Rifting and closure of two branches of the Tethys; from Neotethys to Alpine Tethys

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The western termination of the Neotethys is marked by a complex interaction of several small oceanic basins which were formed and closed progressively. The western end of the Neotethys was opened from Permian to Middle Triassic; spreading started from Anisian. The rifting was associated with acidic, sometimes basic magmatism; Permian intrusions are widespear in certain zones (Eastern Alps), and together with Middle Triassic volcanites, played a role in weakening of the extending continental lithosphere.

The rifting process was interacting with evaporite tectonism in regions where Late Permian evaporites were formed potentially as a post-rift or intra-rift stage. Due to loading of the ovelying Early Triassic clastic-carbonate ramp sequence, and the still ongoing extensional deformation, and/or gravitational sliding of shelf domains toward deepening extended continental margin, salt tectonics probably started in latest Early Triassic. The uprising salt walls strongly influenced shelf and eventually slope deposition; the minibasins between salt walls often hosted carbonate ramp or platform development while collapsing salt structures could turn to deep “intra-platform” basins. The salt tectonics controlled the continuing facies differentiation during the Late Triassic. The development of salt-cored normal faults are not characteristic for a typical post-rift passive margin, but due to their relation to underlying salt, facies differentiation was maintained.

The earliest sign of rifting of the Alpine Tethys can be seen in the Late Triassic deep grabens (Southern Alps, southern Transdanubian Range). This is the reason that separation of salt-related deformation, and crustal extension is not evident in some zones. The closure of the Neotethys started with intra-oceanic subduction, probably with a double polarity, and the formation of a supra-subductional new oceanic lithosphere (the Vardar zone in some interpretations). The age of this process is somewhat controversial in different models. Isotopic ages of metamorphic sole of the Vardar ophiolites suggest 175–170 Ma while neutral to acidic differentiates in the eastern Vardar testify ongoing Late Jurassic oceanic magmatism (~155–155 Ma). A complex system of melange was formed under and in front of the emplacing upper plate Vardar ophiolite. While sub-ophiolitic melange with serpentinitic matrix formed below the overlying hot oceanic lithosphere, the sediment-hosted melange contains blocks from different zones of the passive margin and partly the overlying ophiolite. Stratigraphic ages indicate that this processes happend during the Middle and Late Jurassic. The obduction happened in latest Jurassic (Tithonian) indicated by reef limestone on top of ophiolites. This was followed by the imbrication of the underlying passive margine Adriatic continental lithospere during the entire Cretaceous and Cenozoic. Clastic foreland basins were formed within this lower plate supplied partly by the passive upper plate ophiolite.

The Alpine Tethys went on intensive rifting which ended with break-up in late Middle or in the Late Jurassic on its southern Piemont-Ligurian branch. The onset of subduction is not exactly clear but could happen in the Late Cretaceous resulted in high-pressure metamorphism of the oceanic domains in the Eocene (Tauern window). The Transdanubian Range of Hungary was situated between the two oceanic domains during the whole Mesozoic. While this unit has not been buried and only deformed modestly, the sedimentary events reflect the complex evolution. Middle Triassic rifting resulted in disruption of Early Triassic mixed siliciclastic-carbonate ramp into platform and somewhat deeper grabens. Small-scale synsedimentary faults and neptunian dykes testify this phase. Away from the break-up zone, the area underwent important post-rift subsidence compensated by platform carbonate sedimentation through the Late Triassic. However, the trace of initial Late Triassic rifting is present in forms of synsedimentary faults in the western side, closer to the future Neotethys. Following the earliest Jurassic decline of platform biota, the ongoing Alpine rifting disintegrated the entire TR carbonate platform into shallower, sediment free ridges and somewhat deeper grabens. This rifting and subsidence resulted in deposition of pelagic red nodular limestone in the Aalenian-Bajocian. After cherty sedimentation in the Callovian–Oxfordian, very modest extension appeared in the latest Jurassic. Although this phase could be considered as the final extension of the Alpine Tethys rifting far to the west, it is more probable that in fact this is due to slight downbending of the TR below the distal ophiolite emplacement to the east. The Neotethyan influence prevaild in the eastern TR during the Early Cretaceous. A clastic foreland basin was supplied by ophiolite and supra-ophiolite detritus of the obducted Neotethyan Vardar unit.

Structural cituation changed in the late Early Cretacoues, around 115 Ma (Albian). The entire TR underwent shortening. The unit, formerly the lower plate of the Neotethyan

eISSN 2353-3641 | ISSN 1731-0830

system, was emplaced, as the highest nappe, on to the other continental units of the Austroalpine system. Within the Eastern Alps, this was associated with intracontinental subduction initiated in zone of Permian magmatism having thermally weakened the lithosphere. The relationship of this subduction, and associated high to ultrahigh pressure metamorphism is not clear, but eventually could have connected to large-scale displacement of the Neotethyan subduction zone at its northernmost termination zone. The complete change of the TR, from lowermost position to upper plate, is the reflection of complex 3D geometry of overlapping oceanic domains and could happen in other Tethyan areas.