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From early Paleozoic rifting to Cenozoic subduction: Records of pre-Alpine and Alpine orogenic processes in the External Hellenides

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There is considerable disagreement on the Neoproterozoic to Cenozoic location and configuration of the major crustal components of the External Hellenides (Robertson, 2006). New geochronologic data obtained from pre-Alpine basement of the Phyllite-Quartzite unit of Crete indicate that Crete and surrounding domains (e.g. Cyclades, Menderes) formed peri-Gondwanan Minoan terranes, which did not travel for long distances in Phanerozoic times (Zulauf et al., 2007).

The pre-Alpine basement of Crete consists of at least three different subcomplexes (Mirsini/Chamezi, Kalavros, and Vai crystalline complex), which are interpreted as Minoan terranes (Romano et al., 2006). After having been detached from Gondwana in early Paleozoic times, the Minoan terranes were relocated and accreted to Gondwanan crust in Carboniferous, Permian, and Triassic times. This process of terrane accretion was related to south-directed subduction/collision and resulted in a new composite terrane (Cimmeria). Accretion of the Minoan terranes led to top-to-the north shearing within the crystalline complexes. One of these shear zones has been dated at 238 $\pm$1 Ma (^{39}Ar-^{40}Ar on synkinematic white mica).

In Permian times there were two different basins between Cimmeria and Gondwana. The southern Plattenkalk basin was shallow, whereas the northern Phyllite-Quartzite basin was deep (Kozur and Krahl, 1987) due to its back-arc position above the south-dipping subduction zone. Permian accretion of the Kalavros crystalline complex to Cimmeria resulted in slab rollback and northward migration of the Cimmerian arc. The latter produced andesitic rocks which are major constituents of a Lower Triassic shallow-marine volcanosedimentary sequence, referred to as Tyros unit (sensu Dornsiepen et al., 2001). Detrital zircons of the Tyros unit yielded Devonian fission-track ages (Brix et al., 2002) which pre-date the orogenic imprints of the Carboniferous-Permian basement underneath. This peculiar feature can be explained by a fore-arc setting of the Tyros basin where Triassic sediments and volcanics were deposited on top of the accreted Carboniferous-Permian basement. The arc, on the other hand, was situated on top of Gondwana-derived basement, the latter forming the provenance area of the detrital zircons.

The Tyros basin was closed in Upper Triassic times due to accretion of the Vai crystalline complex. At the same time the Tripolitza and Pindos basins subsided inside the remnants of the Vai crystalline complex further to the north. While the Tripolitza basin remained shallow until Eocene-Oligocene times, the Pindos rift underwent Jurassic extension resulting in the Pindos ocean, the latter separating Pelagonia to the north from Cimmeria to the south. At the Triassic/Jurassic boundary a further shallow basin, referred to as Trypali basin, was present between the Plattenkalk and the Phyllite-Quartzite basin.

Cenozoic convergence led to northward subduction and accretion of Cimmeria to Pelagonia. In Paleocene to Eocene times the Pindos and Tripolitza rocks were accreted to the Pelagonian basement. During this phase of nappe stacking the Tripolitza rocks underwent metamorphism (Feldhoff et al., 1991; Rahl et al., 2005), whereas the Pindos rocks were not deeply buried. In eastern Crete, subduction and accretion of the Plattenkalk and Phyllite-Quartzite unit s.str. to Cimmeria occurred in Oligocene times (ca. 30 Ma, ^{39}Ar-^{40}Ar on synkinematic magnesioriebeckite). As the major constituents of the Trypali unit were gypsum and salt, this unit acted as weak detachment horizon between the Plattenkalk and the Phyllite-Quartzite unit.

The upper part of the Triassic Tyros beds is unmetamorphic and overlain by Neogene conglomerates. The emplacement of the Tripolitza, Pindos and uppermost Pelagonian unit on top of the unmetamorphic Tyros and Neogene rocks occurred at suprastructural levels where $T << 200^\circ C$.

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