Geophysical Research Abstracts
Vol. 20, EGU2018-617-1, 2018
EGU General Assembly 2018

Variation of traction and strain rate with lithospheric thickness: An insight into understanding cratonic stability

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Understanding the stability of cratonic roots has been a long standing problem in Earth science community. Several hypotheses, including low density and high viscosity roots, have been proposed to address the problem. With the advent of numerical techniques, several 2-dimensional box models have been used to test some of the proposed hypotheses. One of the fundamental ways to understand this stability problem is to look into traction and strain rates under the thick cratons and see how they differ from those in other parts of the lithosphere, providing an extra stability to cratons. To test this idea, we have used a 3-D numerical model CitcomS, to examine how traction and strain rates vary with lithospheric thickness. Earlier studies (e.g. Conrad and Lithgow-Bertelloni, 2006) have shown that the magnitude of basal tractions is heavily influenced by the presence of thick continental roots, whereas asthenospheric viscosity does not play a significant role. Additionally, analytical results (Cooper and Conrad, 2009) have shown an exponential increment of strain rates with thicker lithosphere. In our 3-D models, we have used both radial and lateral viscosity structures including high viscosity cratons (0-300 km depth). Our results show that the average global traction at different depths is a function of net viscosity effect of the craton and asthenosphere. Global basal traction increases as the lithosphere thickens with a slight decrease in the asthenosphere. Ratio of strain rates between radial and laterally varying models monotonically decreases with increasing thickness of lithosphere, which is opposite to what has been estimated in analytical results. We explain this as an effect of varying viscosity with lithospheric thickness; thin lithosphere (mid-oceanic ridges) are weak, so they have relatively high strain rates compared to thick lithosphere (cratons). This result would potentially explain the longevity of cratons because of such low strain rates within their roots.