Tectonic evolution of the Alpine–Carpathian mountain belt: review of geochronological data

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New geochronological data including U–Pb zircon, Sm-Nd, Ar–Ar, and fission track ages published during the last years significantly contributed to the knowledge of the Phanerozoic tectonic evolution of the Alpine-Carpathian region. Three major lines of evidence were followed including the timing of metamorphic processes and the subsequent exhumation, the timing of plutonic processes, and the record of detrital minerals for geodynamic processes in the hinterland. Assessment of these data allows the following major conclusions:

No major segment of older crust than Late Precambrian is preserved within the internal Alpine and Carpathian basement. Penetrative, mainly medium-grade metamorphic overprint affected the whole internal Alps and Carpathians (incl. the Apuseni Mountains) during Variscan (c. 360–300 Ma) continental collisional tectonic events. In some units, Variscan metamorphism overprinted a sequence of Cadomian (c. 800–550 Ma) (mainly recorded Danubian units of Southern Carpathians), and early Paleozoic events between c. 520–480 and 450–370 Ma. These relationships may be interpreted to record Early Paleozoic accretion of microplates and final collision of Gondwanian and Central European Variscan tectonic elements. Variscan events include formation of an Andean-type batholith belt (c. 365–335 Ma), subsequent subduction of continental crust and eclogite formation due to continent-continent collision, penetrative amphibolite-grade overprint (c. 330–310 Ma), and intrusion of collisional and post-collisional granites, the latter interpreted to record post-collisional slab break-off and magmatic underplating during the Permian. This process continued into Permian rifting associated with gabbro intrusions, high temperature metamorphism, and ductile deformation and subsequent opening of new oceanic seaways. A second, independent magmatic pulse during Middle/Late Triassic is interpreted to herald opening of Jurassic rifts.

Triassic seaways were closed during the Late Jurassic as recorded in blueschists. Austro–Alpine units were subsequently affected by Cretaceous eclogite-grade metamorphic overprint and, together with internal Carpathians, by subsequent throughout amphibolite- to greenschist-grade overprint. This is explained to result from continent-continent collision where these units came into a lower plate position. Collision appears to be two-stage, respectively diachronous as recorded by ca. 120–110 Ma collisional events in the Romanian Carpathians, and by latter events at ca. 100–90 Ma recorded in the entire region. Subsequent regional exhumation of these units was associated with lithospheric-scale extension and formation of Gosau-type collapse basins as distributed in the whole East Alpine–Carpathian realm.

Nearly no evidence for Cenozoic metamorphic overprint was found within the region under consideration outside of Penninic units of the Eastern Alps. A major Eocene event of regional cooling as evidenced by several apatite fission track studies. This may be easily explained by continent-continent collision and associated surface uplift in the Alpine segment. Neogene reactivation along major fault zones is now well-documented within the entire Alpine–Carpathian region.