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Multiple episodes of extension and contraction in the Eastern Alps

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The Alpine orogen of the Eastern Alps resulted from both multiple periods of extension and contraction. The following discussion mainly summarizes arguments for these from the Austro-Alpine and South-Alpine units.

The Variscan orogeny assembled various tectonic units to the future Austro-Alpine and South Alpine units that widely differed in style and tectonic significance before and during Late Variscan orogenic paroxysm. Widespread post-orogenic I-type granitoid intrusions are interpreted to result from post-Variscan equilibration of the thermal boundary layer in the thickened Variscan lithosphere. The heat input led to thermal weakening of these units resulting in localization of subsequent Permian extension that is thought to have resulted from general sinistral shear due to the specific site within the continent-scaled wrench zone between Laurussia and Gondwana. A pulse of Early to Middle Permian transtensive rifting led to formation of NNE- to NE-trending ductile and brittle normal faults, deposition of syn-rift sediments in half-grabens, gabbro intrusions, low-pressure/high temperature metamorphic overprint (within the stability field of andalusite), and localized melting of the continental crust and pegmatite intrusions within both Austro-Alpine and South-Alpine units. Late Permian to Triassic sequences are interpreted to represent post-rift sediments due to thermal subsidence. A second rifting pulse affected mainly higher Austro-Alpine and the South-Alpine units during early Middle Triassic and led to the formation of the Meliata oceanic domain along the southeastern margin of the Austro-Alpine units (sensu stricto). This rift event was also responsible for passive continental margin formation in both Bavaric/Tirolic units and Upper Juvavic units within the Northern Calcareous Alps. Some of present Middle Austroalpine and central Upper Austro-Alpine units may represent the originally northwestern rift shoulder to that event.

Rhaetian to Early Jurassic tectonic rifting led to the formation of the South Penninic ocean by separation of the Austro-Alpine realm from stable Europe. Evidence for this occurred within the Northern Calcareous Alps, and western Lower Austro-Alpine units.

The contraction history started with rapid Late Jurassic to Early Cretaceous subsidence of the Bavaric/Tirolic passive continental margin, emplacement of remnants of distal Meliata units und the opposite passive continental margin sequences that form now the Upper Juvavic tectonic klippe within the Northern Calcareous Alps. Nappe stacking within Austro-Alpine footwall units is a result of wedging of upper continental crust during a short-living period of A-subduction of Austroalpine units during the early Late Cretaceous, their entire consumation, and subsequent extension within a sinistral, transtensive wrench corridor. Burial and later thrusting resulted in a ramp-like structure of individual Austro-Alpine nappes. The Late Cretaceous sinistral wrenching appears to reflect differential plate motions in respect to the opening of the Atlantic ocean, and is partly responsible for iuaxtaposition of different Austro-Alpine and South-Alpine paleogeographic units. Another result of wrenching is the formation of a major sinistral shear corridor close to the present southern margin of Austro-Alpine units separating northern amphibolite facies metamorphic units from southern greenschist facies units by a transtensive ductile shear zones.

The Austro-Alpine units were affected by Eocene piggy back emplacement onto Penninic oceanic and units in extension of the European foreland. Brittle faults formed in the interior of Austro-Alpine units, and some major N-trending, sinistral strike-slip faults may be related to that event.

Final eastwards prograding shortening (Oligocene to Early Miocene) along the northern margin of the Eastern Alps led to displacement partitioning of contraction due to interferences of the geometry of the continental foreland and the geometry of the South Alpine rigid indenter. Several stages can be distinguished during this process: (1) Formation of a Oligocene, ENE-trending wrench corridor that continued into a (2) Early-Middle Oligocene wrench corridor where a conjugate dextral wrenching along started late in respect to the sinistral wrenching; and (3) final stages of extrusion towards east of a rigid Central Austro-Alpine block. Because of the wedge-like shape of the extrusionial wedge this started from areas with strong shortening (c. 40 % shortening), passed through a pre-Miocene neutrality to a stretching perpendicular to the extrusional displacement vector (with a N-S oriented stretching factor of c. 1.2) during extrusion. All these combined effects led to a strong complication of initial multiple rift configuration within Austro-Alpine paleogeo-graphic domains.