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# The transition from piggy back to pull apart in the Vienna Basin (Austria-Slovakia-Czech Republic)

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The Miocene tectonic evolution of the Vienna Basin includes two stages with distinct kinematics referred to as a Lower Miocene piggy-back and a Middle to Upper Miocene pull-apart phase. Although the latter phase is well constrained by previous investigations, the early period of basin formation remained quite unexplored. Analyses of subcrop from the central part and outcrop data from the margins focus on the complex tectonics prior to the formation of the Vienna pull-apart basin, which is characterised by concurrent folding and thrusting, sinistral wrenching, extensional deformation in the overriding allochthon, and syntectonic basin formation.

Seismic mapping of horizons in a 3D dataset show Lower Miocene piggy-back basins filling up a palaeo-relief. These sediments (Ottnangian-Karpatian) unconformably overly the Alpine-Carpathian thrust nappes and have a thickness of up to 1500 m. The inner architecture shows onlaps on to the basin floor and toplaps to the overlying Middle Miocene sediments. These toplaps are the results of tilting and subsequent erosion of the sediment pile at the Karpatian-Badenian transition, which is related to the onset of pull-apart deformation. Lower Miocene faults from subcrops and structural outcrop data from the margins of the Vienna Basin prove significant deformation of the Austroalpine overriding plate during the Lower Miocene piggy-back stage. Deformation structures include (1) out-of-sequence thrusts, (2) wrench faults and (3) major normal faults. These features seem to affect the leading edge of the Austroalpine nappe system.

(1) Data highlight a thrust fault inside the Austroalpine units (Göller Nappe) as a major out-of-sequence thrust. Ottnangian to Karpatian (∼18-16 Ma) sediments overlying this thrust are folded into a fault propagation fold. The end of the thrust event is constrained by the erosional truncation and the transgressive Lower Badenian, which is not affected by folding (∼ 16.1 Ma).

(2) Thrusting occurred contemporaneously with strike-slip faulting south of the out-of-sequence thrust. Seismic data depict a fault zone with numerous NNE-striking en-echelon splay faults, which root in a common NE-striking master fault. The fault zone is traced over a distance of 9 km along strike. 3D fault geometries and cross sections resembling typical flower structures strongly suggest sinistral strike-slip faulting. This kinematic interpretation is corroborated by fault mapping in the NCA west and east of the Vienna Basin showing several major ENE-striking sinistral wrench faults. In the outcrops these faults are dated pre-Middle Miocene as they are cut by the boundary faults of the Vienna pull-apart basin, which evolved from the Badenian on.

(3) Additional structures mapped subsurface refer to ENE- and WSW-directed normal faults, which delimit major half grabens filled with Lower Miocene growth strata (vertical displacement 400 ms TWT). Lower Miocene stratigraphic ages of the growth strata and faults, which terminate upsection at the top of the Karpatian sediments (∼16.1 Ma) provide the age constraints for these grabens.