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Subsurface Structure and Evolution of Parnaíba Cratonic Basin, Northeast Brazil

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Cratonic sedimentary basins form within stable continental interiors and are underlain by thick (i.e. 200-250 km) lithosphere. They are characterized by prolonged subsidence histories that occur over hundreds of millions of years, resulting in stratigraphic sequences that do not exceed 2-5 km. Despite numerous investigations, the origin and evolution of cratonic basins remain poorly understood, mainly due to a scarcity of geological and geophysical constraints at the crustal and lithospheric scale. In order to address this issue, an integrative and multi-disciplinary investigation of the Parnaíba basin of northeast Brazil has been carried out. Here, we combine the analysis of a 1400 km long deep seismic reflection profile that crosses the basin, teleseismic earthquakes recorded by 12 broadband and 10 short-period, three component seismometers, 25 shallow seismic reflection profiles and 38 well logs. Our main objective is to shed light on the basin's formation mechanisms and on processes driving its spatio-temporal evolution in the context of its sedimentary architecture and crustal structure. Joint modelling of receiver functions and Rayleigh wave dispersion measurements is used to retrieve 1D shear wave velocity profiles beneath each seismometer. The analysis of these velocity profiles is combined with interpretation of the deep seismic reflection profile to construct a two-dimensional crustal model. Results suggest that the Moho occurs at depths of $\sim$35 and $\sim$38 km outside the basin at either end of the deep profile. Beneath the basin, Moho depths of $\sim$39 km and $\sim$40-42 km are observed for the eastern and western regions, respectively. These results suggest that, given the uncertainties, minimal crustal thinning is plausible underneath the sedimentary basin. The validity of the crustal model is tested by applying gravity modelling. Lithologic descriptions and borehole analysis reveal a stratigraphic section that consists of coherent sequences of shallow marine, marginal and continental sedimentary rocks that are bounded by basin-wide erosional unconformities. On shallow seismic reflection profiles, this succession is imaged as packages of parallel-bedded reflections separated by bright, sometimes rugose, reflections that correspond to significant unconformities and resemble ancient landscapes. Rift-type structures filled with Proterozoic and Early Paleozoic rocks are imaged beneath the southwest and southeast regions of the basin, respectively. Water-loaded subsidence curves show an exponential decrease over $\sim$350 Ma. Modelling results suggest that unfaulted subsidence can be characterized by a thermal model with time constants of 70-100 Ma. The relationship between this prolonged thermal subsidence and a possible Early Paleozoic rifting event is explored by calculating the amount of thinning underneath the basin and by investigating variations in strain rate in both time and space. The long-term subsidence pattern is imprinted by small departures from the background trend that match basin-wide unconformities. These departures can be interpreted and modelled as transient uplift events that might relate to changing patterns of dynamic topography. Thanks to these newly acquired datasets, the Parnaíba basin constitutes a good natural laboratory for investigating the fundamental driving mechanisms of cratonic basins. Results from our investigation can be analysed and used to test models of cratonic basin formation generally.