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Alps, Carpathians and Dinarides-Hellenides: about plates, micro-plates and delaminated crustal blocks

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Before the onset of Europe-Africa continental collision in the Dinarides-Hellenides (around 60Ma) and in the Alps and Western Carpathians (around 35 Ma), and at a large scale, the dynamics of orogenic processes in the Mediterranean Alpine chains were governed by Europe-Africa plate convergence leading to the disappearance of large parts of intervening oceanic lithosphere, i.e. the northern branch of Neotethys along the Sava-Izmir-Ankara suture and Alpine Tethys along the Valais-Magura suture (Schmid et al. 2008). In spite of this, two major problems concerning the pre-collisional stage are still poorly understood: (1) by now we only start to understand geometry, kinematics and dynamics of the along-strike changes in the polarity of subduction between Alps-Carpathians and Dinarides-Hellenides, and (2) it is not clear yet during exactly which episodes and to what extent intervening rifted continental fragments such as, for example, Iberia-Briançonnais, Tisza, Dacia, Adria-Taurides moved independently as micro-plates, and during which episodes they remained firmly attached to Europa or Africa from which they broke away.

As Europe-Africa plate convergence slowed down well below 1 cm/yr at around 30 Ma ago these pre-collisional processes driven by plate convergence on a global scale gave way to more local processes of combined roll-back and crustal delamination in the Pannonian basin of the Carpathian embayment and in the Aegean (as well as in the Western Mediterranean, not discussed in this contribution).

In the case of the Carpathian embayment E-directed roll back totally unrelated to Europe-Africa N-S-directed convergence, started at around 20 Ma ago, due to the presence relict oceanic lithosphere in the future Pannonian basin that remained un-subducted during collision. Due to total delamination of the crust from the eastward rolling back European mantle lithosphere the anticlockwise rotating ALCAPA crustal block, consisting of Eastern Alps and Western Carpathian thickened crust ripped of the African plate, invaded the northern part of this oceanic embayment, virtually floating on asthenospheric mantle. The presently still surviving semi-detached Vrancea slab in Romania manifests of the combined effect of roll back and delamination of mantle lithosphere. On the other hand Tisza-Dacia, another crustal block formerly ripped off the European plate and forming a single entity since mid-Cretaceous times, also at least partly floating on asthenospheric mantle, invaded the Carpathian embayment from the south. Thereby the Tisza-Dacia crustal block underwent clockwise rotation by as much as 90° due to the corner effect of the Moesian platform firmly attached to Europe since mid-Cretaceous times (Ustaszewski et al. 2008).

In the Dinaric-Aegean realm collision occurred much earlier than in the Alps and the Carpathians, i.e. at around the Cretaceous-Cenozoic boundary, provided that one accepts that there is yet no convincing evidence for the existence of a second “Pindos oceanic domain” closing later, i.e. in Eocene times. However, in spite of early collision, the old subduction zone that consumed the northern branch of Neotethys (Meliata-Vardar) since at least mid-Cretaceous times persisted in the eastern Hellenides (but not in the Dinarides) until now, penetrating the transition zone all the way to a depth of some 1500km (Bijwaard et al. 1998). Continued subduction of mantle lithosphere in the Aegean since 60 Ma was concomitant with complete delamination of lithospheric mantle and lower crust from non-subducted or re-exhumed high pressure crustal flakes of largely continental derivation that were piled up to form the subsequently extended Hellenic orogen (Jolivet & Brun 2010). At around 25 Ma when the southern branch of Neotethys (the present-day Eastern Mediterranean ocean) entered this subduction zone, massive extension and core complex formation in the upper plate combined with an acceleration of south-directed hinge retreat of the lower plate did set in (van Hinsbergen & Schmid 2012).

Dinarides and northern Hellenides presently expose either a rather short (about 200km), or in case of northern Dalmatia, no mantle slab at all, due to recent slab break-off (Ustaszewski et al. 2008 and referenes therein). The slab gap in northern Dalmatia is instrumental in allowing for the flow of asthenospheric mantle into the Pannonian

realm necessary to drive asthenospheric upwelling in the Pannonian basin. At the same time it allows for the roll back of the Aegean slab.

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