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LITHOSTRATIGRAPHIC UNIT, KASSANDRAS  
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► **To cite this version:**

Kristalina Stoykova, Ivan Zagorchev, Jean-Pierre Suc. SIVIRIS FORMATION (UPPER OLIGOCENE - LOWER MIOCENE), A NEW LITHOSTRATIGRAPHIC UNIT, KASSANDRAS PENINSULA (CHALKIDIKI, NORTHERN GREECE). *Comptes rendus de l'Académie bulgare des Sciences*, 2012, 65 (8), pp.1117-1124. hal-00796926

**HAL Id: hal-00796926**

**<https://hal.science/hal-00796926>**

Submitted on 5 Mar 2013

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SIVIRIS FORMATION (UPPER OLIGOCENE – LOWER  
MIOCENE), A NEW LITHOSTRATIGRAPHIC UNIT,  
KASSANDRAS PENINSULA  
(CHALKIDIKI, NORTHERN GREECE)

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(Submitted on January 11, 2012)

**Abstract**

Upper Oligocene – Lower Miocene marine sediments are found and proven for the first time in Chalkidiki Peninsula. They are designated as Siviris Formation and are dated by their calcareous nannofossil content.

**Key words:** Upper Oligocene – Lower Miocene, Chalkidiki, Calcareous nannofossils, Stratigraphy

**Introduction.** The Late Oligocene and Early to Middle Miocene evolution of the northern parts of the Aegean realm is a subject of controversies. Most of this time interval is devoid of any conclusive biostratigraphic evidence. No data about marine deposits of Late Oligocene - Early Miocene age have been proven up to now, and the northern parts of the Aegean Basin have been mostly regarded as a continental area (e.g. [1]). DERMITZAKIS [2] considers a “Northern Aegean Basin” in Late Oligocene–Aquitani and Burdigalian–Serravallian times but the evidence cited comes from the eastern parts of this hypothetical basin (the area of Komotini). The same area is referred to the transition from lacustrine to shallow-marine shelf conditions in Late Miocene times, and to a narrow and shallow marine corridor in Early Miocene time [3]. The first convincing evidence about the presence of Lower Miocene comes from studies by J. Achéritéguy and I. Matias on samples supplied by A. DRIVALLIARI [4].

The present authors sampled in 2002–2005 several sections that supposedly belonged to the “uppermost Miocene” Trilophos Formation [5]. The finding

and subsequent studies of calcareous nannofossils from the section *Amphitheater Siviris* pointed at a latest Oligocene – earliest Miocene age. Hellenic Petroleum Ltd. kindly gave us in 2004 access to available cores from the borehole made at Possidi. The present preliminary publication is based upon the results of all detailed sampling research performed.

**Geological setting.** The Peninsula of Kassandras (Plate I) is the south-westernmost peninsula at the southern tip of the Chalkidiki Peninsula, situated east of the Thermaikos (Thessaloniki) Gulf. Almost the whole Peninsula of Kassandras is built up of Upper Miocene and Pliocene sediments [5–7]. Only the southeastern tip of the peninsula exhibits some Mesozoic ophiolites, limestones and flysch, and Eocene sandstones and marls with limestone lenses. The state of exposure is generally poor to very poor in the internal parts of the peninsula that represent agricultural fields. Some of the roads and occasional quarries exhibit scarce good outcrops, but (due to the low angle of dip that rarely exceeds 5–10 °C) within limited thickness.

Palaeogene (Eocene) deposits are described [6, 7] onshore only at a distance of about 4 km along the beach south of the ridge of Kalamokia, SSW of Paliouri. The section consists of: 1) basal conglomerate built up of various (mostly dioritic) pebbles, with sandy or shaly reddish matrix, and a thickness of more than 120 m; 2) mica-rich gypsum-bearing gray marls (50 m) with small-sized lenses of bioclastic limestones; the listed fossils consist of brackish ostracods (*Paracypris* sp., *Cytherella* sp.), benthic foraminifers (Miliolidae, Rotaliidae), gastropods, charophytes and fish teeth; 3) thick-bedded yellowish-rusty sandstones with conglomerate interbeds; this formation contains gastropods, bivalves, bryozoans, algae and foraminifers (*Orbitolites* sp., *Chapmanina* sp., *Nummulites incrassatus* de la Harpe). The fauna cited was determined by J.-J. and G. Bizon and referred to the Upper Lutetian, but most probably should indicate a younger age (Upper Eocene – Lower Oligocene). The section cited is covered by the Neogene Triglia and Trilophos Formations.

The generalized Neogene section as studied by SYRIDES [5] can be outlined as follows:

The Antonios Formation is situated at the base of the Neogene section, and covers with a depositional unconformity the Mesozoic limestones. It occupies mostly the southeastern half of Kassandras Peninsula (Plate I). The formation consists [6] of fluvial poorly-sorted loose conglomerates, sands, and some finer-grained red-brown silts and clays. Irregular lenticular and cross bedding is typical. The thickness is estimated at 20–30 m. According to data published [8, 9] the Antonios Formation is referred to the uppermost parts of the Lower Miocene and lower parts of the Middle Miocene.

The Antonios Formation is covered with an irregular unconformity by red beds of the Triglia Formation: coarse clastics (loose pebble conglomerate with a sandy matrix and interlayers of sands and buried soil). The Triglia Forma-

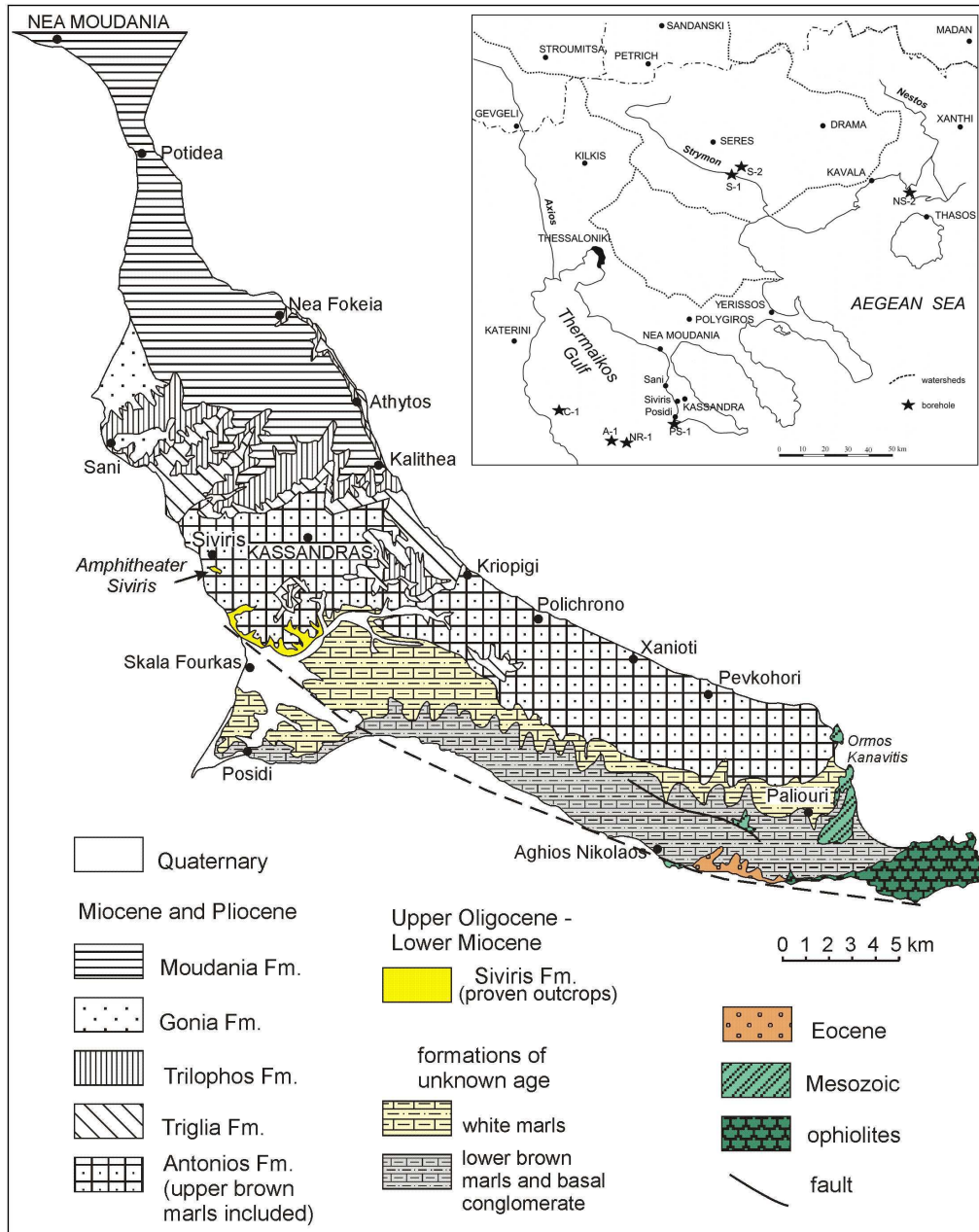


Plate I. Geological map of the Kassandras Peninsula. After [5,6], with revision by the authors.  
 Inset – geographic position of the sites in the Chalkidiki Peninsula and Thermaikos Gulf

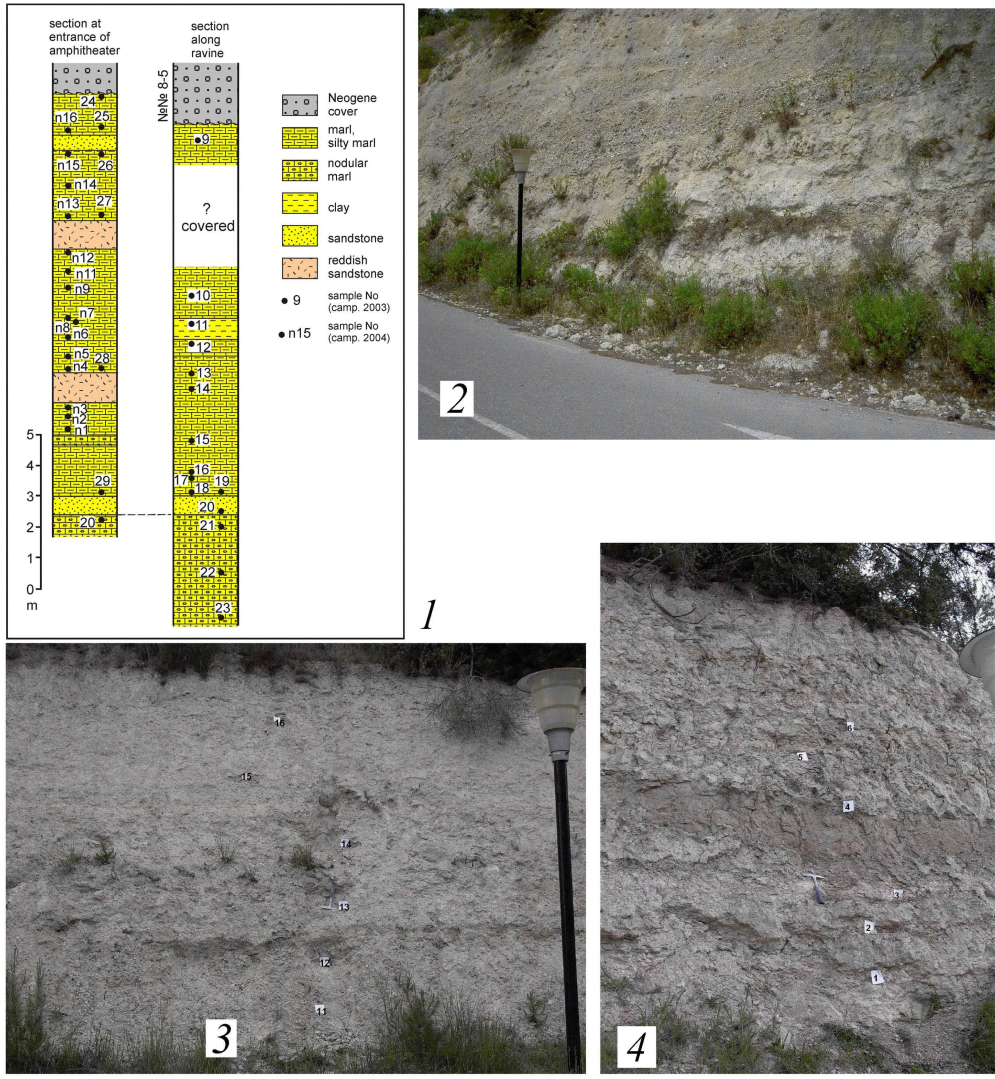


Plate II. Columnar section and field photographs: 1 – Amphitheater Siviris. Columnar section for a part of the stratotype with the places of the samples taken during the two sampling campaigns; 2 – Amphitheater Siviris. Upper part of type section; 3 – Amphitheater Siviris. Samples SIV/n16 – SIV/n11; 4 – Amphitheater Siviris. Samples SIV/n6 – SIV/n1

tion could be correlated with the Sarmatian (Late Vallesian MN10 fauna) Nea Mesimvria Formation of the Axios Basin [10].

The Trilophos Formation (15–25 m) is based [5] on well-stratified and well-bedded brackish – lacustrine fossiliferous sands, siltstones, sandstones, marls and limestones. The analysis of the fossils content indicates a Turolian age for the mammals, and a latest Miocene (Pontian) age for the Trilophos Formation.

The Gonia Formation [5] consists mostly of fluviolacustrine sediments: alternating sandstones, clays, marls and massive marly limestones. Syrides [5] recognizes three different members. The thickness of the formation is estimated to reach 40–50 m in the sections studied. Based on Ruscinian mammal fauna, the formation is referred to the Pliocene.

The last Moudania Formation consists again of red beds. They vary greatly in grain size: from almost chaotic accumulation of pebbles and sand within a clayey-sandy red or brownish matrix, to well-bedded reddish and grayish pebble gravels and sands. The age inferred is Late Pliocene to Late Pleistocene [5].

Obviously previous studies have recorded only continental deposits of Middle Miocene to Pleistocene age. The whole southeastern part of Kassandras Peninsula has been attributed [5] to the Antonios Formation. We found of particular interest the “formation of white marls” (“serie de marnes blanches”) [6] that “is composed of white marls, sometimes sandy, with layers of sandstones, marly limestone and conglomerate... In the southwestern part of the Peninsula a transition towards marine facies is observed. At the small cliff west of Plastara a marine facies with *Ammonia*, *Elpidium*, *Bolivina*, etc. penetrates in the sandstones and red marls, considered as continental. At Koutsomila, the marls contain *Ostrea edulis* var. *lamellosa* and *Chlamys multistriata* (Poli)” [6]. This description incited us towards a more detailed study in the area.

**Section *Amphitheater Siviris*.** The amphitheater at Siviris and the roads and quarries around it exhibit a thick section about 50 m of Neogene deposits. The principal and best exposed section (Plate II) is situated at the entrance to the first parking place to the amphitheater.

Cover: sandstones and conglomerates;

\_\_\_\_\_ parallel unconformity \_\_\_\_\_

Siviris Formation (marls, sandstones and fine-pebble conglomerate):

- (1.2 m) gray marls: sample SIV24 – upper part; samples SIV25 and SIV/n16 – lower part;
- (0.5 m) marly sand;
- (2 m) light-gray marls; samples SIV26 and SIV/n15 – upper part; SIV/n14 – middle part, samples SIV27 and SIV/n13 – lower part;
- (1 m) brownish sand;
- (3 m) light-gray marl and marly silt; sample SIV28 – lower part;
- (0.8 m) reddish brown sand, locally conglomeratic;
- (3 m) gray marl; sample SIV29 in lowermost part – probably corresponds

to sample SIV19 in the parallel section at the beginning of the second parking place;

- (0.4–0.5 m) gray sands;
- (2.5–3 m) in the transition to the second parking place, at the base of the small ravine and old dirt road – nodular marly–calcareous sandstone; sample SIV20 in the uppermost part, sample SIV21 at 0.5 m beneath SIV20, sample SIV22 – at 1.5 m beneath sample SIV20, sample SIV23 – at about 3 m beneath sample SIV20.

The total thickness of the Siviris Formation in the section is estimated at 15 m.

The second section of the Neogene studied at the amphitheater begins in the old quarry on the top of the hill. About 2 m of fluvial rusty-reddish to yellowish conglomerate and sandstone with cross bedding are exposed in the small abandoned quarry. They cover with erosional contact a formation of fluviolacustrine character that consists of interbedding gray sandstones to siltstones with fossilized soil, and small-pebble conglomerate. The total thickness of this formation reaches 25 m. Marly sandstones and siltstones have been sampled as follows (from top to bottom, along the strongly eroded dirt road): SIV5 – at the top; SIV6 – 2 m lower; SIV7 – 3 m lower; samples SIV8, SIV9 and SIV10 are situated at intervals of about 1 m. The boundary between the conglomerate layer at the base of the section and the underlying Siviris Formation (gray to whitish calcareous marls and marly siltstone and sand with interbeds of sands and loose pebbly sand) is not well exposed, but most probably has an erosional discordant character. The thickness of the formation along this section is about 9–10 m. It has been sampled as follows: SIV11 – clayey marl, in the uppermost part of 0.8 m thick bed; SIV12 – in calcareous marl in the upper parts of the underlying layer; SIV13 – 0.5 m lower; SIV14 – in almost the same position, at a distance of several metres laterally along the bed; SIV15 – about 2.5 m beneath SIV14; sample SIV16 – about 1 m lower; SIV17 – 0.2 m beneath SIV16, and SIV18 – at 0.5 m beneath SIV17, in porous light-gray marl. The sampling continues laterally at a distance of about 10–12 m with sample SIV19 situated at the base of the porous marl. It is underlain by 0.4–0.5 m of reddish brown sand, and of more than 3 m of nodular marly and calcareous sand (Plate I) sampled with samples SIV20 to SIV23 (described above).

**Siviris Formation (new Formation). Name and stratotype.** The name of the formation comes from the village of Siviris (the holostratotype being at the Siviris Amphitheater). The rocks of the formation have been previously referred to the Neogene by lithological resemblance.

**Defining features.** The Siviris Formation is built up of conglomerate (mostly in the basal parts) and sandstones. Clay, calcareous clay, silty clay and marl are present as interbeds in different parts of the section as indicated in the stratotype description.

**Calcareous nannofossils and biostratigraphy.** Sample SIV18 yielded the calcareous nannofossils (in brackets – chronostratigraphic range) *Dictyococcites bisectus* (NP17-25), small *Reticulofenestra* sp. indet, *Cyclicargolithus abisectus* (NP24 – NN1) and *Coccolithus pelagicus*. This assemblage clearly indicates a Late Oligocene – earliest Miocene age.

A richer assemblage with the same range has been determined in sample SIV27: *Coccolithus miopelagicus*, *Cyclicargolithus abisectus* (NP24 – NN1), *Cyclicargolithus floridanus* (NP20 – NN7), *Helicosphaera intermedia* (NP19 – NN5), *Dictyococcites bisectus* (NP17–25), *Helicosphaera compacta* (NP20–25) and *Sphenolithus* sp. indet. (aff. *moriformis*).

The new sampling of the same interval yielded the following taxa:

- SVn5 – *Cyclicargolithus floridanus*;
- SVn7 – *Dictyococcites bisectus*, *Sphenolithus moriformis*;
- SVn8 – *Coccolithus pelagicus*, *Cyclicargolithus floridanus*, *Dictyococcites scrippsae*, *Cyclicargolithus abisectus*;
- SVn9 – *Braarudosphaera bigelowii*;
- SVn13 – *Cyclicargolithus abisectus*.

**Occurrence and correlations.** Sections of similar lithology have been studied and sampled at several places between Siviris and Skala Fourkas. The section at Skala Fourkas is about 15 m thick, and the lower 6–7 m (from top to bottom) consist of 2.5 m of sandy marls and marls, 1 m limestone, 0.8 to 1 m of sands to conglomerate, and 2.5 m of limestone and sandy limestone. Five samples taken from the marly beds did not yield any nannofossils with the exception of a single *Coccolithus pelagicus*. At Mola Kaliva, a 25–30 m cliff exposes mostly conglomerates and sandstones with some deformed marls at the base. It is not certain whether the section belongs to the uppermost parts of the Siviris Formation or to some of the Neogene formations described by Syrides [5].

A borehole has been drilled by Hellenic Petroleum Ltd. at Possidi (near the cap of Kassandras), at about 9 km SSE of Siviris. According to Dr P. Proedrou (oral communication, June 2004), the pre-Palaeogene basement has been reached at a depth of 4118 m, and the Palaeogene/Neogene boundary is situated approximately at a depth of 1100 m. Thanks to the kindness of the Greek colleagues of Hellenic Petroleum Ltd., we have been able to look at some parts (although very limited) of the section core, and have taken 3 samples of bituminous marls at depths of 1248, 2647 and 2800 m respectively. The samples from 1248 and 2647 m yielded calcareous nannofossils as follows:

- sample 1248 m – specimens of typical Late Oligocene to Early Miocene taxa are abundant: *Cyclicargolithus floridanus*, *Dictyococcites bisectus*, *Coccolithus pelagicus*, *Sphenolithus moriformis*, *Helicosphaera* spp., *Reticulofenestra* sp., *Calcidiscus premacintyreii*, *Zygrhablithus bijugatus*, *Pontosphaera* spp., *Chiasmolithus* sp., *Reticulofenestra umbilica*, *Sphenolithus editus?*, *Coccolithus eopelagicus*, *Micrantholithus* spp., *Reticulofenestra samodurovi*. Reworked Eocene/Upper Creta-



ceous taxa are recorded as well: *Micula decussata*, *Nannoconus* spp., *Cruciplacolithus intermedius/tenuis*, *Toweius gammation*;

– sample 2647 m – *Cyclicargolithus floridanus*, *Coccolithus eopelagicus*, *Dictyococcites scrippsae*, *Sphenolithus moriformis*, *Coccolithus pelagicus*, *Dictyococcites bisectus* (NP17-25), *Reticulofenestra dictyoda* (NP13-21), *Zygrhablithus bijugatus*, *Reticulofenestra umbilica* (NP17-22), *Braarudosphaera bigelowii*; together with *Corannulus germanicus* (NP18-20) and the Palaeocene to Middle Eocene *Discoaster septemradiatus/nonaradiatus* and *Neochiastozygus concinnus*. The age assessment of this sample (and of the lower parts of the borehole section) is questionable – it could be referred to the Rupelian, or even, to the Priabonian (Upper Eocene).

At Posidi itself, yellowish and whitish marls and fine-grained sanstones appear beneath the reddish conglomerate. Several samples did not yield any fossil content.

Several boreholes have been drilled by Hellenic Petroleum Ltd. in the Thermaikos Gulf. The borehole Nireas-1 exhibits the following evidence (entirely after [4], pp. 123–128) in the interval between the 552 and 1302 m (the borehole reached a depth of 3569 m). The dominant lithologies are limestone, sandstone, gray schistose clay, fine-grained sandstone to silt, lignite. Fragments (pebbles) from bioclastic limestone, volcanics, clay, and calcareous schists are reported. No detailed lithological description of the section drilled has been reported. The interval 760–1200 m is referred by Drivaliari to deltaic sediments of a distal alluvial fan or a proximal braided plain. The interval between 792 and 1000 m yielded (data of Tsaila-Monopoli and Ioakim, 1987, unpublished report, cited in [4], p. 124) foraminifers, ostracodes, gastropods, bivalves, echinids of a wide stratigraphic range (Miocene to Present). At 1152 m oolitic limestones with traces of karstification are reported, and an unconformity (Pliocene? over Lower – Middle? Miocene) is supposed. In the interval 1192–1260 m (marked in the table as NIR 1200) Achéritéguy determined ([4], pp. 126–127) an assemblage referred to the Lower Miocene (NN1–NN3). At the depth of 1302 m (NIR 1302) the presence of *Helicosphaera recta* (NP24–NN1) and *Sphenolithus conicus* (NN1–NN3) points at an earliest Miocene age. On samples from an alternative sampling, Matias supposed ([4], p. 127) the presence of a continuous section from Aquitanian – Burdigalian (zones NN1?–NN3; *Sphenolithus belemnoides* and *Eudiscoaster druggii*, suggesting NN2–NN3) at 1296 m., through NN4 (with *C. floridanus*, *S. moriformis*, *C. pelagicus*, *H. euphratis* and *Calcidiscus leptoporus*) at 838 m and 616 m., and Langhian–Serravallian (NN6) at 600 m. At the time being, and not having access to the samples, we accept the first interpretation on the basis of the unconformity at 1152 m and the determinations by Achéritéguy. The attribution of the levels from 1152 to 1302 m to Aquitanian and Burdigalian is without any doubt. The pollen flora rich in *Engelhardia* from these levels is in good accordance with this age. There is a problem concerning the higher levels because the pollen

flora does not indicate the warm conditions that are typical of the Langhian but is similar to the Zanclean flora as documented by the borehole Nestos-2. Taking into consideration also the presence of a thick (100 m) conglomerate over an erosion surface at the depth of 1152 m, and the presence of the Messinian Erosional Surface at the periphery of the basin (e.g. covered by the Trilophos Formation), we estimate as plausible to refer the sediments above 1152 m to the Zanclean [11].

**Discussion and conclusions.** New evidence from the type section *Amphitheater Siviris* and the borehole *Possidi* (between 1248 and 2647 m) proves the presence of Chattian to Aquitanian (+ Burdigalian?) sediments along the western coast of Kassandras Peninsula. Similar sediments have been drilled in the Nireas-1 borehole beneath the level of 1152 m, and they most probably belong to the Lower Miocene (Aquitanian–Burdigalian). A formal lithostratigraphic unit (Siviris Formation) is introduced herewith, with a total maximal range Chattian–Burdigalian. The same formation most probably crops out also at Skala Fourkas and Mola Kaliva. The thickness of the formation may vary between 50 and 1500 m. Thus the formation is exposed in the eastern parts of the Thermaikos Gulf and the easternmost coastal area of Kassandras Peninsula. No traces of such sediments have been found up to now along the western [12] and northern [5] coasts of Thermaikos Gulf, although terrestrial sediments of the same age have been supposed at the northern coast (Axios Basin – [1]).

The map of the southern and eastern parts of the Kassandras Peninsula [6] exhibits a wide occurrence of the white marls (“série des marnes blanches”). For the time being, we are not in possession of sufficient evidence to assert whether this formation has Middle? Miocene age, some parts of it being parts of the Siviris Formation (Upper Oligocene – Lower Miocene), or else the whole band of “white marls” between Skala Fourkas and Paliouri to Ormos Kanavitis should be referred to the Siviris Formation. Obviously, extended revision and sampling are needed to improve the very good basic geological map of the peninsula with some modern data supplied by newly-introduced micropalaeontological methods.

The new evidence confirms the palaeogeographic ideas about the existence of a North Aegean Basin [2, 3, 13].

**Acknowledgements.** A version of the present paper was written in 2007 as a tribute to Prof. Ilias Mariolakos on the occasion of his 75th birthday. Prof. Mariolakos made substantial contributions to the understanding of the Cenozoic tectonics of the Balkan Peninsula, and greatly encouraged and helped the collaboration between Bulgarian and Greek geologists. Unfortunately, the publishing of a Special Volume in his honour had been greatly delayed, and the authors decided to publish this preliminary contribution to make our results available to the geological community. We hope that the Special Volume will be finally published with the full text of our paper where we supply more detailed biostratigraphic evidence, and also deal with the palaeogeographic aspects of our findings.

We are indebted to many Greek colleagues and friends who helped us with

literature and access to data. Special thanks are due to Hellenic Petroleum Ltd. and its Kavala Branch for the permission and help in inspecting and limited sampling of the cores from boreholes Stry-1, Stry-2, Stry-3 and Possidi.

## REFERENCES

- [1] SCHRÖDER B. In: Jacobshagen V. *Geologie von Griechenland*. Gebr. Berlin, Bornträger, 1986, 209–240.
- [2] DERMITZAKIS M. *Geologica Balcanica*, **20**, 1990, No 3, 3–16.
- [3] POPOV S. V., F. RÖGL, A. Y. ROZANOV, F. F. STEININGER, I. G. SHCHERBA, M. KOVAC, M. (Eds.) *Cour. Forsch.-Inst. Senckenberg*, No 250, 2004, 1–46.
- [4] DRIVALIARI A. Ph. D. Thesis, Univ. Montpellier 2, 1993, 333 p.
- [5] SYRIDES G. Aristotle University of Thessaloniki, School of Geology, *Scientific Annals*, **1**, 1990, No 11, 243 pp.
- [6] GUY M., J. BORNOVAS, J.-J. BIZON, G. BIZON. Geological map of Greece 1:50 000, Peninsula of Kassandras. Institut de Geologie et de Recherche du Sous-sol, Athenes, 1969.
- [7] BORNOVAS J., T. RONDOGIANNI-TSIAMBAOU. Geological map of Greece. 1:500 000. IGME, Athens, 1983.
- [8] VASILEIADOU K., G. KOUFOS. 5th Intern. Symp. on Eastern Mediterranean Geol., *Proceeding*, 2004, 359–362.
- [9] KOUFOS G., G. SYRIDES. *C. R. Acad. Sci. Paris, Sciences de la Terre et des Planetes*, **325**, 1997, 511–516.
- [10] PSILOVICOS A., G. KOUFOS, G. SYRIDES. *Annales Inst. Geology Publ. Hungary*, **70**, 1987, 509–516.
- [11] BACHE F., S.-M. POPESCU, M. RABINEAU, C. GORINI, J.-P. SUC, G. CLAUZON, J.-L. OLIVET, J.-L. RUBINO, M. C. MELINTE-DOBRINESCU, F. ESTRADA, L. LONDEIX, R. ARMIJO, B. MEYER, L. JOLIVET, G. JOUANNIC, E. LEROUX, D. ASLANIAN, A. T. DOS REIS, L. MOCOCHAIN, N. DUMURDŽANOV, I. ZAGORCHEV, V. LESIĆ, D. TOMIĆ, M. N. ÇAĞATAY, J.-P. BRUN, D. SOKOUTIS, I. CSATO, G. UCARKUS, Z. ÇAKIR. *Basin Research*, **23**, 2011, doi: 10.1111/j.1365-2117.2011.00521.
- [12] SYLVESTROU I. *Proceedings, 5th Intern. Symp. on Eastern Mediterranean Geology*, **1**, 2004, 197–200.
- [13] DERMITZAKIS M., D. PAPANIKOLAOU. *Annales géologiques des pays helléniques*, **4**, 1981, 245–266.

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