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Rapid South Atlantic spreading changes and coeval vertical motion in surrounding continents: Evidence for temporal changes of pressure-driven upper mantle flow

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The South Atlantic region displays (1) a topographic gradient across the basin, with Africa elevated relative to South America, (2) a bimodal spreading history with fast spreading rates in Late Cretaceous and Eo-Oligocene, and (3) episodic regional uplift events in the adjacent continents concentrated in Late Cretaceous and Oligocene. Here we show that these observations can be linked by dynamic processes within Earth's mantle, through temporal changes in asthenosphere flow beneath the region.

The topographic gradient implies westward, pressure-driven mantle flow beneath the basin, while the rapid spreading rate changes, on order 10 million years, require significant decoupling of regional plate motion from the large-scale mantle buoyancy distribution through a mechanically weak asthenosphere. Andean topographic growth in late Miocene can explain the most recent South Atlantic spreading velocity reduction, arising from increased plate boundary forcing associated with the newly elevated topography. But this mechanism is unlikely to explain the Late Cretaceous/Tertiary spreading variations, as changes in Andean paleoelevation at the time are small.

We propose an unsteady pressure-driven flow component in the asthenosphere beneath the South Atlantic region to explain the Late Cretaceous/Tertiary spreading rate variations. Temporal changes in mantle flow due to temporal changes in regional mantle pressure gradients imply a correlation of horizontal and vertical motions: we find that this prediction from our models agrees with geologic and geophysical observations of the South Atlantic region, including episodes of passive margin uplift, regional basin reactivation, and magmatic activity.