence is made of basic to intermediate volcanics and tuffs similar to the sequence found in northern Evia. It is of middle to late Triassic age. It can be interpreted as the result of the Paleotethys slab detachment.

The Liri unit is a flysch type sequence with olistoliths of Carboniferous to late Permian age. The flysch is of Middle Triassic age, and its geodynamic interpretation is to be found in the Paleotethys suture.

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