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The mantle lithosphere and the Wilson Cycle

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In the view of the conventional theory of plate tectonics (e.g., the Wilson Cycle), crustal inheritance is often considered important in tectonic evolution. However, the role of the mantle lithosphere is usually overlooked due to its difficulty to image and uncertainty in rheological makeup. Deep seismic imaging has shown potential scarring in continental mantle lithosphere to be ubiquitous. Recent studies have interpreted mantle lithosphere heterogeneities to be pre-existing structures, and as such linked to the Wilson Cycle and inheritance.

In our study, we analyze intraplate deformation driven by mantle lithosphere heterogeneities from ancient Wilson Cycle processes and compare this to crustal inheritance deformation. We present 2-D numerical experiments of continental convergence to generate intraplate deformation, exploring the limits of continental rheology to understand the dominant lithosphere layer across a broad range of geological settings. By implementing a “jelly sandwich” rheology, characteristic of stable continental lithosphere, we find that during compression the strength of the mantle lithosphere is integral in controlling deformation from a structural anomaly.

We posit that if the continental mantle is the strongest layer within the lithosphere, then such inheritance may have important implications for the Wilson Cycle. Furthermore, our models show that deformation driven by mantle lithosphere scarring can produce tectonic patterns related to intraplate orogenesis originating from crustal sources, highlighting the need for a more formal discussion of the role of the mantle lithosphere in plate tectonics. We outline the difficulty in unravelling the causes of tectonic deformation, alongside discussing the role of deep lithosphere processes in plate tectonics.