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Late Cretaceous inversion and synchronous regional uplift in central Europe

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The Late Cretaceous pulse of intraplate shortening is an outstanding event in the Mesozoic history of Central Europe. Exhumation and uplift associated with it have reached by far the highest magnitudes and affected individual blocks within a huge area extending, at least, from the Ardennes in Belgium to the Holy Cross Mountains in south-central Poland. Beyond these uplifted blocks, inverted sedimentary (sub)basins are common in the Central European Basin system, which includes significant parts of The Netherlands, the southern North Sea, Denmark, northern Germany, and Poland. The uplifted blocks include (i) prominent fault-bounded mountainous regions such as the Harz Mountains or the Karkonosze Mountains, which experienced pronounced Late Cretaceous exhumation, and (ii) other basement blocks, which experienced less pronounced and longer-lasting Mesozoic-Cenozoic exhumation like the Rhenish Massif or the Holy Cross Mountains. The tectonic and/or other causes for the distribution, magnitude and timing of uplifted areas in Central Europe represent a matter of long-standing debate, including models of strike-slip faulting and intraplate contraction and thrusting related to either Alpine orogeny or Africa-Iberia-Europe convergence. However, there is still no consistent geophysical-geological model explaining the early formation of topography in Central Europe which in part persists to the present day.

In this contribution we will (i) review the existing literature on thermochronology and exhumation of the uplifted basement blocks in Central Europe, and (ii) present new apatite fission track and apatite and zircon (U-Th)/He data from areas between these blocks, focusing on central Germany. The results indicate that the area experiencing pronounced Late Cretaceous exhumation and uplift must have been considerably larger than previously thought and is thus not restricted to thrust-related basement blocks. This implies that the causes for basement thrusting may be decoupled from the causes for the roughly contemporaneous uplift of the entire area, i.e. basement thrusting and (sub)basin inversion were superimposed on regional uplift of much larger wavelength.

A striking feature is the persistence of positive relief in the area affected by Late Cretaceous regional uplift. The absence of subsidence over some 100 Myr may indicate the isostatic effect of a slowly thinning lithospheric mantle. Increasing mantle temperature through the Late Cretaceous and Cenozoic in Central Europe is consistent with sparse occurrences of latest Cretaceous to early Tertiary alkaline volcanics and later with three rift branches (Upper Rhine graben, Lower Rhine graben and Eger rift) arranged in an approximate triple junction geometry around the central Vogelsberg area which exhibits more frequent and voluminous Miocene basalt eruptions. However, the rapidity of the initial uplift as documented by the thermochronologic data suggests a process other than lithospheric thinning, possibly a pulse of mantle upwelling inducing dynamic topography. If this inference is correct, the total Late Cretaceous (to Cenozoic) uplift signal was caused by three different mechanisms operating at different rates and spatial scales: Localized thrusting, dynamic topography, and lithospheric thinning. Whether these mechanisms operated together by coincidence or by cause-and-effect relationships remains an open question.