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Anomalous subsidence at South China Sea rifted margin: Sediments digging their own hole

Sascha Brune (1,2), Peter Clift (3), and Javier Quinteros (2)

(1) EarthByte Group, School of Geosciences, University of Sydney, Australia, (2) German Research Centre for Geosciences (GFZ-Potsdam), Geodynamic Modelling Section, Potsdam, Germany, (3) Department of Geology and Geophysics, Louisiana State University, Baton Rouge, USA

Rifted continental margins subside as a consequence of combined crustal thinning and mantle lithosphere cooling. While standard models predict a slowing of subsidence after the end of rifting, the deep basins on the northern margin of the South China Sea, notably the Baiyun Sag exhibit subsidence that accelerated several million years after the end of active extension. Additionally, backstripping analysis at the South China margin has shown that the amount of subsidence is much greater than that predicted from the degree of brittle upper crustal extension seen in seismic profiles.

Here we explain these observations by linking climate change onshore and deformation of the crystalline crust offshore: Early Miocene monsoon intensification increased erosion and thus the sediment flux to offshore basins after the cessation of active extension. When the sediment load encountered the weak crust of the South China Sea margin, it induced lower crustal flow away from the basin axis so that the deep Baiyun basin was formed nearly without brittle extension. We corroborate this concept using seismic observations and backstripping techniques, as well as thermo-mechanical forward modeling. The numerical forward model is a 2D version of the finite element code SLIM3D. The code includes nonlinear temperature- and stress-dependent elasto-visco-plastic rheology and is able to reproduces a wide range of rift-related deformation processes such as flexure, lower crustal flow, and faulting.

We find that two factors allow to satisfy the observational constraints: (1) Post-rift increase of sediment load: The East Asian Summer Monsoon strengthened around the start of the Miocene ($\sim$23 Ma), several million years after continental rupture. Changes in the flora of continental China date from around this time and sedimentation rates across continental margins and deltas in South and Southeast Asia increased, as might be expected under the influence of heavier precipitation driving faster erosion in the source regions. (2) Weak continental crust: Extension in the South China Sea occurred in wide rift mode, which indicates the existence of a thick, weak crustal layer that decoupled deformation of brittle crust and mantle, ultimately forming symmetric margins with an extraordinary width of more than 300 km.

Lateral crustal flow below the Baiyun basin is a consequence of the weakness of the crust, caused by high heat flow, a weak quartz-rheology and is triggered by sediment loading. We suggest that super-deep rift basins, like Baiyun Sag, are likely often linked to the flow of ductile crust in this fashion and would not be expected in cooler rift settings, such as found along the Atlantic margins.