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Modification of western Gondwana craton by plume-lithosphere interaction

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The longevity of cratons is generally attributed to neutrally-to-positively buoyant and mechanically strong lithosphere that shields the cratonic crust from underlying mantle dynamics. Large portions of the cratonic lithospheres in South America and Africa, however, have experienced significant modification since the Mesozoic, as demonstrated by widespread Cretaceous uplift and volcanism, present-day high topography, thin crust, and the presence of seismically fast but neutrally buoyant upper-mantle anomalies.

We show that these observations reflect a permanent increase in lithospheric buoyancy due to plume-triggered lithosphere deformation and deep lithospheric loss during Late Cretaceous to early Tertiary, as further evidenced by positive lithosphere residual topography, negative lithosphere residual gravity and the realignment of seismic anisotropy in the cratonic roots.

Lithosphere in these regions has been thermally reestablished since then, as confirmed by its present-day low heat flow and high seismic velocities. We conclude that lowermost cratonic lithosphere is compositionally denser than the asthenospheric mantle and can be episodically removed when perturbed by underlying mantle dynamics, while the shallower buoyant lithosphere helps to stabilize cratonic crust over billions of years. We further propose that zones where lithosphere was lost would take tens of millions of years to recover thermally, but the density of the new thermal root would remain less than that of the intact root.