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Cretaceous long-distance lithospheric extension revealed by seismic reflection profiling of South China

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Geological and geophysical data coupled with numerical simulations have shown that lithospheric extension at passive margins may be classified into three end-member scenarios of pure shear, simple shear, and depth-dependent deformation. However, how lithospheric extension evolves in an intraplate setting remains enigmatic due to the lack of reliable constraints on the deep lithospheric architecture. Here we use seismic reflection profiles across the ~800-km-wide Cretaceous intraplate extensional system of South China to illustrate depth-dependent kinematic decoupling of extension in a mechanically stratified lithosphere. The extension was initially distributed in magma-poor conditions as expressed by normal faulting in the upper crust and lower-crustal flow toward the rift axis. Necking of the crust and Moho uplift led to mantle shear-zone formation, lower-crustal flow toward the rift flanks, and deep mantle flow. We demonstrate that the extensional modes vary with decreasing mantle strength from magma-poor to magma-rich domains, as reflected in decreasing crust-mantle decoupling with increased Moho temperatures and the replacement of a two-layer (brittle vs ductile) mantle by a fully ductile mantle. These findings reveal a first-order lithospheric configuration of intraplate depth-dependent extension driven by far-field stresses attributable to slab retreat. Extension-related strain fields across the lithosphere are uniform ~NW-SE, indicating vertically coherent deformation. Stress transmission across this coherent system might occur via (1) basal tractions that dominated passive stretching of the lithospheric mantle and (2) localized mantle shearing that prompted correlated crust and mantle strain fields. We suggest a tectonic coupling among slab rollback, mantle flow, and lithospheric extension. The rollback-induced mantle flow might have driven lithospheric extension by imposing basal shear forces.