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# Craton stability in a thermal-chemical convection system: the role of compositional dependent rheology

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Maintaining cratonic roots in an earth-like system for over billions of years has been a challenge for geodynamic modelling. Buoyancy alone has been proved to be insufficient for stability and longevity. Instead, the high strength of cratonic root is considered to be the most important factor. Some studies suggest that the viscosity ratio between cratonic root and normal mantle needs to be 1000 in order to maintain the thick cratonic root (Lenardic et al., 2003). Other studies argue that the high strength induced by its cool state can prevent the cratonic root from eroding away for billions of years without any compositional difference, provided the viscosity contrast induced by temperature is high enough (Beuchert, et al., 2010).

Because any mechanism for creating lithosphere creates strong compositional stratification, it is important to explore the role played by a composition dependent rheology. We perform numerical simulations to investigate craton stability using both Newtonian and non-Newtonian rheology. Our results show that the composition dependent rheology is needed to have cratonic lithosphere and normal lithosphere coexisting with each other over billions of years. From our model, a modest compositional rheological factor (about 10) in non-Newtonian rheology is enough for cratonic roots to survive erosion by mantle convection. Using Newtonian rheology, it requires a larger rheological factor (about 100) to have similar results. Furthermore, our models show the role of buoyancy on craton stability is secondary. Once a suitable composition dependent factor is used, the thick cratonic root can be maintained for over billions years with little or no intrinsic buoyancy. Hence, we are able to explain the longevity of cratons in a thermal-chemical convection system using compositional rheology factor within the range of laboratory experimental data (Hirth&Kohlstedt, 1996). Finally, this also implies that the strict “isopycnic” state of cratonic lithosphere is not necessary, if reasonable compositional strengthening is considered.