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# **BOOK OF ABSTRACTS**

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## Distinct periods of flysch deposition in the External Hellenides during their geodynamic evolution

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The Hellenides are distinguished in : 1) the External Hellenides, characterized by continuous stratigraphic columns from the early Mesozoic to the early Paleogene, and one major tectonism from early Eocene to Late Miocene and 2) the Internal Hellenides, characterized by stratigraphic unconformities mainly during the Cenomanian, that separate the pre-orogenic Triassic-Jurassic stratigraphic sequences from the post paleo-Alpine orogenic Upper Cretaceous-Eocene transgressive sequences featured by two major phases of tectonism in Late Jurassic-Early Cretaceous and in the Eocene (Papanikolaou, 2021 and references therein). The overall evolution of the External Hellenides fold and thrust belt is marked by the onset of flysch sedimentation in its foreland, which expands as a wave from the more internal segments to the external ones, in-between late Maastrichtian to Late Miocene. This shift to younger ages towards the external segments of the belt is nevertheless not chronic but characterized by several principal breaks that correspond to major tectonic structures during the orogenic evolution, leading to subduction, metamorphism and duplication of the paleogeographic units.

The age of the transitional beds to flysch in the various geotectonic units of the Hellenides has been documented by stratigraphic and micropaleontological methods; mostly foraminiferal evidence, however calcareous nannofossil dating have been so far acquainted in several cases:

-in *Eastern Greece Unit*, the flysch onset on top of the Upper Cretaceous transgressive sediments has been constrained to Maastrichtian-Danian (Mercier & Vergely, 1984; Papanikolaou, 1986)

-the *Beotian Unit* red pelites, overlain by typical flysch deposits, have been dated in Paleocene based on the presence of globigerinids (Papanikolaou & Sideris, 1979)

-the *Parnassos Unit* red pelites, overlain by typical flysch deposits, are of Paleocene age (Aronis et al., 1964). In particular the base of red pelites (location Kokkinochoma) has been dated as late Paleocene at ~58 Ma (nannofossil biozone NP6; Richter et al., 1995); a similar age has been recorded at a flysch exposure towards to Arachova based on the contemporaneous presence of *H. klempellii* and *F. tympaniformis* (nannofossil biozones NP6-NP7; present study). The biozones NP7 (*H. klempellii*, *F. tympaniformis*, *D. mohleri*, *S. anarrhopus*) - NP11 (*S. conspicuus*, *Ch. solitus*, *C. crassus*) have also been recorded in the red pelites of Prosilio location; Gouliotis, 2014, present study); the recorded diachroneity is obviously associated with paleorelief differentiation due to synrifting tectonism

-the *Vardousia Unit* presents transitional beds to red pelites within Paleocene (Celet, 1979; Gouliotis, 2014)

-in *Pindos Unit* the transitional beds are of Maastrichtian-Danian age, marked by the presence of *Globotruncana* (Aubouin, 1955; Fleury, 1980). Upwards in the flysch sequence, Ananiadis et al. (2004), determined that Pindos flysch sedimentation in northern Epirus spans from Paleocene (Danian-Selandian) at ~58.5 Ma (based on the presence of *F. billii* and *P. bisulcus*; nannofossil biozones NP4-NP7, emend. this study), and in central Thessaly, transitional beds to Pindos flysch at the location of the dam of the artificial Lake of Tavropos, revealed the contemporaneous presence of *F. tympaniformis* and *H. klempellii* associated with the presence of NP6-NP7 biozones in Thanetian (~57 Ma, present study). In Peloponnese, Richter & Muller (1993) defined an heterochronous transition to clastic sedimentation that began in the western part of the Pindos basin in the Campanian or at the Campanian/ Maastrichtian boundary and in the eastern part not before the middle Maastrichtian or even the late Paleocene (between biozones NP1 and NP9)

-the *Arvi Unit* displays pelagic carbonates of late Maastrichtian age containing *Contusotruncana contusa*, *Globotruncana stuarti*, *Rugoglobigerina* and Heterohelidae that are transitional upwards to Maastrichtian-Paleocene interbedded sandstones, siltstones, shales and conglomerates (Palamakumbura et al., 2013)

-within *Ethia Unit*, the Pindos unit s.s. equivalent in Crete, flysch sedimentation begins in late Eocene/Priabonian, similarly to Gavrovo and Tripolis units (Renz, 1955; Creutzburg & Papastamatiou, 1969; Bonneau & Zambetakis, 1975)

-the *Olympus Unit* flysch sequence is overlying upper Eocene *Nummulites*-bearing limestones (Godfriaux, 1968)

-similarly the *Amorgos Unit* is featured by upper Eocene *Nummulites*-bearing limestones below the flysch deposits (Fytrolakis & Papanikolaou, 1981)

-the *Tripolis Unit* transitional beds at the base of flysch are deposited in Priabonian (Dercourt, 1964; Fleury, 1980); in Doliana Peloponnese they are dated at ~36 Ma (biozone NP19/20; Late Eocene, present study)

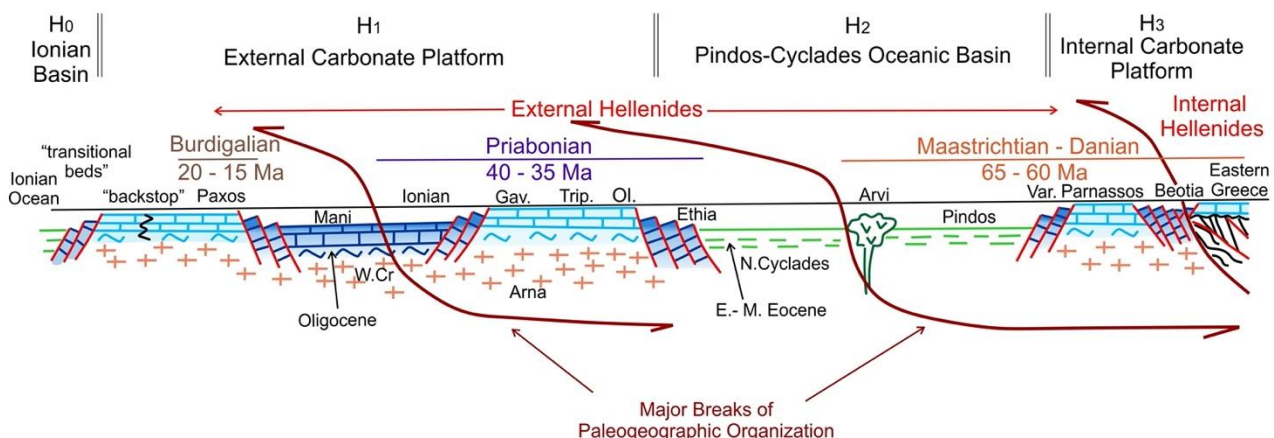
-within *Gavrovo Unit*, the flysch deposition started in Priabonian (IGSR & IFP, 1966; Fleury, 1980) at a mean age of ~36 Ma (nannofossil biozone NN19/20) (Triantaphyllou, 2013 and references therein)

- in the *Ionian Unit* the onset of flysch sedimentation (base of transitional beds) has been recorded in Priabonian (Renz, 1955; IGSR & IFP, 1966; Bellas, 1997) at ~36 Ma (biozone NP19/20; external/internal Ionian), and at ~41 Ma (biozone NP16; middle Ionian) (Triantaphyllou, 2013 and references therein, emend.)

-the *Mani Unit* presents early Oligocene meta-flysch with *Gl. ampliapertura* and *T. cerroazulensis* (Thiebault, 1980)

-the *Paxos Unit* on Lefkas Island exposes the classic transition to terrigenous clastics in the late Burdigalian to early Langhian (early Middle Miocene), (Bornovas, 1964; De Mulder, 1975), while Triantaphyllou (2010) documented biozones NN4-NN5 (~15 Ma; early Langhian). The basal layers of Paxos atypical flysch on Zakynthos Island have been detected in Ag. Nikolaos-Lagopodon section (Dermitzakis, 1978) and correlated with planktonic foraminiferal biozone N4 (~22 Ma).

Hence, it is evident that there exist two major breaks in the continuity of the orogenic wave (Fig. 1). The major one is observed between Paleocene (characterizing all the units from Eastern Greece to Beotia, Parnassos, Pindos and Arvi) and late Eocene (characterizing the Ethia Unit and the majority of the external carbonate platform units). The early-middle Eocene missing time interval most probably corresponds to the age of the metamorphosed flysch found at the top of subducted Cycladic units. Interestingly, this jump in the paleogeography during the orogenesis did not occur at the margins/boundaries of the tectonostratigraphic terranes but within the Pindos-Cyclades oceanic terrane H2. Thus, the synchronous onset of flysch deposition in the Pindos Unit s.s. and the Vardoussia-Parnassos units implies their paleogeographic/orogenic continuity from the inner half of the Pindos-Cyclades oceanic terrane H2 towards the Internal Carbonate Platform, H3, while Ethia Unit corresponds to the external half of the Pindos Basin towards the External Carbonate Platform H1. The second break is recorded between the late Eocene (in the Ionian Unit and the more internal segments of the platform) and Burdigalian characterizing the Paxos transitional beds. The missing period of Oligocene corresponds to the metamorphosed flysch of the subducted Mani Unit, which should be initially located between the Paxos and Ionian units. Thus, both breaks mark the lost paleogeographic areas due to subduction and metamorphism of the Metamorphic Hellenides (Papanikolaou, 1980, 1986) during Early-Middle Eocene for the Cyclades in the Medial Tectono-metamorphic Belt and during Oligocene-Early Miocene in the External Tectono-metamorphic Belt of Peloponnese-Crete.



**Figure 1.** The orogenic evolution of the External Hellenides fold and thrust belt based on the different ages of the transitional beds to the flysch and the resulting breaks (modified from Papanikolaou, 1986; 2021; Papanikolaou & Vassilakis, 2010).

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