Environmental significance of bioturbations in the Grund Formation (Miocene, Lower Badenian) in northern Lower Austria

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Sedimentology, paleontology and ichnology of the lower Badenian (early Middle Miocene) Grund Formation could be studied during field campaigns in 1998 and 1999. Several deep trenches (profiles A, B, C, D, E, F, G, H) were excavated in the farmland between the villages of Grund and Guntersdorf north of Hollabrunn in northern Lower Austria.

The profiles at the type locality Grund show sediments from a shallow marine, highly erosive environment with small channels. The channel-fill with densely packed (bioclast supported) shell-layers at the base, fining upward cycles of coarse to fine sands, and thin pelitic layers on the top indicate periodically high-energy events with rapidly decreasing energy level. The channels always have a sharp erosive base and maximum visible extentions of 7 to 8 meters with depths of 0.5 to 1 meter.

In the lower part of the sequence sandy beds with a thickness from 60 to 120 cm contain up to 40 cm thick layers of pelitic clasts, showing strong reworking. Besides the clasts these layers contain a mixed allochthonous fauna with marine mollusks, terrestrial gastropods and bones of different vertebrates (turtles, whales, rhinos, small carnivores and micro mammals).

Towards the top of the sequence thickness and grain size of the beds are decreasing. In the middle part of the sequence 20 to 45 cm thick medium- to fine-grained sandy beds show fining upward and even lamination. Current ripples and plant debris at the top of some beds show the reduction of current velocity too. Several cm-thick pelitic layers mostly cover the laminated sands. Intense but monospecific bioturbation (*Asterosoma*) starts from these layers but reaches down only up to 5 cm into the sandy layers. The sand bodies in this part are mostly tabular sometimes slightly wedge-shaped. In rare cases small and narrow runnels, 60 to 80 cm wide and 10 to 25 cm deep, with erosive base and filled with pelitic clasts can be found.

The uppermost part also contains evenly laminated, medium to fine sands with graded bedding but thickness of the pelitic layers is increasing (up to 20 cm) towards the top of the sequence. Developing from the pelitic layers a diverse trace fossil community reaches down into the sands. *Rhizocorallium*, *Teichichnus* and *Zoophycos* are very frequent structures but also *Ophiomorpha* can be observed. The chemosymbiontic bivalve *Thyasira michelottii* occurs as exclusively autochthonous inhabitant of these layers. The Thyasira-shells sometimes are connected with deep shafts, but in most cases with ventral tunnels reminiscent of *Chondrites*.

The distribution and diversity of bioturbations is highly correlated to the hydrodynamic level. The basal sections of the sequence show the highest disturbance of the benthos. Only oportunistic organisms with burrowing strategies fitting to the mobile sediment can settle during short periods of quiet conditions.

Probably the deepening of this environment caused the increase of calm periods toward the top. Longer periods of benthic recovery after physical disturbances lead to the increase of burrowing depth and diversity. Deposit feeding and chemosymbiontic strategies are characteristic features of the uppermost parts in the excavated sections of the Grund Formation.

The decrease of the hydrodynamic energy level from the base of the sequence to its top is obvious in the sedimentological record as well as in the development of trace fossil assemblages. This fits very well to the regional transgressive trend of the Lower Badenian.

Detrital blue amphiboles in the Paleocene flysch deposits of the Othrys Mountain, Pelagonian Zone, Greece: Evidence of pre-Tertiary blueschist facies metamorphism in the Hellenides

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Blueschist facies metamorphic (HP/LT) rocks occur in many tectono-metamorphic units of the Hellenides. Widespread blueschist occurrences are restricted, however, to the Olympos and Ossa areas, the Pelion peninsula and southern Evia, the Cycladic islands, and the Phyllite-Quartzite Series in Peloponess and Crete.

Despite of pre-Tertiary ages that have been suggested long time ago, radiometric determinations from Cycladic rocks and from the external Hellenides have coined the idea in the last two decades that blueschist facies metamorphism in the Hellenides was of Tertiary age.

However, a pre-Tertiary age for the onset of HP/LT metamorphism is supported by the occurrence of detrital blue amphiboles found within Paleocene flysch deposits of the Othrys Mountain that lie over karstified, occasionally strongly eroded Upper Maastrichtian limestones. These deposits contain frequently minor amounts (<10%) of blue amphiboles. Analyses of these detrital grains were compared with published analyses of blue amphiboles from known blueschist terrains in order to reveal their potential provenance.

Blue amphiboles from Pelagonian rocks (Olympos and Ossa) show a very wide variation that does not coincide with that of the detrital grains. This is mainly due to the widely varying bulk composition and their incomplete overprinting relations. For example, in many cases, blue amphiboles have been reported as overgrowths over green amphiboles, suggesting incomplete HP/LT overprinting of greenschist or amphibolite facies precursors. A Pelagonian source for the detrital grains is also excluded because this incomplete HP/LT overprint took place in post-Paleocene times.

Most Cycladic sources show a narrow compositional variation that generally coincides with that of the detrital blue amphiboles. However, currently available evidence suggests that the Cycladic islands reached the erosion surface at Miocene times. This precludes the Cyclades as sources of the detrital blue amphiboles in the Paleocene flysch deposits. We therefore suggest the following:

1. Blueschist facies metamorphism in the Hellenides started at pre-Tertiary times.
2. The source of the detrital blue amphiboles in the Paleocene flysch deposits of the Othrys Mountain is presently not exposed, but may have been covered tectonically during the Tertiary. It has been exposed to erosion during Maastrichtian/Paleocene times.
3. This source as well as the Cycladic blueschists and those of the Ambelakia unit were slices of HP/LT rocks that (a) originated by subduction of the Pindos ocean at the external active margin of the Pelagonian and (b) were extruded from the orogenic wedge at different times.

The new Metamorphic Core of Serifos (Western Cyclades, Greece)

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The Southern Aegean area of the Cycladic islands is characterized by a N-S directed extension since the Miocene. This extension led to the formation of metamorphic core complexes (Naxos, Paros, Ios in the eastern Cyclades). In most cases, the shallow dipping extensional detachments show a top-to-N directed movement. This work presents a similar, but S-directed structure exposed on the western Cycladic island of Serifos.

Serifos is dominated by a Hbl + Bt-granodiorite that intruded before 8-9 Ma a low-grade metamorphosed volcano-sedimentary series comprising marbles as well as metabasic and lesser metapelitic rocks. The intrusion induced conduct phenomena and extensive formation of Ca-Fe-Mg-skarn and Fe-ore deposits. The metasomatic and hydrothermal processes have been extensively studied by Salemink (1985). The position of Serifos within the tectonic framework mentioned above is, however, less clear.

Based on extensive structural and geologic mapping, it can be convincingly shown that the island of Serifos corresponds to the foot wall of a metamorphic core that is characterized by S-directed movements. Parts of the ductile detachment zone comprises commonly lineated sericite±graphite schists and marble mylonites and occur in form of patches exposed mostly at the margins of the island. The shallow-dipping mylonitic foliation follows the shape of the island and underlines its dome structure. Well-developed stretching lineations strike firmly NNE-SSW and numerous kinematic indicators (scc' fabrics, σ- and δ-clasts, flanking folds, mica-fish etc.) suggest unequivocally S-directed extensional movements. Relic patches of the hanging wall are restricted only at the SW part of the island. They occur above a thick cataclasite horizon and comprise allochthonous serpentinites and ankeritic limestones.

The granodiorite shows a rather unstrained core. Towards its southern margin, it becomes more intensively foliated. It finally has been wrapped by the detachment zone and evolved to an ultra-mylonite. Its northern margin lies markedly below the detachment zone and shows clear intrusive contacts against the country rocks. These features suggest that the granodiorite is syn- to post-kinematic.

The foot wall rocks form the northern part of the island. They are folded and show persistent E-W directed stretching lineations that pre-date the formation of the detachment zone. Towards the detachment zone, these structures become overprinted by younger N-S directed extensional movements.

The latest evolution of Serifos is documented by conjugate WNW-ESE striking brittle faults that are associated with sub-volcanic vein intrusion. These veins are mostly unstrained and cross-cut the granodiorite as