Δελτίο της Ελληνικής Γεωλογικής Εταιρίας τομ. XXXVI, 2004
Πρακτικά 10ου Διεθνούς Συνεδρίου, Θεσ/νίκη Απρίλιος 2004

Bulletin of the Geological Society of Greece vol. XXXVI, 2004
Proceedings of the 10th International Congress, Thessaloniki, April 2004

AGE DETERMINATION AND PALAEOGEOGRAPHIC RECONSTRUCTION OF PINDOS FORELAND BASIN BASED ON CALCAREOUS NANNOFOSSILS

Vakalas I.[1], Ananiadis G. [1], Kontopoulos N. [1], Stoykova K.K.[2], and Zelilidis A. [1]

[1]*Laboratory of Sedimentology, Department of Geology, University of Patras, 26500, Rio, Patras, Greece, ivakalas@upatras.gr, gananiad@upatras.gr, a.zelilidis@upatras.gr Kontopou@upatras.gr*

[2]*Department of Paleontology and Stratigraphy, Geological Institute of Bulgary, Academy of Scinces,* Stoykova@router.geology.bas.bg

ABSTRACT

The study area is part of the Pindos foreland (Underhill, 1985). Pindos foreland is a tertiary turbiditic foreland basin fill trending parallel to the external Hellenides and occupies Gavrovo and Ionian isopic zones (Aubouin, 1959).

The age of Pindos foreland sediments is still a matter of discussion. B.P. (1971) proposed an early Miocene to middle Miocene age, explaining the presence of Oligocene fauna as a product of large scale erosion and reworking of older sediments during Miocene. IGSR&IFP(1966) suggested a late Eocene to early Miocene age for the basin fill while Fleury (1980), Leigh (1991), Wilpshaar (1995), Bellas (1997) assigned an Oligocene age. Avramidis et al (1999) proposes a middle Eocene to early Miocene age assessment, using nannofosil zones from three studied cross sections in the Klematia-Paramythia basin (middle Ionian zone).

The determination of the sediment ages was based on the study of calcareous nannofossils, which came from almost 120 samples covering 11 geological cross sections. The nannofosil marker species that were found in the samples were classified using the biozones proposed by Martini in 1971.

According to the age assessments arose from the studied samples, clastic sedimentation in the study area began in the Middle Eocene, with small differences among the basin. The end of clastic sedimentation seems to be at different times in different parts of the basin.

1 GEOLOGICAL SETTING

The study area is part of the Pindos foreland (Underhill, 1985) and comprises the Epirus, Akarnania and NW Peloponnesus regions. Pindos foreland is a Tertiary turbiditic foreland basin fill trending parallel to the external Hellenides and occupies the Gavrovo and Ionian isopic zones (Aubouin, 1959). The basin is bounded to the east by the Pindos thrust and to the west by the Ionian thrust. The Gavrovo thrust separates the Gavrovo and Internal Ionian zones. In addition to these major thrusts, two minor thrusts divide the Ionian zone into the internal, middle and external Ionian zone (from east to the west) (IGSR&IFP, 1966).

The accumulation of the turbiditic deposits resulted from the deformation of the external Hellenides which migrated in a westward direction. During this migration, the Gavrovo and Ionian zones acted as a foreland basin (Underhill 1985; 1989, Clews 1989, Alexander et al. 1990, Avramidis 1999). Therefore the turbiditic deposits of Gavrovo and Internal Ionian zones are considered as a uniform genetic system (Alexander et al. 1990). The age of Pindos foreland sediments is still a matter of discussion. B.P. (1971) proposed an early Miocene to middle Miocene age, explaining the presence of Oligocene fauna as a product of large scale erosion and reworking of older sediments during the Miocene. IGSR&IFP (1966) suggested a late Eocene to early Miocene age for the basin fill while Fleury (1980), Leigh (1991), Wilpshaar (1995), and Bellas (1997) assigned an Oligocene age. Avramidis et al. (2000) proposed a middle Eocene to early

Miocene age, using nannofosil zones from three studied cross sections in the Klematia-Paramythia basin (middle Ionian zone).

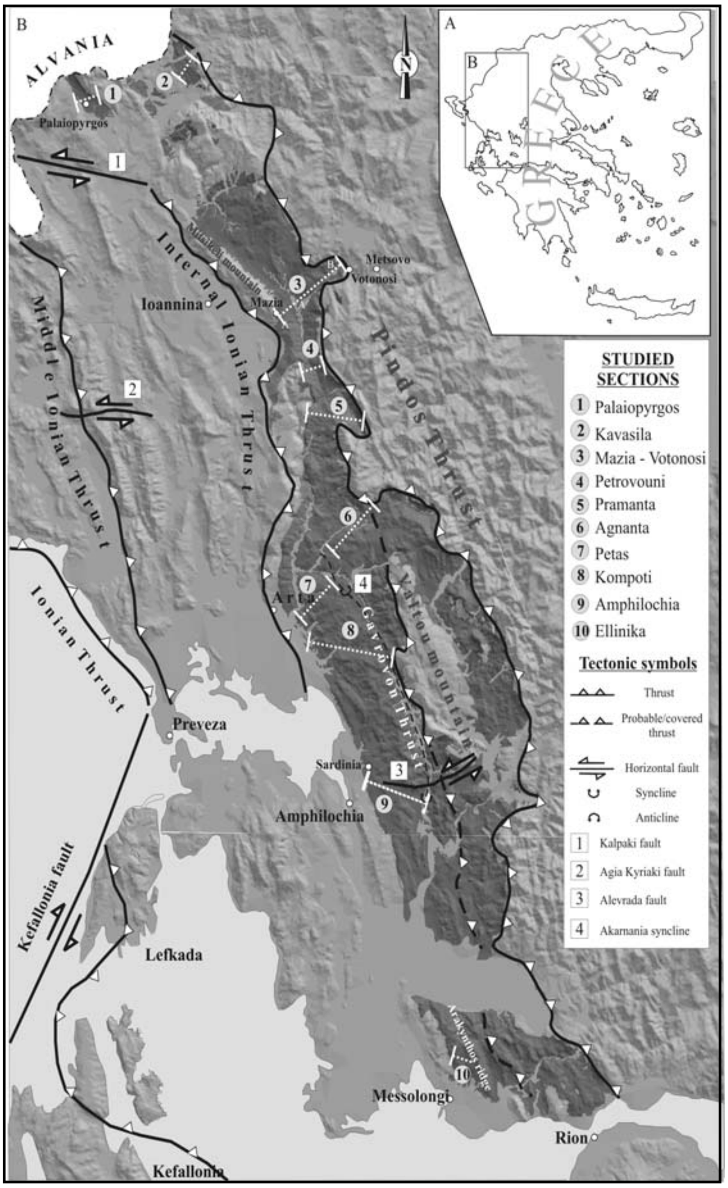

Figure 1: Geological map of the study area. The studied sections are shown by white line, while the dark grey color represents the submarine fan deposits.

2 METHODOLOGY

The determination of the sediment ages was based on the study of calcareous nannofossils, originating from 116 samples, distributed in 11 geological cross sections along the Internal Ionian and Gavrovo zones. Samples were from the base and the top of the section. At the base were over limestones and specially from transitional beds to turbidites in order to have the exact start age of sedimentation. The cross sections have a west – east orientation and cover the Epirus and Akarnania regions, bounded northwards by the Hellenic-Albanian borders and southwards by the

Corinth gulf. The nannofosil marker species that were found in the samples were classified using the biozones proposed by Martini in 1971 and showed in the following two plates (plates 1 and 2).

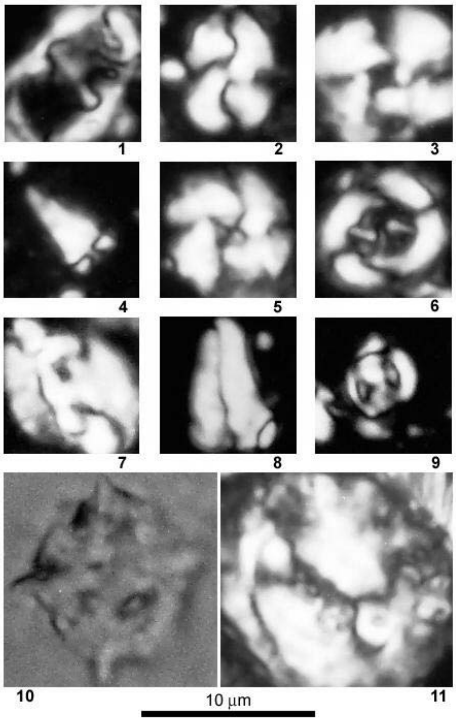

Plate 1: 1. *Helicosphaera seminulum*. Section Petrovouni PV1, Upper Eocene, NP18-20, 2. *Dictyococcites scrippsae*. Section Petrovouni PV20, Upper Eocene-Oligocene, NP20-23, 3. *Cyclicargolithus floridanus*. Section Agnanta AGN3, Upper Eocene-Oligocene, NP20-23, 4. *Sphenolithus predistentus*. Section Agnanta AGN1, Upper Eocene-Lower Oligocene, NP20-21, 5. *Cribrocentrum reticulatum.* Section Agnanta AGN3, Upper Eocene-Oligocene, NP20-23, 6. *Chiasmolithus solitus.* Section Agnanta AGN3, Upper Eocene-Oligocene, NP20-23, 7. *Helicosphaera recta.* Section Metsovo MB16, Upper Oligocene, NP24-25, 8. *Zygrhablithus bijugatus.* Section Metsovo MB13, Lower Oligocene, NP21-23, 9. *Ericsonia subdisticha.* Section Petrovouni PV1, Upper Eocene, NP18-20, 10. *Nannotetrina fulgens.* Section Palaiopyrgos KB7, Middle Eocene, NP16, 11. *Coccolithus eopelagicus.* Section Agnanta AGN68, Lower Oligocene, NP21-23.

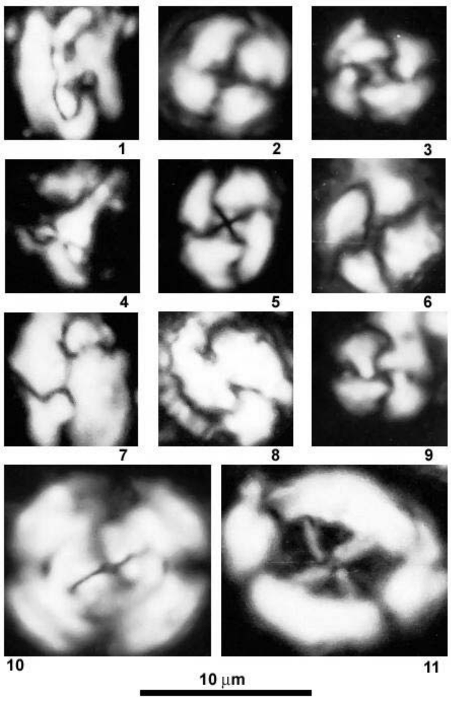

Plate 2: 1. *Helicosphaera recta*. Section Kompoti FLO15, Upper Oligocene NP24-25, *2. Ericsonia formosa.* Section Amphilochia AMB2, Upper Eocene-Lower Oligocene NP21, *3. Reticulofenestra oamaruensis.* Section Amphilochia AMB10, Lower Oligocene NP21-22, 4. *Sphenolithus distentus.* Section Kompoti FLO2, Upper Oligocene NP24-25, *5. Cribrocentrum reticulatum.* Section Pramanta PR35, Upper Eocene NP18, *6. Coccolithus pelagicus.* Section Elinika AGR9, Upper Eocene NP17-20, *7. Dictyococcites scrippsae.* Section Elinika AGR10, Upper Eocene NP17-20, *8. Helicosphaera compacta.* Section Elinika AGR9, Upper Eocene NP17-20, *9. Cyclicargolithus floridanus*. Section Amphilochia AMB2, Upper Eocene-Lower Oligocene NP21, *10. Dictyococcites bisectus.* Section Amphilochia AMB2, Upper Eocene-Lower Oligocene NP21, 11. *Chiasmolithus expansus.* Section Elinika AGR9, Upper Eocene NP17-20.

3. AGE ASSESMENTS

3.1. Palaiopyrgos – Kavasila sections

In Kavasila section 6 samples have been studied. The results of the analysis are shown in the following table:

Sample/strat. level	Age	Biozone	Nannofossil marker – species in association (in situ)
KB15/740m	Late Eocene	NP20-21	D. bisectus, D. scrippsae, C. pelagicus, D. barbadiensis, D. saipanensis, R. umbilica, Cribrocentrum reticulatum, Sphenolithus orphanknolensis, E. formosa
KB14/610m	Late Eocene	NP20-21	Zygrhablithus bijugatus, D. scrippsae, Sphenolithus moriformis, C. floridanus, C. pelagicus
KB18/240m	Late Eocene	NP20-21	C. pelagicus, S. moriformis, Cy. floridanus, E. subdisticha, D. saipanensis, R. umbilica, Z. bijugatus
KB19/170m	Late Eocene	NP20-21	Discoaster saipanensis, D. bisectus, D. scrippsae, C. pelagicus, Cy. floridanus, Z. bijugatus
KB17/30m	Late Eocene	NP20-21	R. umbilica, D. bisectus, Sphenolithus orphanknolensis, E. formosa, Cy. floridanus
KB16/0m	Late Eocene	NP20-21	Cy. floridanus, D. bisectus, Bicolumnus ovatus, S. moriformis, Helicosphaera euphratis, Discoaster tanii, S. moriformis

Table 1: Nannofossil marker species and age determination of the analysed samples in Kavasila section. The stratigraphic level of each sample has been estimated according to Vakalas (2003).

In Palaiopyrgos section 4 samples have been studied. The results are the following:

Sample/strat. level	Age	Biozone	Nannofossil marker – species in association (in situ)	Reworked species
KB4/	Late Eocene	NP20	Ericsonia subdisticha, E. formosa, Dictyococcites bisectus, D. scrippsae, Discoaster germanicus, D. tanii, D. septemradiatus, D. binodosus, Reticulofenestra umbilica, Cribrocentrum reticulatum, Coronocyclus nitescens, Coccolithus pelagicus, C. miopelagicus, Zygrhablithus bijugatus, Sphenolithus moriformis, S. conspicuus	Strong reworking of Upper Cretaceous, Paleocene, Eocene species.
KB5/	Late Eocene	NP20-21	Reticulofenestra umbilica, Helicosphaera reticulata, H. euphratis, Cy. floridanus, C. pelagicus, Sphenolithus moriformis, Discoaster deflandrei, D. tanii, D. distinctus, Zygrhablithus bijugatus, Chiasmolithus grandis, E. formosa	Fasciculithus bobii, F. shaubii, Rhomboaster spineus, R. contortus, Toweius eminens, Discoaster lodoensis, D. perpolitus, D. gemmifer
KB6/	-	-	Empty sample	
KB7/	Middle Eocene	NP16	Discoaster germanicus, D. barbadiensis, D. saipanensis, D. deflandrei, D. nonaradiatus, D. binodosus, Sphenolithus radians, E. formosa, Reticulofenestra umbilica, R. dyctioda, R. pelycomorpha, R. clatrata, Micrantolithus vesper, Helicosphaera compacta, C. floridanus, C. pelagicus, C. miopelagicus, D. bisectus, D. scrippsae, Zygrhablithus bijuatus	Strong reworking of Paleocene species.

Table 1: Nannofossil marker species and age determination of the analysed samples in Palaiopyrgos section

3.2 Metsovo section

In Metsovo section two sections have been studied. The first section is located at the road axis that connects Mazia village and Baldouma bridge, while the second ranges from Baldouma bridge to Votonosi village. Although the two sections are continuous, they have been studied separately due to their different tectonic style (Vakalas, 2003).

3.2.1 *Metsovo A-A' section*

In Metsovo A-A' section the following samples have been analyzed (table 2):

Table 2 : Metsovo A-A' section age determination

Sample/strat. level	Age	Biozone	Nannofossil marker – species in association (in situ)	Reworked species
MB10/2200m	Late Eocene-Early Oligocene	NP18-22	Helicosphaera euphratis, H. compacta, Sphenolithus moriformis, Discoaster tani nodifer, D. deflandrei, Dictyococcites bisectus.	
MB6/1850m	Middle-Late Eocene	NP17-20	Reticulofenestra umbilica, R. dictyoda, Braarudosphaera bigelowii, Pontosphaera spp., Ericsonia formosa, Discoaster barbadiensis, Chiasmolithus grandis, Coccolithus miopelagicus.	
MB4/1450m	Middle-Late Eocene	NP17-20	Helicosphaera compacta, Dictyococcites bisectus, D. callidus, Discoaster barbadiensis, D. deflandrei, Coccolithus pelagicus, Sphenolithus moriformis	
MB3/1100m	Middle Eocene	NP16	Reticulofenestra umbilica, R. hillae, Dictyococcites bisectus, Sphenolithus radians, Coccolithus miopelagicus	
MB2/400m	Early-Middle Eocene	NP13-16	Ericsonia formosa, R. dictyoda, Chiasmolithus consuetus	
MB1/75m	Early-Middle Eocene	NP13-16	Reticulofenestra dictyoda, Discoaster lodoensis, D. barbadiensis, C. pelagicus, C. miopelagicus, Helicosphaera seminulum, Ericsonia formosa, Cruciplacolithus tenuis, Sphenolithus primus	M. decussata, L. cayeuxii, Q. Gartneri

3.2.2 *Metsovo B-B' section*

In Metsovo section 7 samples have been analyzed resulting in the age assesments that are presented in the following table (table 3):

Table 3 : Metsovo B-B' section age determination

Sample/strat. Level	Age	Biozone	Nannofossil marker – species in association (in situ)	Reworked species
MB17/1875m	Late Oligocene	NP24-25	Coccolithus pelagicus, C. miopelagicus, D. bisectus, Cy. Floridanus	
MB16/1650m	Late Oligocene	NP24-25	Sphenolithus ciperoensis (NP24-25), S. moriformis, S. pseudoradians, Helicosphaera recta (NP24-25), Cy. abisectus, Cy. floridanus, R. umbilica, D. bisectus, Z. bijugatus, Coccolithus pelagicus, Coccolithus miopelagicus	
MB15/1350m	-		Coccolithus pelagicus, S. Moriformis	
MB14/1100m	Early Oligocene	NP22-23	Reticulofenestra umbilica, Cyclicargolithus floridanus, Cy. abisectus, Coccolithus pelagicus, Coccolithus miopelagicus, S. moriformis, Dictyococcites bisectus	E. Cretaceous and Paleocene species: Quadrum sissinghi, Cr. tenuis,
MB13/700m	Early Oligocene	NP21-23	Cyclicargolithus floridanus, D. deflandrei, E. formosa, R. umbilica, R. oamaruensis, Z. bijugarus, Helicosphaera euphratis, H. compacta, Sphenolithus predistentus	Reworking of Paleocene and Eocene species: Fasciculithus spp., Discoaster wemmelensis, Toweius gammation, Ch. consuetus
MB12/400m	Early Oligocene	NP21-22	Reticulofenestra umbilica, Sphenolithus moriformis, Helicosphaera compacta, Cyclicargolithus floridanus	
MB11/85m	Early Oligocene	NP21-22	Dictyococcites bisectus, Reticulofenestra umbilica, Cy. floridanus, Coccolithus pelagicus, Coccolithus miopelagicus, S. moriformis, D. Deflandrei	Reworked K2 and Paleocene-Eocene species: P. cretacea, Prinsius dimprphosus Ch. mutatus, Ch. grandis, Ch. consuetus

3.3 Petrovouni section

In Petrovouni section 10 samples have been analysed (table 4):

Table 4 : Petrovouni section age determination. Reworked nannofossil species are absent at this section

Sample/s. level	Age	Biozone	Nannofossil marker – species in association (in situ)
PV20/1800m	Late Eocene - Oligocene	NP20-23	Reticulofenestra oamaruensis, R. umbilica, Transversopontis fibula, Ericsonia formosa, Coccolithus pelagicus, C. miopelagicus, Zygrhablithus bijugatus, Chiasmolithus grandis, Sphenolithus conspicuus, Discoaster saipanensis, D. barbadiensis
PV19/1750m	Late Eocene – Oligocene	NP20-23	Sphenolithus moriformis, Helicosphaera intermedia, Ericsonia formosa, Coccolithus pelagicus, D. Bisectus
PV18/1700m	Late Eocene – Oligocene	NP20-23	Helicosphaera euphratis, H. compacta, Coccolithus pelagicus, Cy. floridanus, Sphenolithus moriformis, S. predistentus, D. bisectus, Ericsonia formosa
PV17/1650m	Late Eocene – Oligocene	NP20-23	Helicosphaera compacta, Cy. floridanus, Sphenolithus moriformis, D. bisectus
PV13/1100m	Late Eocene – Oligocene	NP20-22	Coccolithus miopelagicus, C. pelagicus, Thoracosphaera spp., Cy. floridanus, D. Scrippsae
PV12/980m	Late Eocene – Oligocene	NP20-22	Coccolithus miopelagicus, Ret. umbilica, Cy. floridanus, Ericsonia formosa
PV7/680m	Late Eocene – Oligocene	NP20-23	Sphenolithus pseudoradians, S. predistentus, S. moriformis, Helicosphaera compacta, Cyclicargolithus floridanus, Coccolithus miopelagicus
PV5/380m	Late Eocene – Oligocene	NP20-22	Reticulofenestra umbilica, Discoaster saipanensis, D. barbadiensis, Chiasmolithus grandis, Coccolithus miopelagicus, C. pelagicus, Cribrocentrum reticulatum, Cyclicargolithus floridanus, Sphenolithus predistentis
PV2/30m	Late Eocene	NP19-20	Ericsonia formosa, Coccolithus miopelagicus, C. pelagicus, Cyclicargolithus floridanus, Discoaster saipanensis, D. barbadiensis, D. deflandrei, Dictyococcites scrippsae, D. bisectus
PV1/0m	Late Eocene	NP18-20	Isthmolithus recurvus, Discoaster saipanensis, D. tanii, D. barbadiensis, D. deflandrei, Chiasmolithus grandis, Reticulofenestra umbilica, Coccolithus miopelagicus, Ericsonia obruta, Dictyococcites scrippsae, D. bisectus, Sphenolithus obtusus.

3.4 Pramanta section

In Pramanta section (southwards of Petrovouni) 13 samples have been analysed (table 5):

Table 5 : Pramanta section age determination. Reworked nannofossil species are absent at this section

Sample/strat. Level	Age	Biozone	Nannofossil marker – species in association (in situ)
PR10/3980m	Late Eocene	NP19-20	Reticulofenestra oamaruensis (FO NP20), R. umbilica, Bicolumnus ovatus, Ericsonia formosa, C. pelagicus, Sphenolithus moriformis, Discoaster deflandrei, D. tanii nodifer.
PR12/3290m	Late Eocene	NP19-20	C. miopelagicus, Helicosphaera reticulata, Ericsonia formosa, S. moriformis, D. barbadiensis, Reticulofenestra umbilica, Chiasmolithus consuetus
PR14/3220m	Late Eocene	NP19-20	C. pelagicus, C. miopelagicus, Reticulofenestra umbilica, Chiasmolithus solitus, Dictyococcites bisectus, Ericsonia Formosa
PR16/3150m	Late Eocene	NP19-20	C. miopelagicus (acme), C. pelagicus, Cribrocentrum reticulatum, Chiasmolithus oamaruensis, Ericsonia formosa, Discoaster tanii, D. binodosus, D. barbadiensis, D. deflandrei, Sphenolithus radians, Reticulofenestra umbilica
PR43/2570m	Late Eocene	NP18-20	Sphenolithus moriformis, Dictyococcites bisectus, Discoaster deflandrei, Helicosphaera euphratis, H. intermedia, C. Pelagicus
PR39/1900m	Late Eocene	NP18-20	Poor sample: Dictyococcites bisectus, Discoaster deflandrei, Ericsonia formosa, Chiasmolithus grandis, C. pelagicus
PR38/1600m	Late Eocene	NP18-20	Poor sample: Ericsonia formosa, Reticulofenestra umbilica, Dictyococcites bisectus, Sphenolithus moriformis, S. predistentus
PR35/1280m	Late Eocene	NP18	Reticulofenestra umbilica, R. dictyoda, Dictyococcites bisectus, D. scrippsae, D. callidus, Ericsonia formosa, E. obruta, Helicosphaera lophota, H. euphratis, C. miopelagicus, C. pelagicus, Sphenolithus moriformis, Cribrocentrum reticulatum
PR31/1060m	Late Eocene	NP18	Cribrocentrum reticulatum, Discoaster tanii, D. barbadiensis, D. saipanensis, D. sublodoensis, Chiasmolithus grandis, C. miopelagicus, C. pelagicus, Helicosphaera compacta, Ericsonia formosa, Reticulofenestra umbilica, Sphenolithus moriformis,
PR28/930m	Middle Eocene	NP17	Reticulofenestra umbilica, Discoaster barbadiensis, D. saipanensis, D. tanii nodifer, Ericsonia formosa, Chiasmolithus grandis, C. miopelagicus, Dictyococcites bisectus
PR23/480m	Middle Eocene	NP17	Reticulofenestra umbilica, Chiasmolithus gigas, Ch. solitus, Discoaster barbadiensis, D. saipanensis, D. tanii, Coccolithus pelagicus, C. Miopelagicus
PR21/30m	Middle Eocene	NP17	Dictyococcites bisectus (acme), Reticulofenestra umbilica (acme), Discoaster tanii (acme), D. deflandrei, Ericsonia obruta
PR20/0m	Middle Eocene	NP16	Reticulofenestra dictyoda, Ericsonia obruta, Dictyococcites bisectus, Coccolithus pelagicus, C. Miopelagicus

3.5 Agnanta section

Twenty samples have been analysed in Agnanta section. The results of the analysis are shown in the next table (table 6):

Table 6 : Nannofossil marker species and their age assesment in Agnanta section.

Sample/strat. Level	Age	Biozone	Nannofossil marker – species in association (in situ)	Reworked species
AGN65/3180m	Oligocene	NP21-23	Sphenolithus moriformis, Helicosphaera euphratis, H. compacta, Coccolithus pelagicus, Cy. floridanus, D. bisectus, Braarudosphaera bigelowii	-
AGN66/3140m	Oligocene	NP21-23	Coccolithus miopelagicus, Coccolithus pelagicus, Sphenolithus distentus, S. moriformis, Cy. floridanus, D. bisectus (abundant), Reticulofenestra clatrata	Reworked Upper Cretaceous and Paleocene, Eocene species.
AGN67/3120m	Oligocene	NP21-23	Discoaster deflandrei, Reticulofenestra umbilica, R. clatrata, D. bisectus, Coccolithus miopelagicus, S. Moriformis	-
AGN68/3070m	Oligocene	NP21-23	Poor sample. Coccolithus miopelagicus, Coccolithus pelagicus, Cy. floridanus, E. Formosa	Reworked Upper Cretaceous and Middle and Upper Eocene species
AGN62/2700m	Oligocene	NP21-23	Reticulofenestra clatrata, R. umbilica, S. moriformis, S. predistentus, Cy. floridanus, Discoaster deflandrei, D. bisectus (abundant), C. miopelagicus, C. pelagicus	Reworked Upper Cretaceous and Middle Eocene species
AGN61/2650m	Oligocene	NP21-23	C. miopelagicus, C. pelagicus, E. formosa, D. bisectus, Cy. floridanus, Reticulofenestra umbilica	Reworking of Upper Cretaceous species.
AGN60/2600m	Oligocene	NP21-22	D. bisectus, C. miopelagicus, Thoracosphaera spp., Reticulofenestra umbilica, S. Moriformis	-
AGN58/2400m	Oligocene	NP21-23	Reticulofenestra clatrata, Helicosphaera euphratis, H. intermedia, S. moriformis	-
AGN57/2180m	Oligocene	NP21-23	C. miopelagicus (abundant), Cy. floridanus, Helicosphaera compacta, Sphenolithus moriformis, D. bisectus, C. Pelagicus	-
AGN54/1380m	Oligocene	NP21-23	Helicosphaera euphratis, Ericsonia formosa, E. obruta, Coccolithus pelagicus, D. bisectus, Cy. floridanus, S. Moriformis	-
AGN53/1270m	Oligocene	NP21-23	Cy. floridanus - abundant, Sphenolithus predistentus, S. moriformis, C. pelagicus, C. miopelagicus	-
AGN48/1060m	Oligocene	NP21-23	Cy. floridanus, E. formosa, Thoracosphaera spp., Helicosphaera intermedia	-
AGN46/870m	Oligocene	NP21-23	Sphenolithus pseudoradians, S. predistentus, C. miopelagicus, C. pelagicus, Dictyococcites bisectus, Cy. Floridanus	-
AGN44/810m	Oligocene	NP21-23	Sphenolithus moriformis abundant, Transversopontis fibula, Dictyococcites bisectus, Cy. Floridanus	-
AGN43/780m	Oligocene	NP21-23	Ret. umbilica, R. clatrata, Cy. floridanus, Dictyococcites bisectus, C. pelagicus, C. miopelagicus, Sphenolithus predistentus	-
AGN42/700m	Oligocene	NP21-23	Cy. floridanus abundant, Helicosphaera willcoxonii, Helicosphaera compacta, S. moriformis, Sphenolithus pseudoradians, C. miopelagicus, Dictyococcites bisectus	-
AGN41/680m	Oligocene	NP21-23	Braarudosphaera bigelowii, Helicosphaera compacta, Sphenolithus pseudoradians, Dictyococcites bisectus, D. scrippsae, Sphenolithus moriformis, C. pelagicus, Ericsonia Formosa	-
AGN39/630m	Oligocene	NP21-23	Poor sample . Small coccoliths	-
AGN37/570m	Oligocene	NP21-22	Sphenolithus moriformis, Helicosphaera euphratis, H. compacta, Coccolithus pelagicus, Cy. floridanus, S. predistentus, D. Bisectus	-
AGN36/500m	Oligocene	NP21-22	Ericsonia obruta, E. formosa, C. pelagicus, C. miopelagicus, Cy. Floridanus	-

3.6 Petas section

Eight samples have been analysed in Petas and showed an Oligocene age.

3.7 Kompoti section

In Kompoti section 9 samples have been analysed (table 7):

Table 7 : Kompoti section age determination.

Sample/strat. Level	Age	Biozone	Nannofossil marker – species in association (in situ)	Reworked species
FLO1/1000m	Late Oligocene	NP24-25 (NN1?)	D. deflandrei, C. floridanus, Cy. abisectus, Coccolithus pelagicus, C. miopelagicus, S. moriformis, D. adamanteus	
FLO2/900m	Late Oligocene	NP24-25 (NN1?)	Cy. abisectus, C. floridanus, D. deflandrei, Coccolithus pelagicus, Helicosphaera compacta, Dictyococcites bisectus, S. moriformis	Reworked Upper Cretaceous species
FLO7/720m	-		Coccolithus pelagicus, Cy. abisectus και Sph. Moriformis	
FLO10/680m	Late Oligocene	NP24-25	Helicosphaera recta, C. floridanus, Cy. abisectus, Coccolithus pelagicus, Sph. moriformis	
FLO11/420m	Late Oligocene	NP24-25	Cy. abisectus, Sphenolithus moriformis, Coccolithus pelagicus, C. miopelagicus	Reworked Upper Cretaceous and Paleocene and Eocene species
FLO12/400m	Late Oligocene	NP24-25	Helicosphaera recta, H. compacta, Coccolithus pelagicus, C. miopelagicus, Cy. abisectus, C. floridanus, Sph. Moriformis	Reworked Upper Cretaceous and Paleocene and Eocene species
FLO13/380m	Late Oligocene	NP24-25	Sphenolithus moriformis, Helicosphaera euphratis, Discoaster calculosus, D. deflandrei, Cy. abisectus, Coccolithus pelagicus, C. Miopelagicus	Reworked Upper Cretaceous and Eocene species.
FLO14/150m	Late Oligocene	NP24-25	Cyclicargolithus abisectus, C. floridanus, Coccolithus pelagicus (acme), Helicosphaera euphratis, H. compacta, H. bramlettei, D. bisectus, D. scrippsae, Sph. moriformis	
FLO15/100m	Late Oligocene	NP24-25	Cyclicargolithus abisectus, C. floridanus, Helicosphaera recta, H. compacta, H. euphratis, D. bisectus (acme), Sph. moriformis, Coccolithus pelagicus, C. miopelagicus	Reworked Upper Cretaceous species

3.7 Amphilochia section

Twenty four samples were analyzed in Amphilochia section. The results of the analysed samples are shown in the next table (table 8):

Table 8 : Amphilochia section age determination.

Sample/strat. Level	Age	Biozone	Nannofossil marker – species in association (in situ)	Reworked species
AMB41/3150m	Oligocene	NP23-24	C. pelagicus, Helicosphaera cf. recta, Sphenolithus pseudoradians, S. moriformis, Dictyococcites bisectus, Cy. Abisectus	
AMB40/2600m	Oligocene	NP23-24	Helicosphaera bramlettei, Cy. floridanus, Cy. abisectus, Sph. pseudoradians, S. moriformis, C. pelagicus, Pontosphaera multipora	Late Cretaceous species
AMB30/1450m	-		Poor sample	
AMB29/1400m	Early Oligocene	NP21-23	Helicosphaera compacta, Coccolithus pelagicus, C. miopelagicus, Cy. floridanus, D. Bisectus	Early Eocene species
AMB28/1290m	-		Poor sample	
AMB27/1270m	-		Poor sample	
AMB26/1200m	-		Poor sample	
AMB24/1150m	Early Oligocene	NP21-22	R. umbilica, D. bisectus, E. formosa, Coccolithus pelagicus, C. miopelagicus, S. Moriformis	
AMB22/980m	Early Oligocene	NP21-22	Sphenolithus moriformis, Coccolithus pelagicus, Cy. floridanus, D. bisectus, Ericsonia formosa	
AMB21/850m	Early Oligocene	NP21-22	Helicosphaera compacta, Cy. floridanus, Sphenolithus moriformis, D. bisectus, R. Umbilica	
AMB20/800m	Early Oligocene	NP21	C. pelagicus, D. bisectus, Cy. floridanus, Ericsonia formosa, Sph. Moriformis	
AMB19/760m	Early Oligocene	NP21	Reticulofenestra oamaruensis, C. pelagicus, D. bisectus, Cy. Floridanus	
AMB18/730m	-	-	Poor sample	
AMB14/680m	Early Oligocene	NP21-22	Helicosphaera compacta, H. euphratis, Cy. floridanus, C. pelagicus, D. bisectus	
AMB17/620m	Early Oligocene	NP21-22	Coccolithus pelagicus, C. miopelagicus, Reticulofenestra umbilica, Cy. floridanus, Ericsonia Formosa	
AMB13/550m	Early Oligocene	NP21-22	Cy. floridanus, C. pelagicus, D. bisectus, Ericsonia obruta, R. umbilica	
AMB11/470m	Early Oligocene	NP21-22	Dictyococcites bisectus, Sphenolithus radians, S. moriformis, S. predistentus, Helicosphaera intermedia	Early Eocene species

AMB10/420m	Early Oligocene	NP21-22	Coccolithus pelagicus, C. miopelagicus, Cyclicargolithus floridanus, Sphenolithus predistentus, Reticulofenestra umbilica, Helicosphaera compacta, H. euphratis, Zygrhablithus bijugatus, E. Formosa	
AMB9/410m	Late Eocene-Early Oligocene	NP21	E. formosa, E. subdisticha, Cyclicargolithus floridanus, Dictyococcites bisectus	
AMB8/320m	Late Eocene-Early Oligocene	NP21	Cyclicargolithus floridanus, Sphenolithus predistentus, S. moriformis, Dictyococcites bisectus	
AMB7/220m	-	-	Poor sample	
AMB5/200m	Late Eocene-Early Oligocene	NP21	Reticulofenestra umbilica, Dictyococcites bisectus, D. scrippsae, Coccolithus miopelagicus, Cyclicargolithus floridanus, Helicosphaera intermedia	Early Eocene species
AMB4/170m		-	Poor sample : Dictyococcites scrippsae	
AMB2/150m	Late Eocene-Early Oligocene	NP21	Helicosphaera moorkensis, Sphenolithus moriformis, S. predistentus, Coccolithus miopelagicus, C. pelagicus, Dictyococcites bisectus, Cyclicargolithus floridanus, Reticulofenestra oamaruensis, R. umbilica, Ericsonia formosa	Early-Middle Eocene species

3.8 Ellinika section

At Ellinika section nine samples were used in order to estimate the period that the clastic sedimentation was active. The results of the analysed samples that were examined are shown at the following table (table 9):

Table 9: Ellinika section age determination.

Sample/strat. level	Age	Biozone	Nannofossil marker – species in association (in situ)	Reworked species
AGR2/1800m	Late Oligocene	NP24-25	Sphenolithus distentus, C. pelagicus, Cy. abisectus	
AGR3/1620m	Late Oligocene	NP24-25	Helicosphaera recta, H. compacta, Sphenolithus moriformis, S. distentus (NP24-25), C. miopelagicus, C. pelagicus, Dictyococcites bisectus, Cy. abisectus	
AGR4/1400m	Oligocene	NP21-23	Helicosphaera granulata, Sphenolithus moriformis, Dictyococcites daviesi	
AGR5/1090m	Oligocene	NP21-23	H. euphratis, Sphenolithus moriformis, Reticulofenestra umbilica, Dictyococcites scrippsae, S. predistentus,	
AGR6/1080m	Oligocene	NP21-23	S. moriformis, S. predistentus, C. floridanus, C. abisectus, C. miopelagicus, C. pelagicus	
AGR7/690m	Early Oligocene	NP21	Reticulofenestra umbilica, D. deflandrei, S. moriformis, C. pelagicus, Coronocyclus nitescens, Ericsonia formosa, E. Subdisticha	
AGR8/380m	-	-	Empty sample	
AGR9/210m	Late Eocene	NP17-20	Helicosphaera compacta, Reticulofenestra umbilica, S. moriformis, C. pelagicus, C. miopelagicus, Pontosphaera sp., C. floridanus, Ericsonia formosa, Discoaster barbadiensis	
AGR10/20m	Late Eocene	NP17-20	C. floridanus, C. pelagicus, C. miopelagicus, Dictyococcites scrippsae, D. bisectus, S. moriformis, Reticulofenestra umbilica, R. oamaruensis, Ericsonia formosa, Discoaster barbadiensis	Reworking of Upper Cretaceous, and Paleocene species: M. decussata, A. cymbiformis, Discoaster wemmelensis

4 CONCLUSIONS

Considering the results of the studied sections the following conclusions can be made:

1. Clastic sedimentation began in the Middle Eocene, with small differences among the basin. Especially in the Metsovo A-A' section, a Lower to Middle Eocene age assessment is possible, while in Amphilochia section a delay may have been present, as the lowest stratigraphic sample gave an Upper Eocene-Lower Oligocene age. In the Agnanta, Petas

and Kompoti sections it was not possible to determine the starting point of the clastic sedimentation because the part of these sections which is in contact with the Eocene limestones is covered by recent sediments.

2. The end of clastic sedimentation seems to be at different times in different parts of the basin. In the Kavasila, Palaiopyrgos, Petrovouni and Pramanta sections, which are located at the northern part of the study area, clastic sedimentation stopped at the boundary of Upper Eocene – Lower Oligocene, while in the southern sections including the Metsovo sections the clastic sedimentation stopped in the Upper Oligocene.
3. The end of sedimentation in the Petrovouni and Pramanta sections at the boundary of Upper Eocene – Lower Oligocene is an indicator that Pindos thrust was active at least until this period, as the samples that gave these age assessments are very close stratigraphically to the tectonic contact of the flysch deposits with the Pindos thrust.
4. The fact that in the Metsovo section, which is very close to the Petrovouni and Pramanta sections, the sedimentation lasted for a longer period (Upper Oligocene) is an indicator that the basin was deeper in this area. The presence of the Kastaniotikos line seems to be related with this observation, affecting probably the morphology of the area and eventually the sedimentation.
5. The activation of the Internal Ionian thrust probably took place in the Late Eocene. This is supported mainly from observations in the Metsovo and Pramanta sections where the change from an outer fan to an inner fan environment, which is also pointed out by the modification of the flow regime, took place at this time.

REFERENCES

Alexander J., Nichols G.J., Leigh S., 1990. The origins of marine conglomerates in the Pindos foreland basin, Greece. *Sedimentary Geology*, 66, 243-254.

Aubouin J., 1959. Contribution à l'étude géologique de la Grèce Septentrionale. Les confines de l'Epire et de la Thessalie, *Ann. Geol. d. Pays Helen*. 10, 1-525, Athènes

Avramidis P., 1999. Depositional environments and hydrocarbon potential of Tertiary formations in Klematia-Paramythia basin, Epirus*, PhD thesis, University of Patras.*

Avramidis P., Zelilidis A., Kontopoulos N., 2000. Thrust dissection control of deep-water clastic dispersal patterns in the Klematia-Paramythia foerland basin, Western Greece. *Geol.Mag.,* 137, 667-685.

Avramidis P., Zelilidis A., Vakalas I., Kontopoulos N., 2002. Interactions between tectonic activity and eustatic sea-level changes in the Pindos foreland and Mesohellenic piggy-back basins, NW Greece: Basin evolution and hydrocarbon potential. *Journal of Petroleum Geology*, 25, 1, 53-82.

Bellas S. M., 1997. Calcareous nannofossils of the Tertiary flysch (Post Eocene to Early Miocene) of the Ionian zone in Epirus NW-Greece: Taxonomy and Biostratigraphical correlations. *Berliner Geow. Abh.*, 22, 173

British Petroleum Co Ltd. (B.P.), 1971. The geological results of petroleum exploration in western Greece. *Inst. for Geology and Subsurface Research*, Special report no. 10, Athens.

Clews J., 1989. Structural controls on basin evolution: Neogene to Quaternary of the Ionian zone of western Greece*. J. Soc. London*, 146, 447-457.

Fleury J.J., 1980. Evolution d'une platforme et d'un basin dans leur cadre alpin: les zones de Gavrovo-Tripolitze et du Pinde-Olonos. *Soc .Géol. Nord, Spec. Publ.* 4, 651.

IGSR&IFP, 1966. Etude geologique de l'Epire. Paris: Technip, 306pp.

Leigh S. P., 1991. The sedimentary evolution of the Pindos Foreland Basin Western Greece, *Phd thesis. University of Wales.*

Martini E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proceedings of the II Planktonic Conference, Roma,* 1970, 2, 739-785.

Vakalas J., 2003. Evolution of foreland basins in western Greece. *Ph.D. thesis, University of Patras.*

Underhill J. R., 1985. Neogene and quartenary tectonics and sedimentation in western Greece. *Phd thesis, University of Wales, Cardiff.*

Underhill J. R., 1989. Late Cenozoic deformation of the Hellenide foreland, western Greece. *Geol. Soc. Of Amer. Bull.*, 101, 613-634.

Wilpshaar M., 1995. Applicability of dinoflagellate cyst stratigraphy to the analyses of passive and active tectonic settings. *Ph. D. Thesis, University of Utracht, Netharlands.*