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Thermally-driven subsidence of large platformal basins: linking growth of the lithosphere subsidence patterns on the surface

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A large number of areas which have experienced platformal subsidence during the Phanerozoic are located upon regions of juvenile accretionary crust. These include the Palaeozoic basins of North Africa, the Paraná and Parnaíba basins in South America, the Cape-Karoo basin in South Africa, the Mesozoic Scythian and Turan platforms in Central Asia and the Eastern Australian basins. We hypothesise that the juvenile accretionary crust is initially underlain by a thin mantle lithosphere. This is most likely inherited from the island arcs, accretionary prisms and microcontinents that collided to form this juvenile crust, although it could also be due to lithospheric delamination as a result of the collision. Once the crust has stabilised the lithosphere begins to cool and thicken, which drives the observed subsidence.

To test this we constructed a simple 1D forward finite difference model which calculates heat conduction through a column of crust, mantle lithosphere and upper mantle as it cools. The model then isostatically calculates the water loaded subsidence produced by this process. This allows us to use subsidence curves calculated from the sedimentary record preserved within the basin to test whether the basins could be forming in response to growth of the lithosphere. The results from the model showed that the subsidence produced was most sensitive to variations in crustal thickness and plate thickness (final lithospheric thickness). The modelled subsidence curves were then compared to subsidence curves acquired by backstripping the sediments within the basins mentioned above. The parameters were varied iteratively to find the best fit between the modelled and the observed subsidence. This produced good fits and also provided another method to validate the model results. The crustal thickness and final lithospheric thickness from the models were then compared to measurements of these parameters from other sources such as deep seismic lines and tomographic imaging of the Low Velocity Zone. These generally agreed well with the values used in the model and were used to further constrain the model.

However, subsidence of thin lithosphere is not necessarily limited to unmodified accretionary crust, as described above. For instance the subsidence of the West Siberian Basin, outside the rift system, is similar to the platformal basins mentioned above except that there is a delay of 50 – 90 Myrs between the rifting (and associated eruption of the Siberian flood basalts), and the onset of sedimentation. We used a variant of our model that incorporated an anomalously hot layer beneath a thinned lithosphere to represent a cooling mantle plume head. This produced a good match to the subsidence patterns from the West Siberian Basin. This coupling of deep processes with surface processes allows us to further understand how the basins form, but inversely the sedimentary record could be used to investigate the growth of the lithosphere and provide a prediction of present day lithospheric thickness independent of seismic methods.