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Birth and death of oceanic core complexes

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Oceanic core complexes (OCCs) are the uplifted footwalls of very-large-offset low-angle normal faults that exhume lower crust and mantle rocks onto the seafloor at slow-spreading ridges. Although it is suggested on the basis of numerical modelling that they form during periods of relatively reduced magma supply, little is known about how they initiate or how they are terminated, nor why only certain normal fault systems develop into core complexes. Here we present results from a near-bottom sidescan sonar/bathymetric profiler survey and sampling study of the Mid-Atlantic Ridge near 13˚N that demonstrate the critical controls on OCC development and evolution. OCC detachment faults initiate as high-angle (65˚±10˚) normal faults no different from surrounding valley-wall faults and, like them, rapidly flatten to dips of ~30˚ in response to flexural unloading; however, on certain structures displacement continues rather than jumping inward onto a new normal fault, resulting in locally enhanced uplift of the footwall and further flattening of the fault to the horizontal or beyond. Detachment fault formation is triggered primarily by local waning of magma supply, greatly aided by strain localisation due to seawater penetration and talc formation along the fault zones. Volcanism is suppressed or absent when the OCCs are active. The detachments are terminated as neovolcanic ridges propagate laterally across them from magmatically robust segments along strike. Our observations demonstrate how spatial ($\sim 10^0$-10^1km) and temporal (10^5-10^6yr) variations in magma flux to the ridge axis directly control the formation, extent and duration of tectonic spreading at the Mid-Atlantic Ridge.